European Commission

JRC Technical Report

The impact of IoT and 3D printing on job quality and work organisation: a snapshot from Spain

JRC Working Papers Series on Labour, education and Technology 2021/10

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LABOUR EDUCATION TECHNOLOGY

Joint Research Centre

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EU Science Hub
https://ec.europa.eu/jrc

JRC125612

Seville: European Commission, 2021

How to cite this report: Grande, R., Vallejo-Peña, A., Urzí Brancati, C.., *The impact of IoT and 3D printing on job quality and work organisation: a snapshot from Spain*, Seville: European Commission, 2021, JRC125612.

The impact of IoT and 3D printing on job quality and work organisation: a snapshot from Spain

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Abstract

This paper analyses how the introduction of advanced digital technologies affected the business model, work organisation, and job quality in selected establishments in Spain. The focus is on two technologies: 3D printing and Internet of things (IoT). Two case studies were carried out in Spain: TTI-Algeciras (stowage and logistic port container terminal) and Airbus (manufacture of aerospace and defence equipment). A qualitative research methodology through semi-structured interviews was implemented. The results show the selected digital technologies has a positive impact on the business model of TTI-Algeciras and Airbus, either by increasing efficiency and competitiveness, or by improving work organisation. The main findings in terms of job quality, are: improvements in the physical environment resulting from a reduction in occupational hazards: the upskilling of the workforce, due to the need of new technical skills; the increase in worker responsibility and autonomy to the detriment of routine tasks; and, on the negative side, an intensification of work that is now determined by the technology. The analysis also shows the importance of communication and new ways of organising teamwork as a crucial factor for the successful introduction of digital technologies in both companies. Finally, the consequences of the restrictive measures against Covid-19 during 2020 have favoured an acceleration of technological change in the workplace.

Keywords: 3D printing; Internet of Things (IoT); digitisation; digitalisation; digital technologies; future of work.

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Acknowledgements:

The authors would like to thank Sara Riso for providing the analytical model and the research framework this paper is based on and for her invaluable advice and suggestions. Gratitude is also extended to Enrique Fernández-Macías for his advice and support.

The authors would also like to express their gratitude to anonymous interviewees at TTI Algeciras and Airbus Getafe for their collaboration and making this study possible.

Joint Research Centre reference number: JRC125612

Related publications and reports:

Matteo Sostero, 2020. "Automation and Robots in Services: Review of Data and Taxonomy," JRC Working Papers on Labour, Education and Technology 2020-14, Joint Research Centre

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1 Introduction

The digitisation of processes —that is, the conversion of analogue or mechanical elements of the physical world into bytes (and vice versa) via means of sensors or rendering devices— is one of the main channels through which the digital revolution is changing the nature of work (Fernández-Macías, 2018). According to the latest version of the Eurofound framework (Eurfound 2021), adopted in this study as a guide, the digitisation of processes affects work organisation and job quality via changes to the business model. These changes can be broken down into impacts on tasks, occupations, working and employment conditions, and industrial relations.

Generally, the digitisation of processes leads to a reduction in costs and better resource utilisation, and therefore to an increase in revenues. The main areas of job quality affected by digitisation are likely to be skills, work intensity, autonomy (discretion) and the physical environment (Eurofound, 2021).

The digitisation of processes is driven by three cutting-edge technologies: 3D printing, Internet of things (Iot), and Virtual/Augmented reality (VR/AR) (Peruffo et al., 2017; Fernández-Macías et al., 2018). While this paper focuses on assessing the impact of 3D printing and IoT, it is useful to start by briefly describing all three of technologies to better understand what digitisation means in practical terms.

3D printing, included in the broader category of "Additive manufacturing", is a technology that transforms digital information into a physical object by carrying out instructions from a Computer Aided Design (CAD) file. 3D printers create solid objects by adding or fusing layers of a range of materials, such as polymers, metals, and ceramics (European Commission, 2017; Lipson and Kurman, 2013). The fields of application for 3D printing include: architecture; biotechnology; construction; fashion; food; footwear; and industrial design. It is used on a commercial scale to make everything from aircraft parts to prosthetic arms and legs (Lipson and Kurman, 2013; Schniederjans, 2017).

Internet of things (IoT) is a system of interconnected sets of entities encompassing smart devices, sensors, and products collecting and analysing data and autonomously performing actions; it relies on ubiquitous and pervasive connectivity, computing capability, and large amounts of data. The fields of application for IoT technologies are numerous and diverse, including transportation and logistics; healthcare; smart environments (home, office, plant); and, of course, the personal and social domain (Atzori et al, 2010; Peruffo et al, 2017; Khodadadi et al, 2016). The term IoT was coined by British technology pioneer Kevin Ashton in 1999 to illustrate how connecting Radio-Frequency Identification (RFID) tags to the Internet would allow the collection, processing and transmission of data without the need for human intervention, thereby greatly reducing costs (Kramp et al, 2013).

Finally, **virtual and augmented reality (AR/VR)** are similar technologies, but based on different concepts. VR is a computer generated setting which, through the use of projections screens, tracking devices and head mounted displays (HMDs), creates a "virtual experience in which the user is effectively immersed in a responsive virtual world" (Berg and Vance, 2017). By contrast, AR technology does not create a new reality, but rather enhances our perception of it, by integrating computer-generated objects and/or virtual content into the physical world (Hugues et al., 2011). AR/VR are actively used in a variety of sectors, such as healthcare, transport, construction, and education and training.

Among the three technologies, IoT is the most widespread in Europe, as the next section will show. It is followed by 3D printing, whose presence is, however, still relatively marginal and confined to a handful of sectors. On VR/AR we could not find any hard data. We selected establishments which adopted 3D printing and the Internet of Things as they are more widespread in Spain compared to AR/VR, as the lack of available data suggests. These two technologies are also more likely to be presented in combination with other projects for automation, innovation and digitisation of workplaces.

Given our need to understand potential causal links and pathways through which these technologies affects the nature of work, we present results of in depth interviews carried out with employees, employee representatives and managers in two Spanish establishments: the first establishment, operating in the stowage and logistics sector is Total Terminal International (TTI) in Algeciras (NACE code: 52.22 Service activities incidental to water transportation). The second establishment, operating in the aerospace and defence sector is Airbus with a focus on its establishment in Getafe (Madrid) (NACE code 35.30 Manufacture of aircraft and spacecraft). TTI Algeciras has been selected for our study for its adoption of IoT, whereas Airbus has been selected for its adoption of 3D printing, even the establishment also introduced IoT and augmented reality, but on a much smaller scale.

The next section presents a short overview of the literature and some descriptive statistics on the distribution of digital technologies in Spain to contextualise our findings; section 3 describes the research methodology including the criteria for selecting the companies, the qualitative interview technique and the analytical strategy. The analysis of the results will be illustrated by describing the process of introduction and implementation of the technologies, the effects on work organisation, the impact on job quality and the role of social dialogue and employee participation throughout the digitalisation process (section 4). The paper ends with a summary of the main findings, implications and scope of future results, with a special focus on the role of institutions and labour policies (section 5). A detailed description of the two selected case study companies can be found in the Appendix 1.

2 3D Printing and IoT: an Overview

This short overview of the literature focuses on studies analysing the impact of digital technologies in general, and 3D printing and IOT in particular, on the business model, work organisation and job quality. The expected impact of the introduction of new digital technologies on working conditions has been discussed in recent literature. Some previous research (Grande et al., 2020), at company level, a positive association between process innovation and job quality has been found for 32 European countries, but there is no clear relationship with other types of innovation (product, marketing and organisational)

The digitisation of processes can affect the business model and production process of a firm by bringing production costs down, reducing transport needs and enhancing efficiency in a number of ways. For instance, IoT provides employers with the ability to constantly monitor production processes, hence improving maintenance and the conditions of machinery; in the transportation and storage sector, IoT is commonly used for fleet or asset monitoring and optimisation (Eurofound, 2021). The availability of real time data can improve managers' ability to plan and make better decisions in several fields, such as farming and agriculture, predictive farming, or predictive maintenance in storage and transportation (Eurofound, 2021; European Commission, Digital Strategy[1]).

Companies which are part of global supply chains can use IoT to track all their products, thereby reducing operating expenses and improving productivity (Kramp et al., 2013). Similarly, 3D printing can reduce the fixed costs of tailoring products, but it can also reduce transports costs and energy consumption (Lipson and Kurman, 2013; Schniederjans, 2017; Huang et al., 2013; Baumers et al., 2016). One of the most sizeable predicted changes brought about by 3D printing (mainly in manufacturing) is the shift from production based on economies of scale to "economies of one" – with high customisation, more localised collaboration, a variety of competitors, and higher weight of

[1] https://digital-strategy.ec.europa.eu/en/policies/digitisation-agriculture

variable costs (Petrick and Simpson, 2013). Finally, AR/VR can be used to help design, develop, and evaluate early concepts before resorting costly physical prototypes (Lawson et al, 2015; Berg and Vance, 2017; Seymour et al., 2002). IoT in healthcare enables scenarios where machines with decision support systems interact and communicate among them (Aceto et al, 2018). It can greatly improve the provision of services and optimise resource utilization, for instance via setting up 'one stop' services to the residents conveniently even at remote locations (Yuehong et al, 2016), but also enabling the personalisation of services, and improving diagnostics via the constant monitoring of patients and collection of vital data (Kulkarni and Sathe, 2014; Aceto et al, 2018; Eurofound, 2021). Similarly, 3D printing can vastly benefit healthcare systems via the customisation of products (Huang et al, 2012); it has already been used extensively to produce prosthetics, dental implants, and hearing aids (Petrick and Simpson, 2013)

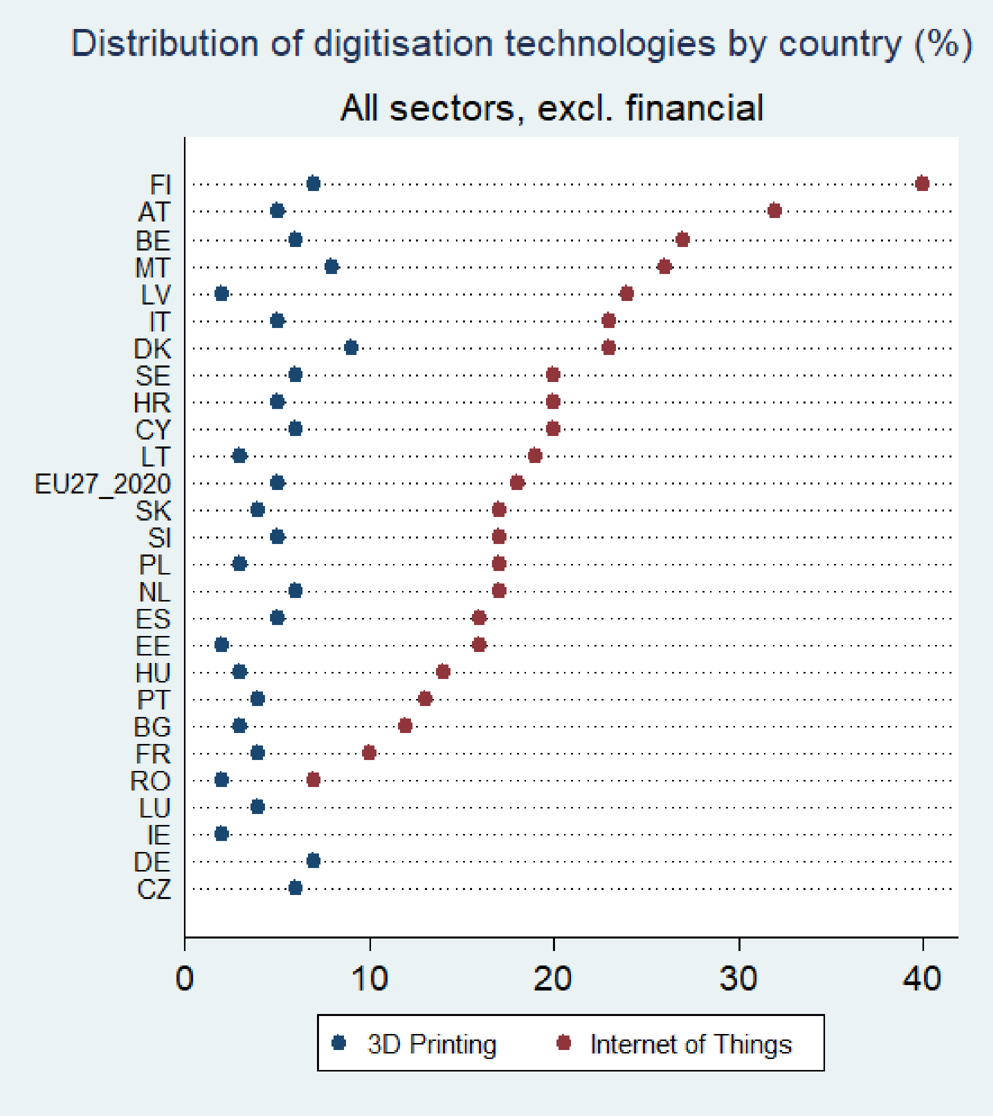
The case studies conducted by Eurofound (and which are part of the same project) revealed that the positive impacts of the introduction of digital technologies generally relate to changes in the physical environment, by making the workplace safer; researchers have also unearthed some negative impacts on workers' autonomy and on the social environment, especially following the introduction of IoT (Eurofound, 2021). As previous studies already mentioned, the massive collection of data (enabled by IoT, wearables and other surveillance technologies) and the potential for intrusive monitoring and surveillance practices, raise some serious concerns on worker's privacy (Eurofound, 2020b; Fernández-Macías, 2018). In this respect, firm-level research in Europe concludes that union representation plays an important positive role (Grande et al., 2020).

Several other studies have reported a positive impact of the digitisation of processes on the work environment, especially in terms of accident reduction. For instance, Perlman et al (2014) describe how AR/VR are used to provide high quality training to help workers identify potential hazards in construction; Gavish et al., (2015) report the same for Industrial maintenance and assembling. By contrast, the raw materials used for 3D printing can be potentially dangerous to workers' health. For instance, in industrial 3D printing, one of the most commonly used materials is polyamide (nylon) in liquid and powder form; when heated, it released toxic fumes, so the environment has to be ventilated (or the printer enclosed) (EU-OSHA, 2017).

2.1 Digital technologies in Europe and the Spanish case

Eurostat ICT usage in enterprises survey 2020 (ICT survey) has collected information on the use of 3D printing and IoT across Europe in enterprises with at least 10 people employed. As Figure 1 shows, the prevalence of IoT is substantially larger than 3D printing, with approximately 18% of the enterprises with at least 10 workers in EU27 using the former technology and only approximately 5% using the latter. There is, however, significant heterogeneity across countries; for instance while in Finland 40% of the enterprises with 10 or more employees uses IoT, the same is true for only 7% of the corresponding enterprises in Romania. A similar picture can be painted concerning 3D printing, with only 2% of the Romanian enterprises with 10 or more employees using the technology as opposed to 9% of the corresponding enterprises in Denmark. For what concerns the adoption of IoT, Spain is slightly below the EU average, with 16% of enterprises with 10 or more employees using the technology, whereas the use of 3D printing at 5% of the enterprises stands in line with the EU27 average.

Figure 1: Distribution of 3D printing and IoT in Europe, all enterprises with at least 10 people employed, year 2020

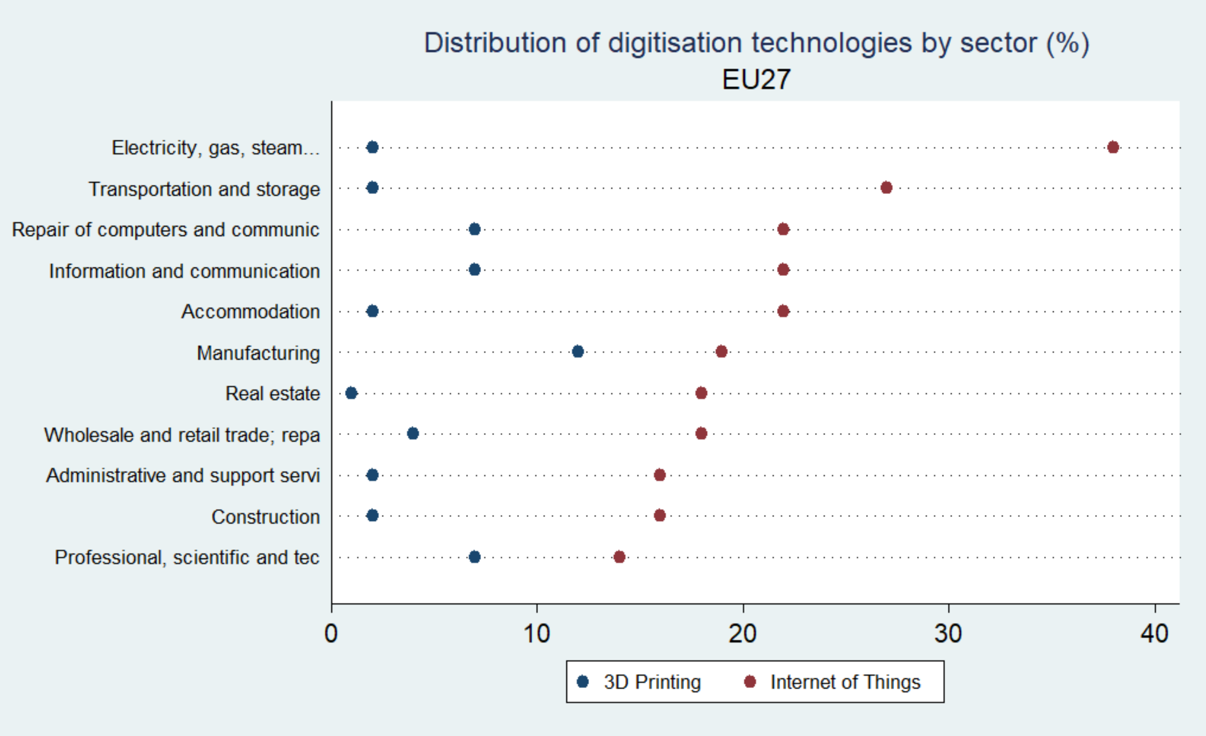


Source: Eurostat - ICT usage in enterprises (isoc_e)

Figure 2 shows instead the distribution of 3D printing and IoT across all sectors (excluding financial) in EU27 for enterprises with at least 10 people employed. The first thing we notice is a relatively low correlation between the two technologies, in that while 38% of the enterprises in the electricity, gas, steam, air conditioning and water supply sector (NACE 35 to 39) use IoT, only a meagre 2% of the enterprises in the sector use 3D printing. Similarly, IoT is remarkably prevalent in transportation and storage, with 27% of the enterprises with at least 10 people employed using it, but only 2% of the enterprises in the same sector use 3D printing. By contrast and unsurprisingly, 3D printing is particularly prevalent in manufacturing, as it is used by approximately 12% of the EU27 enterprises with at least 10 people employed operating in the sector.

Clearly, the diffusion of a specific technology depends on the activity carried out. For instance, IoT in the energy sector is used mainly for maintenance and or to optimise energy consumption through the use of smart meters, smart thermostats, and so on. Another important distinction concerns whether the activities are business to business (B2B) or business to consumer (B2C), as only in the second case we can study the impact of the technologies on working conditions and job quality.

Figure 2: Distribution of 3D printing and IoT across sectors, EU27 – all enterprises with at least 10 people employed, year 2020



Source: Eurostat - ICT usage in enterprises (isoc_e)

It should also be mentioned that both technologies are more likely to be found in large enterprises (with 250 or more people employed) than smaller ones, and therefore the diffused presence of small/medium enterprises in some countries, as well as their industrial structure, is a strong determinant of the prevalence of the technologies.

As we have seen, Spain is in line with the European average for the implementation of IoT and 3D printing in firms. If we look at broader indicators of digitisation, such as the European Commission Digital Economy and Society Index (DESI), we find that Spain performs slightly better than the EU average[2]. In 2020, Spain ranked 11th out of the 27+UK EU Member States. In the past few years, its performance improved in all of the DESI dimensions measured (i.e. connectivity, human capital, use of internet services, integration of digital technology, and digital public services). On the Integration of Digital Technology by businesses, Spain ranks well above the EU average. According to the 2020 DESI country report, Spain will invest more than €200 million for the recovery and digitisation of businesses, and especially of SMEs[3].

Some factors about the 4th industrial revolution in the Spanish context should be briefly reviewed. Firstly, Spain's own productive structure, with a relevant number of SMEs, a lower weight of industrial sectors and a predominance of the service sector in many regions, may generate an uneven adaptation to technological change in the workplace. This may also prevent the full potential of new technologies from being exploited in terms of job quality and work organisation, favoured by the trend towards labour deregulation and decreasing influence of social dialogue (Muñoz de Bustillo & Pinto, 2016).

[2] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi

[3] https://digital-strategy.ec.europa.eu/en/policies/desi-spain

Grande (2018) found that automation and digitisation technologies in Spain had a positive impact on the quality of manual jobs, especially in terms of wages, but also health and safety, and intrinsic quality of work dimensions; at the same time, his study revealed a stagnation of improvements in job quality for high skilled white collar workers during the post-crisis period 2010-2015.

In addition, the financial and economic crisis of 2008-2014 slowed down the processes of modernisation and introduction of digital innovation in many companies (Grande, 2018), even though the current crisis caused by Covid-19 seems to be having the opposite effect, boosting technological change (Soto-Acosta, 2020).

In 2014, Spain launched the initiative "Connected Industry 4.0 (CI 4.0)" aimed at boosting the digitisation process and improving competitiveness of the Spanish industrial sector, by providing a strategy to support companies in their digital transformation[4]. However, Industry 4.0 still has little public opinion visibility in Spain. Although companies have started to introduce different types of digital innovations that can improve their competitiveness, this has not yet been translated into the strategic plans of organisations (Bondar, 2018). Lazaro (2017) indicates the lack of knowledge about the industry 4.0 initiative as a challenge for digitising.

3 Methodology

The main objective of this study is to investigate the impact of the digitisation of processes on work organisation, working and employment conditions, and industrial relations in two company establishments in Spain, by focusing on the adoption of two of the main technologies used for the digitisation of processes, namely 3D printing and IoT.

In particular, the paper tries to answer the following research questions:

- Did the selected technologies bring changes to: the business model; tasks and occupations; work organisation; employment and working conditions?
- If so, which were the changes and which were the driving mechanisms?
- How did the technologies affect/were affected by employee participation and social dialogue/industrial relations?
- Did management adopt specific strategies to manage the digital transition? What did the strategies entail? And were employees involved in the process?
- Which were the main drivers/barriers to the adoption of the selected technology?

3.1 Conceptual model

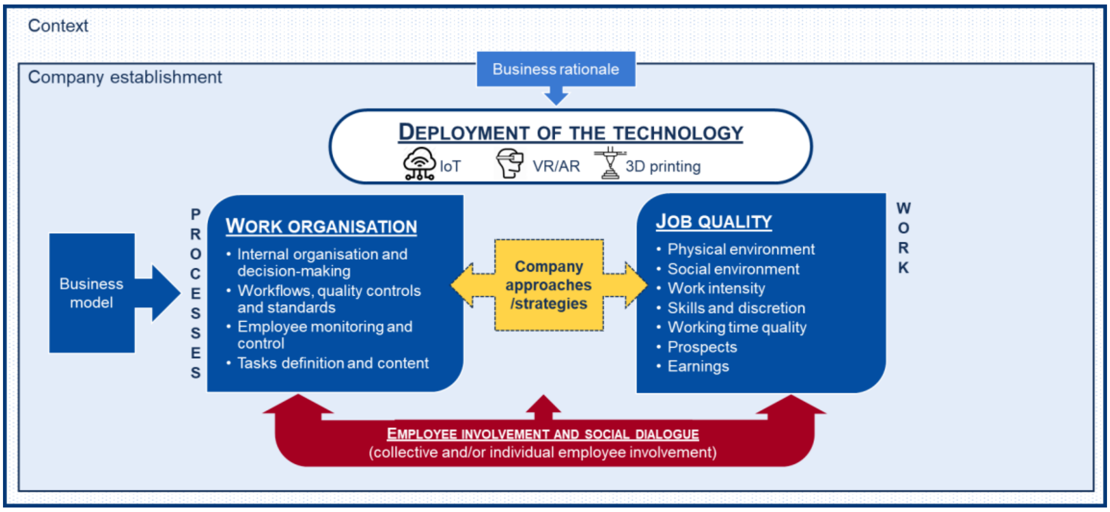
To guide our analysis and understand in detail how the digitisation of processes affects the nature of work, we adopt Eurofound's conceptual model to provide guiding principles for the latest research on the future of work (Eurofound, 2021). This conceptual model is in turn based on the conceptual framework elaborated by Fernández-Macías (2018).

In Eurofound's conceptual model (Figure 3), the technology –depending on its level of embeddedness in work processes– changes the business model, which in turn affects the work organisation and elements of job quality. It blends together two core dimensions, a cross-cutting dimension, and some contextual elements. The two core dimensions are: work organisation and job quality; the cross-cutting dimension consists of employee participation and social dialogue. The adoption of a new technology and the strategies surrounding its deployment affect the two core dimensions by changing the business model, whereas employee participation and social dialogue can both influence and be influenced by the introduction of a new technology.

[4] https://ati.ec.europa.eu/sites/default/files/2020-06/DTM_Industria%20Connectada_ES%20v1.pdf

Employee participation and social dialogue are crucial in the workplace as they underlie workplace innovation and contribute to shape working conditions. Contextual factors or company's specificities may drive or hinder the technology adoption process and should also be taken into account when performing the analysis.

Figure 3: Conceptual model for this study



Source: Eurofound 2021.

Below, a detailed description of all the elements in the framework:

- **Work organisation** refers to "how work is planned, organised and managed"; it refers to decision-making processes, workflows, quality controls and standards; employee monitoring and control; task definition and content[5].
- **Job quality** covers all the characteristics (both positive and negative) of work and employment that have shown an empirical relationship with workers´ well-being.

The job quality indicators are based on those developed by Eurofound (2017)[6]: physical environment; work intensity; working time quality; social environment; skills and discretion; prospects; earnings. The indicators developed by Eurofound adhere to the multidimensional perspective deemed necessary by other authors, such as Muñoz de Bustillo et al. (2011).

The cross-cutting dimensions of employee participation and social dialogue refer to the "involvement of employees in management decision-making in the workplace, either in relation to wider company issues (workplace social dialogue) or in their immediate job (task discretion)".[7]

Among the contextual factors, we should include conditions of employment, such the institutional framework and labour regulations that apply to the workplace, which relate to issues of stability, opportunities for development and pay; these elements, in turn, depend on the institutional framework and labour regulation, with the effect of technology being more indirect.

[5] The framework of reference we use is the JRC-Eurofound task framework elaborated by Fernández-Macías and Bisello (2020), which provides a complete taxonomy to differentiate between the "what" and the "how" of work activity. What: content of tasks – physical (strength, dexterity and navigation), intellectual (information processing, problem solving, and their sub-categories), social tasks (serving/attending, teaching/training/coaching, selling/influencing, managing/coordinating, and caring); How: methods of work organisation (autonomy, teamwork, routine) and tools used at work (digital, non-digital, others). For a thorough description and explanation of the rationale please refer to Fernández-Macías and Bisello, 2020)

[6] https://www.eurofound.europa.eu/topic/job-quality.

[7] https://www.eurofound.europa.eu/topic/participation-at-work

3.2 Selection criteria for case studies and company profiles

This research has been carried out using a qualitative approach through case studies for Spain, in the context of the Eurofound-led research project on the impact of digitisation on work organisation and job quality[8].

As Flick (2007) argues, qualitative research aims to understand and describe social phenomena from the inside, based on the experiences of individuals (biographical trajectories, daily and professional practices, social and environmental interactions, etc.); in other words, understanding individual experiences in a humanistic and interpretive approach. In this way, qualitative methods make it possible to study the impact of the digital revolution on employment, work organisation and quality of work by accessing the experiences, contributions and opinions of workers from the natural context of their workplace, thus making room for the particularities of the complex relationship between the digital transformation and working conditions.

Furthermore, case studies have the advantage of allowing for a more in-depth investigation of intricate phenomena within a specific context (Stake, 1995; Yin, 2009). The use of case studies makes it possible to assess how the introduction of technology has influenced work organisation and job quality with a special interest in day-to-day changes, decision-making and employee participation throughout the process.

The selection criteria and the qualitative sampling procedure of the study, the use of the semi-structured interview technique and the analytical strategy of the study are described below.

As mentioned in the introductory section, the unit of analysis consists in companies or establishments in Spain that have introduced any of the technologies associated with digitisation; in this case, Internet of Things and 3D printing.

To identify and select potential case studies by means of qualitative sampling, homogeneity and heterogeneity criteria were used, as detailed below.

All potential cases had to have introduced at least one of the two technologies, or both. In all cases the implementation of these technologies had to be fully integrated in the work and business processes for at least two years, which will allow us to explore the changes that the technology has brought about in the workplace and the adjustments made to cope with the digital transition.

Three criteria of heterogeneity with respect to digital technology were used for selecting the potential case studies. Firstly, the level of implementation of the technology: low (the company is conducting a pilot using the technology); medium (the technology is regularly applied as a substitute or complement to the previous methodology) or high (the technology is an integral part of the business process and is widely adapted in all applicable areas). Second, the level of impact on working conditions, again with three categories: low (technology has little influence on employees); medium (technology is frequently used in the work process and requires active engagement) and high (technology transformed the employee's key daily tasks or resulted in a new understanding of the employee's role). Third, the companies selected as potential case studies could operate in any economic sector of activity and could be a public or private body. Cases with a diversity of company sizes were also sought, summarised in three groups: small (less than 50 employees); medium (50 to 249 employees) and large (more than 250 employees).

With respect to the main characteristics of the company, the criteria for homogeneity of the sample were exclusively two: being in Spain, even if it had foreign capital, and having formal employee representative that allows the companies' employees to influence issues related to their work, remuneration or working conditions.

[8] Work organisation and job quality in the digitised workplace | Eurofound (europa.eu).

During the first phase of the study, the research team searched for companies based on these criteria of homogeneity and heterogeneity. Following one of Patton's (2002) proposals, cases were purposively sampled per their intensity in the implementation and impact of digital technology and the maximum variation with respect to sector, ownership and size. This way, a collection of contacts and cases was established to build a corpus reflecting the diversity of the phenomenon under study.

Six potential case studies were identified and discussed by the research team, and two of them were finally selected for a detailed study in the second phase: Total Terminal International (TTI) Algeciras and Airbus. TTI-Algeciras was selected based on its introduction of IoT, whereas Airbus was selected based on its introduction of both technologies.

Total Terminal International (TTI) is one of the two container terminals operating in the Port of Algeciras Bay, in the strait of Gibraltar - a Geostrategic node for international trade and logistics where most of the world maritime transport network converge. Funded by the Korean Hanjin Shipping in 2008, the company is now (since 2021) owned by the Korean shipping line HMM (50% +1 share) and Isla Verde Algeciras Terminal Holding, SL (50% -1 share).[9]

It operates in the maritime transport sector (stowage and container terminal) and describes itself as the first semi-automated terminal in Southern Europe and the Mediterranean area. The Port is considered the Western Mediterranean's benchmark logistics, marine and port platform.

TTI Algeciras was built with the adoption of advanced digitisation and automation technologies in mind, as Hanjin Shipping wanted to replicate the model adopted by the South Korean port of Busan (the fifth busiest container port in the world). However, since operations started in 2010, the digitisation process has been constantly updated and improved, by adopting ancillary technologies which facilitated container traceability.

The core of the activity takes place in the fully automated container yard where maritime and land transport are connected. All machinery (see appendix for a detailed description) is endowed with IoT and ancillary technologies. All operations are controlled by a tailor-made Terminal Operating System (TOS) - an advanced computer system managed remotely by the operations and systems department in the Terminal's headquarters. The TOS controls the terminal's logistics (vessel planning[10], container inventory maintenance, gate operations) as well as managerial functions (billing, reporting, and communication among the terminal carriers, transport companies etc.). The TOS generates automated orders by processing all the information received through IoT technology. In addition, the TOS can process and analyse data at high speed, providing useful information (e.g. a longitudinal analysis of the energy consumption of machines) to engineers and managerial staff. In this way, further improvements can be introduced by management.

Airbus (Getafe, Madrid) is a French aerospace company with extensive military capabilities and a strong presence across Europe. It is currently the world's leading aircraft manufacturer. Airbus has been operating in Spain since 2000, following a merger with the Spanish company Construcciones Aeronáuticas, SA. (CASA). The Spanish sites employ approximately 12,700 workers, and nearly half of them (6,030 employees) are located in the Getafe establishment. Airbus-Getafe produces: the horizontal stabilisers[11] for the entire range of Airbus commercial aircraft; rear fuselages for the entire range of Airbus helicopters (rotary-wing aircraft are designed, developed and integrated, as

[9] It should be mentioned that the TTI project has been funded with support from the Ministry of Industry, Tourism and Trade of Spain under the Aid Program for Reindustrialization.

[10] Vessel planning is a core module of a state-of-the art terminal operating system. The application module plans the sequence of discharge/loading of container from/onto a vessel taking into consideration the ship structure and the stowage of containers on board the vessel.

[11]Horizontal stabilisers (or tailplane) are part used to maintain the aircraft in longitudinal balance.

well as flight tested and certified); and finally, military transport aircraft. The military and defence area employs the largest share of the company's Spanish workforce (approx. 70%).

Interviewees stress that the introduction of digital technology is limited and conditioned by a highly regulated environment (safety of design, manufacture, use and maintenance). The three areas in which digital technology is adopted are: the production process and improvement of operations; the organisation of work and communication; and security.

Airbus Getafe has adopted 3D printing two years ago to manufacture components and tooling for aircraft and ground installations (using both plastic and metallic materials[12]). The technology has been introduced with the aim to replace traditional supply chain logistics with 3D printing manufacturing for low-volume and highly complex parts. The benefit is that now the establishment can quickly produce relatively simple parts that previously would take a long time to arrive or require a minimum quantity, therefore slowing down the whole operation.

Airbus Getafe has also introduced IoT and AR technologies, but within a very limited scope. Basic IoT technology is used for the electronic toolbox (so that tools are easily located, therefore increasing efficiency of the production chain); digitally connected sensors are also used to prevent lack of oxygen for the pilots. AR technology is used for hololens, that is, for the cable router in aircrafts superimposed on the parts; it is also used to provide training and coaching to employees.

The use case of 3D printing is a good example of how digital technology can be introduced to solve small problems and improve efficiency, without a structural change to the entire manufacturing process.

3.3 Qualitative approach: semi-structured interviews

The qualitative approach of the study is based on semi-structured interviews. The focus is on workers and managers with experience with the object of our research. In other words, we are looking for positions that have been involved in the process of introducing digital technology and its consequences, and who have sufficient seniority in the company to be able to assess the changes that have taken place.

During the first phase, data were collected by means of brief semi-structured interviews (see master interview guidelines in the Appendix 3), both face-to-face and virtual, with the company management contact persons, to obtain all the preliminary information that would allow the selection of the case studies of greatest interest for the second phase. These interviews enquired about the structural characteristics of the company identified, the forms of employee representation, the type(s) of digital technology introduced in the company with details of the working environments, the tasks and processes to which the technology is applied and the occupations most affected; and a brief description of the main changes in the organisation and job quality resulting from the introduction of the digital technologies in question.

In the second phase of the research, four profiles were identified for interviews in each case study. These profiles are based on the criteria of proximity to the phenomenon under study and to have a balanced reporting which takes into account the perspective of management, employees and employee representatives, with special attention to the role of staff in middle management. These are the four profiles interviewed:

- HR manager or responsible in the HR department.

[12] The manufacturing technology used for metallic materials is powder bed fusion (PBF) based on the fusion of metallic powder using laser or electron beam as source of energy. Plastic materials are developed following two different techniques: Filament Layer Manufacturing (FLM) and Selective Laser Sintering (SLS) working with Polyetherimide and Polyamide respectively (Romero et al, 2019).

- Innovation manager, those responsible for digitalisation projects and implemented technologies.
- Employee representative, this can be a member of the works council, a trade union representative or a member of a trade union linked to the social side of the company.
- Workers whenever their tasks are directly or indirectly affected by the introduction of technology in the workplace. At least two workers are interviewed in each case study, one of them selected by the HR manager or company management and the other by the employee representative.

The semi-structured qualitative interviews follow a standard script, slightly different for each of these profiles (see master interview guidelines in the Appendix 4). This standardisation facilitates comparability between the different company cases. In addition to the issues raised in the phase 1 interviews, the entire process of technology introduction (developments, business strategy, external and internal factors, etc.), the effect on the organisation of work processes, the impact on job quality, social dialogue and employee participation in the introduction and evaluation of technology, and the specific challenges and risks arising from technological change are discussed. In addition, all interviews addressed the impact of the Covid-19 pandemic on the establishments and the role that digital technologies have played during this time.

The fieldwork for the second phase was carried out in November and December 2020. A total of 11 interviews were conducted, 6 at TTI-Algeciras and 5 at Airbus, whose characteristics and profiles are shown in Table 1.

In each case study, a person linked to the human resources department, one of the company's innovation managers who has overseen the digitalisation process in recent years, a workers' representative or member of a trade union organisation and at least two workers were interviewed. In the case of TTI-Algeciras, employees from operations, maintenance and yards and gates were interviewed. In addition, a site visit to the plant was carried out with participant observation. At Airbus, the employees belonged to different establishments in positions linked to the technology studied: operators of additive layer manufacturing (3D printing) and maintenance tasks.

Table 1: Profiles interviewed in the two case studies

Profile	**TTI-Algeciras**	**Airbus**
Phase 1		
Managers	Manager1_TTI 20/07/2020 (face to face)	Manager1_AIR 4/11/2020 (virtual)
Phase 2		
HR manager	HR1_TTI 10/12/2020 (virtual)	HR1_AIR 17/11/2020 (virtual)
Innovation manager	Innovation1_TTI 25/11/2020 (face to face)	Innovation1_AIR 02/12/2020
Employee representation	Representation1_TTI 16/12/2020 (virtual)	Worker3_AIR 14/12/2020 (virtual)
Workers	Worker1_TTI 25/11/2020 (face to face)	Worker1_AIR 15/12/2020 (virtual)
	Worker2_TTI 25/11/2020 (face to face)	Worker2_AIR 18/12/2020 (virtual)
	Worker3_TTI 25/11/2020 (face to face)	

Source: own elaboration

All interviews were conducted in Spanish language. Although the qualitative interviews were initially designed to be conducted face-to-face, in the end the fieldwork followed a mixed face-to-face and virtual method due to the health restrictions imposed by Covid-19. Beyond the disadvantage of not being able to conduct all the direct observation in the workplace, online interviews are a good option that gives flexibility to the qualitative fieldwork and place the interviewee in a comfortable context with low social pressure (see James & Busher, 2009; Sadaba, 2012). In addition, the Covid-19 context has popularised the use of video-conferencing tools, which has made the use of online interviews more accessible.

3.4 Analytical strategy

Based on our field research, the analysis was carried out using secondary and primary sources of information. On the one hand, desk research was carried out relying on documents and data provided by the companies' management, which were used especially for the description of the case studies. On the other hand, a qualitative content analysis and discourse analysis of the interviews was carried out based on the audios and transcripts of the interviews. For this purpose, patterns and themes relevant to the target of this study were detected through codes and qualitative items that allow the comparison of the interviews in each of the case studies.

4 Results

4.1 Deploying digital technologies

4.1.1 Digitisation strategy adopted by TTI-Algeciras and changes to the business model

Motivation for the introduction of the technologies

In 2010, the terminal became a pioneer in the introduction of automation in terminal operations in southern Europe and the Mediterranean. The main objectives pursued were boosting productivity and reducing costs, so that the terminal would be able to fit the requirements of carriers deploying mega-ships in the Asia-Europe trades and to compete in an environment with labour costs lower than in Europe.

In particular, the introduction of IoT technology was intended to:

- Reduce stowage and unstowage times as well as movements within the terminal. The high level of digitisation via IoT achieved at the terminal allows movements within the yard to be precisely synchronised, always choosing the shortest path for a movement. It also avoids the waiting times associated with a traditional container terminal, where a machine has to stop, waiting for the previous movement to finish.
- Reduce personnel and personnel costs due to the large amount of automated operations – in particular, human intervention has been eliminated in the fully automated container yard and the gate (the whole yard is fenced preventing the entrance of workers except those authorised to do repairs or preventive maintenance of the cranes); similarly, machine repairs can be executed from the operations department, without displacing mechanics. With the new model exported from South Korea, the terminal operates with half as many staff as traditional terminals facing the same conditions.
- Reduce errors and introduce agile management and resolution of breakdowns, as a result of its advanced monitoring systems throughout the terminal. IoT allows engineers and other technical staff to apply predictive maintenance, as they can observe the operation of machinery in detail. The system provides warnings of any deficiencies that could develop into breakdowns, or on parts that need to be replaced in advance, based not only on the time elapsed but also on their condition.

- Reduce accidents, which in turn has led to an improvement in subjective perception of well-being and safety at work.

Place in the workplace for the technology and its embeddedness

The terminal's activity is concentrated in phase A of the Isla Verde Quay, in a large container terminal that occupies an area of more than 300,000 square metres. The core of the activity takes place in the container yard where the stevedoring activity is carried out and maritime and land transport are connected.

As already mentioned in the description of the company provided in section 3.2, all operations in TTI Algeciras are controlled by a tailor-made Terminal Operating System (TOS) - an advanced computer system that carries out logistic functions (vessel planning, container inventory maintenance, gate operations) as well as managerial functions (billing, reporting, and communication among the terminal carriers, transport companies etc.). The TOS is located in the company's headquarters, inside the terminal itself, and is able to generate automated orders by processing all the information received through IoT technology.

The tracking and managing of containers and equipment is achieved through the full integration and communication among different systems. For instance, a high-tech optical character recognition (OCR) system is mounted on the ship-to-shore (STS cranes); the automatic stacking cranes (ASC) are equipped with laser or infrared sensors, advanced camera imaging technology, navigation sensors and crane management information systems. Finally, radio frequency identification tags (RFID) are mounted on the base of the shuttle carriers. In addition, the terminal is endowed with a sophisticated Real Time Locating System (RTLS) and automated transfer point management system (TPMS) in the automated storage areas, which combined with the aforementioned technologies facilitate container traceability. All this machinery is connected to the TTI Algeciras headquarters - offices in the terminal itself - from where it is continuously supervised, managed and controlled by the operations and systems departments. Most of the technical tasks are carried out from the offices, given the use of advanced remote control systems, which allow modifications in real time, as well as to resolve breakdowns - in many cases - without having to travel to the location of the machines.

Timing of the introduction and progress thus far

The implementation of a semi-automatic terminal with cutting-edge technology was conceived back in 2008 (date of the concession of the Port of Algeciras Bay to TTI), with a view to replicating the model already existing in the port of Busan (South Korea). The activity began in 2010 under the ownership of the company Hanjin Shipping. Between 2010 and 2014 was the growth cycle, applicable to both machinery and personnel. The 88 staff already employed in 2011 gradually increased to 95 in 2014, a figure that continues today. Shortly afterwards, the Human Resources Department was created (2015). At present, due to continuing technological progress, there is some downward pressure on demand for less technical and lower qualified jobs. Given the social and trade union pressures, a line has been taken to maintain the level of employment in the company.

Managers and technicians indicate that over the last 5 years the technological implementation and automation process in the TTI terminal has slowed down, with several ports in the world already identified as being ahead in this aspect. They explained that the objective of handling the same number of containers as a traditional terminal with half the number of workers had been achieved, thanks to the high level of digitisation and that presently they would be in the phase of amortisation of these large investments. According to the interviews, the challenge in the short term is to make new investments, betting on automation and technological improvements in IoT. In this process, they should be able to generate employment in new technical positions (e.g. operations coordinators, development engineers) to compensate for the operational positions that would necessarily eliminate further progress in digitisation and automation (e.g. shuttle drivers, operations assistants).

An emerging challenge for TTI is the elimination of shuttle drivers through further investments, moving to fully automated versions, gaining precision, reducing times and avoiding occupational hazards. In the opinion of management, reconciling this commitment to economy and competitiveness with the natural defence of implicit labour interests will be a challenge for the immediate future.

Initial expectations for the introduction of the technology

The company's initial expectations regarding its heavy investment in cutting-edge technology were to obtain, in a short period of time, significant competitive advantages over other terminals in the Mediterranean. Investment in IoT and automation was a process that did not start from scratch: the Korean company transferred to Algeciras previous experiences successfully developed in previous years in the Port of Busan (South Korea). In order to amortise such a technological investment, the plan included hiring a small workforce: only 95 workers on the main chart to run a terminal of large dimensions (already described in Appendix 1.1). Management states that the current technological design makes it possible to work with almost half the staff, and two thirds of the stevedoring labour that would be required in a traditional terminal. Once the workforce is reduced in numbers, the cost reductions will be achieved through further benefits: lower proportion of manual labour, fewer materials, lower training costs (simply due to the smaller number of people who get trained), etc. In addition, the strategy for the introduction if IoT accounted for improvements in safety at work (reduction of accidents, above all), staff organisation and labour conflict.

Initial strategy for the introduction of the technology and adjustments during its deployment

From the beginning, there was a clear project, with a roadmap to develop the semi-automatic container terminal of Busan. It was a top-down strategy that did not involve any employee consultation.

The TOS was developed by the South Korean engineers who created the new terminal, applying their previous experience in the port of Busan. As part of the digitisation strategy, TTI provided a series of training courses, both in house (by the company itself), and through interventions by supplier companies, especially during the first years since beginning of activities (from 2010 to 2015). In particular, staff received training on how to use the new machineries to operate the IoT and TOS system, and all ancillary technologies. In that cycle, the terminal acted as a school, as the Korean company had to transfer the mastery of its complex systems to a predominantly local workforce, usually coming from port companies below the level of automation of the new project (source: Innovation Manager). According to the testimonies of managers, employee representatives and workers alike, informal training by peer-learning or mentoring also proved crucial: they argued that being next to workers who already use these tools is the best way to learn, reinforcing communication and teamwork. Some workers, however, mentioned that more training would be required due to the rapid pace of technological developments in the sector. Also, they point out that not all workers want to continue their training, as many do not wish to dedicate too much time to improving their education. This has an impact on their career prospects (more detail in section 4.3.6.).

Even though the technology was introduced following a top-down approach, workers' feedback is considered essential to improve the system, especially when it comes to container traceability and error reduction. By committing to the regular use of feedback, TTI introduced improvements in the use of technology that benefit both employers and employees.

The benefits (to the company) obtained by the extensive technological implementation can all be ascribed to cost reduction and efficiency improvements – which were among the main reasons for introducing the technology in the first place – as well as improvements in health and safety, ergonomics, comfort of the workspace and so on.

4.1.2 Digitisation strategy adopted by Airbus and changes to the business model

Motivation for the introduction of the technologies

The company's management adopted and fully embraced 3D Printing and its applications (i.e. powder bed fusion (PBF) used for manufacturing metallic materials and Filament Layer Manufacturing (FLM) and Selective Laser Sintering (SLS) used for manufacturing plastic materials) because they are perceived as the technologies that will dominate the production process in the aerospace industry in the coming decades (Airbus is not the market pioneer in this field, it has simply adapted).

Through these organisational efforts and financial investments, Airbus aims to:

- Internalise a large part of the production, avoiding dependence on third parties and facilitating the autonomy of the teams themselves;
- Reduce times, thanks to the short cycles that 3D Printing allows;
- Promote design and creativity within the work team, facilitating agile production systems that allow them to create for themselves;
- Reduce costs, both in the manufacture of parts (frequent use of plastics) and in other processes (storage, transport and supply of spare parts);
- Invest in a technology that has a relatively short payback cycle.

The motivations for the introduction of IoT are to:

- Enhance communication of work teams and coordination between them (knowing where everything is, in what state, at what time);
- Monitor all steps of the assembly line, providing access to status reports for each phase;
- Improve flight safety (e.g., oxygen deprivation detectors in pilots' helmets);
- Process and analyse real-time data on any aspect of the manufacturing process (e.g. consumption of a specific assembly material); and perform longitudinal data analysis once long series are recorded (e.g. duration of different operations of the quality control checks performed before delivering an aircraft).

Place in the workplace for the technology and its embeddedness

The main activity of ALM/3D printing takes place in the Getafe workshops, although the activity is already carried out locally in the remaining 7 sites where aircrafts are manufactured. For this purpose, Airbus owns hundreds of printers of different sizes and technological levels. In addition, the company coordinates the training and familiarisation of the staff involved in the design and manufacturing, both in white and in blue collar positions. The process is articulated through an intense exchange of information in a network, in which the designs of the parts are distributed and can be generated in the production centre itself (Getafe). In addition, there is intense collaboration and communication between the Spanish sites and other Airbus sites around the world (3D printing designs in particular). In Spain, parts are designed for the US and Germany, and designs from the rest of Europe are also exploited.

Timing of the introduction and progress thus far

The chronological process of implementing 3D Printing dates back to 2015, with the development of the first prototypes, although the strategy for its adoption had already been in the pipeline since 2012. Prototyping and certification phases in the sector are slow, since in order to get legal approval the company has to prove that materials and part were safe, resistant and sustainable, so 3D printers did not start to be used –within the production process– until more recently (2018). Currently, 3D printing is used to manufacture real components and tooling for aircraft and ground installations, using both plastic and metallic materials.

In the three years from the start of their use to date (2018-2020), 3D printers have exceeded expectations: managers highlight the short amortisation cycle of the printers (months in some cases), as well as the trend towards cost reduction, since the price of the most accessible printers is steadily falling. Technicians report how the staff quickly adapted to a technology that allows great versatility and autonomy, and the blue collars (assembly line and manual workers in the manufacturing process) now have the possibility of intervening in a creative and self-taught process, which has been reducing dependence on external suppliers. The difficulties encountered in its introduction are unavoidable (bureaucracy and adaptation of human capital), but the process is fed back by its results, so the idea has spread among the staff that only a continuous adaptive attitude to this technological development is possible.

Further future investments in 3D printing will promote the reduction of process times and costs, allowing Airbus to remain at the international forefront of the industry. This line is seen as a must in order not to miss the boat. At the same time, from an HR perspective, talented and trained personnel will be recruited and the adaptation of the workforce -at all levels- to the new changes will be intensified.

As for the development of IoT-based technologies, they have been gradually implemented over the last decade (since 2010), significantly boosting the company's internal communication systems and its ability to generate and analyse data in real time.

Initial expectations for the introduction of the technology

Airbus cannot be considered a pioneer in the introduction of these new technologies since, in a way, its commitment to them was made when their implementation in the industry was already a reality. Above all, the pressure from the international market itself led the company to a process that was considered unavoidable. Moreover, in the case of 3D printing, the implementation was relatively slow, as the development of protocols and the obtaining of certifications are complicated by the requirements of the military sector and the aerospace industry. In any case, the prevailing opinion in the workforce is that the commitment was late but effective from the moment it was launched. In addition, the demands of enhancing internal communication systems in the aerospace industry have led the company to a continuous process of IoT implementation and improvement over the last decade (2010-2020).

Middle managers and technicians describe the first steps in the adoption of 3D printing as a complex process, described by a hill curve: the enthusiasm of the initial novelties and improvements gave way to the inevitable problems (technical and bureaucratic). In short, it was required to overcome the staff's natural resistance to change, adapt their training, adjust the assembly lines to the new technology, create specific 3D printing workshops, as well as overcome all the protocol phases prior to a part being placed on an aircraft. Once these were overcome -in the first 3 years (2015-2018) - developments reached a satisfactory rhythm, as staff familiarised with the emerging technology. In the case of the introduction of IoT, staff state that there was no major revolution in this area. The company was simply responding to the new technological requirements of the aerospace industry in order to remain competitive.

Initial strategy for the introduction of the technology and adjustments during its deployment

The 3D digitisation strategy was defined before 2015 - which was officially the starting point. In 2015, a large network of technicians was set up to act as an advisory group for 3D, providing input to management (e.g. new designs, new materials). Some business pilot testing was promoted, starting with small printers to produce plastic parts that could replace aluminium. Given the success of the test phase, it did not take long to transfer these innovations to production of actual parts and tooling (2018).

Employee training was a fundamental aspect of the strategy to implement new technologies. Managers mentioned that the company is in constant need of training in new skills because the digital technology is undergoing rapid change. In the first approach cycle, the technical staff involved in the technological developments went through the Airbus Training Centre in Hamburg (Germany) to receive appropriate training. Gradually, the knowledge of the internal network was strengthened in the establishment, acquiring autonomy and organising its own training locally (courses, seminars and workshops) with both internal and external trainers.

The implementation process followed a top-down approach, in which the company's management exercised control from the outset. However, participation was opened up to the informal group and, eventually, the intervention of workers has been decisive, both in terms of advice at the most technical levels, and of proposals made by common employees on part modifications, with suggestions that can only be adequately visualised from the lowest levels. The technical staff themselves point out that there has never been such fluid communication with management as when this technological revolution arrived, both parties made an important effort and the feedback generated at this stage has been considered a key factor.

4.2 Impact of technology on work organisation

In the following section, we will assess the impact of digitisation on work organisation and task content in TTI Algeciras and Airbus. Work organisation encompasses how work is organised, the forms in which work is coordinated with the aim of producing the outputs. More specifically, in the conceptual model presented in section 3, work organisation encompasses areas such as: decision-making processes; workflows, quality controls and standards; employee monitoring and control; task definition and content.

4.2.1 The impact of digitisation on internal organization and decision-making processes

The introduction of digital technologies has affected internal organization in both companies, by intensifying communication via digital means, reducing the necessity of in-person execution of orders, and by automating most of the decision-making process (especially in TTI-Algeciras) or extending it to non-managerial staff (through the use of feedback in Airbus).

The level of automation in TTI-Algeciras' TOS largely affected decision-making processes, both at the workers' level and at the managerial level. Movements that are still executed by people are subject to the system's authorisation, which can block any unplanned operation (if a driver wanted to leave a container in a place not intended by the TOS, he would not be able to do so). In sum, the technology largely eliminates the necessity for operators to make decisions, given the automation of every movement to be made. Choosing the route along which a container moves, from the point of origin to the destination, is one of the few exceptions where the worker's own judgement comes into play. White collar task automation has a somewhat lesser impact. Remote control systems simplified and reduced time spent on managerial functions such as control, supervision, planning and execution; by contrast, it allowed more time to be spent on the analysis of data generated by the daily activity itself, as well as on innovation and proposals for improvements related to the technology.

However, even though automation and IoT take over a large part of the decision-making processes, the worker must intervene to solve instances which cause work peaks (e.g. containers that are lost by IoT sensors or refrigerated containers that need to be connected to the power grid.), where the human factor is crucial. Another important aspect pointed out by workers in the interviews is that there is a continuous transfer of responsibilities between the machine and the workers and between different departments, which requires a high degree of coordination and flexibility. In this sense, technology has also modified working methods, as mentioned above: less manual work has been transformed into greater responsibility on the part of workers, which requires them to be constantly connected and requires a high level of concentration in the workplace to manage a large amount of information.

The digitization of processes in Airbus appears to have strengthened communication among the more technical occupations and promoted a strong culture of sharing available resources, as well as agile exploitation of the data provided by these networks. The introduction of 3D printing appears to have affected decision-making processes by giving workers more of a say in how the technology can be adjusted and improved, as top managers make use of constant feedback.

In addition, thanks to new IoT developments since 2010, Airbus has created an agile networked communication system, which allows a large part of the workforce to quickly access information shared on the network on a variety of working processes (e.g. duration of a maintenance operation and further comparison of such an operation with the series of all previous of that type). At the same time, a wide range of possibilities for data analysis has been opened up (e.g. the number of times the design of a component has been shared, or the satisfaction that workers have shown with that design through a rating). Management highlights the improvements in information flow, the reduction of response times to work orders, requests or proposals, the extensive possibilities for exploiting the available information and the consequent improvements in decision-making processes. Other IoT applications developed at the company include, for example, Electronic Toolboxes or oxygen real-time monitoring sensors for pilots. According to the Innovation Manager, the innovation network facilitated the exchange of fluid and direct communications, and managed to stimulate the more creative side of 3D printing and IoT, generating substantial interest among professionals in technical fields. Interdepartmental communication has worked effectively and the company's middle managers have become major players in this transformation.

4.2.2 The impact of digitisation on workflows, quality controls and standards

The digitization of processes in both TTI Algeciras and Airbus has led to a streamlining of work processes and improvement in quality controls, especially as a result of the interconnected network of IoT sensors.

In TTI Algeciras, all work sequences (loading, unloading and all types of movements in the yard) are programmed from the TOS, whose algorithms are able to maximise performance in terms of time and energy consumption. The TOS records all this information through IoT technology, with sensors connected at each point (cranes, shuttles and so on), and generates orders automatically (e.g. indicating the next step in relation to a container movement in the yard). The availability of precise information due to the system's ability to process and analyse data at high speed allowed managerial staff to introduce further improvements. In addition, one of the benefits of the IoT network in TTI-Algeciras is that staff can carry out a wide variety of interventions remotely, from the operations department; for example, machines can be repaired without sending workers where they are located.

The extensive IoT network in TTI also increased the efficiency of work processes and a caused a general reduction in operation times; it also facilitated maintenance tasks thanks to remote control systems (resolution of breakdowns or other technical problems). Finally, it allowed a minimisation of errors in processes, also as a result of predictive maintenance, and led to a general improvement in safety and control of occupational risk.

As already mentioned in section 4.1.2, the introduction of 3D printing in Airbus resulted in highly flexible processes, allowing internal offshoring, since the design site, the printing order site (often remote) and the final printing of a given part can be separated. Indeed, some parts designed in Spain are meant for the US and German markets, whereas other parts printed in the establishment are designed in the rest of Europe. The use of IoT is widespread in all Spanish (Airbus) sites and is vital for streamlining production processes. These systems allowed intense monitoring of manufacturing processes, facilitated work review by technicians and decision making by management. IoT improved coordination in the Airbus environment (large volumes of activity, wide special dispersion and large work teams), and supported maintenance tasks through early detection of potential problems. In addition, all of the above are meant to save time and money. For white collar workers, mainly for engineers, 3D Printing opens up a wide range of possibilities that affect the design, planning and execution of the production of aircraft parts. The great flexibility and adaptability offered by this technology promotes both the agility of operations and the development of a creative side.

4.2.3 The impact of digitisation on employee monitoring and control

The introduction of new digital technologies does not seem to have led to increased monitoring of workers. According to the interviews, both companies surveyed report that connectivity and IoT produce a large amount of data on workers, but in neither case is this data used in monitoring or supervisory systems, or to measure worker performance. HR managers recognise that so much data are produced that it is impossible to analyse it all - the process of adapting the organisation to data analysis is slow. Nor do workers and employee representatives report a sense that their work is more controlled by managers/supervisors by new technology.

In the case of TTI-Algeciras, IoT is used essentially for monitoring assets, the conditions of machines and predictive maintenance.

The potential of IoT for control is being focused in these companies towards better control of production, quality and more transparency of information for all workers, but it is not being used for surveillance or ways to control workers. However, even though the technology is not used to monitor performance or for intrusive surveillance, it is still used to monitor workers' activity; for instance, in TTI, tasks that are still carried out by workers are subject to the system's approval.

4.2.4 The impact of digitisation on task content

Task contents can be physical (strength, dexterity and navigation), intellectual (information processing, problem solving, and their sub-categories), or social (serving/attending, teaching/training/coaching, selling/influencing, managing/coordinating, and caring). The methods of work organisation refer to autonomy, teamwork, routine, and tools used at work can be digital, non-digital, others (Fernández-Macías and Bisello (2020).

In TTI-Algeciras, automation resulted from IoT and TOS has led to manual and physical jobs being performed mostly by machines driven by digital devices; for example, the positioning of containers with automatic cranes and portainers that do not require drivers and have reduced the size of the groups of stevedoring workers used. By contrast, cognitive tasks such as data analysis or responsibility for operational control and supervision have increased in recent years. In this sense, the general opinion of the employees is that digitisation and automation have favoured non-repetitive tasks, more autonomy and greater responsibility in decision-making on processes, with a procedural substitution of the operational line by more technical roles (especially for maintenance workers, machine operators or yard controller jobs, etc.). The Works Council points to a more profound change in the yard and maintenance tasks, as these have been transformed the most by machinery, automation and the predictive functions of the IoT (e.g. less malfunctions of machines, less workers' activities walking in the yard, etc.). However, employees also indicate the importance of the human factor when it comes to solving specific problems in an unpredictable environment. As explained above, the semi-automated system at TTI-Algeciras is quite specialised and requires little intervention, but at specific moments ("few, but very important") intervention by the worker is needed to make decisions and provide feedback for process improvement.

In the case of Airbus, the change in task contents has been significantly different between blue-collar (assembly line and manual workers in the manufacturing process.) and white-collar workers (engineers, design teams, administrative jobs) and between types of technologies (IoT and 3D printing). According to all interviews, there has been no significant substitution of staff due to the introduction of the IoT and 3D printing technology. On the contrary, new jobs have appeared linked to the creation of an internal 3D printing network. In general, these two technologies do not affect routine and repetitive tasks too much, but they have caused a very significant increase in complex and cognitive tasks with more added value and greater autonomy. The impact has been stronger especially for managers who, due to IoT are becoming more oriented towards data analysis, connectivity, programming, predictive maintenance, etc. and engineers, programmers or designers, who due to 3D printing are becoming more oriented to design, product quality and durability etc. These are all tasks that generally require concentration and precision, and has caused change to their job profile. A representative of the HR department explained that the burden of the technological revolution the company is experiencing falls mainly on middle management, as these positions have changed their tasks the most due to their importance in process control.

Blue collar workers have seen their tasks modified to a lesser extent by the introduction of digital technology because it has affected the assembly line on a more ad hoc basis. According to the workers interviewed, these manual jobs have been affected because all the connectivity of IoT and 3D printing works as a loop in which all parties must participate in its constant evaluation and feedback that requires constant communication between the design and production departments. In addition, assembly-line workers now have 3D printers they can use whenever they need it to solve small problems in their workplace, such as the printing of tooling. There is a significant increase in prototyping and lab work thanks to 3D printing. In this sense, an innovation manager highlights that the introduction of these technologies enables manual workers to come up with innovative and practical ideas, for example on final modification of pieces used on the assembly line, which changes the nature of their work and increases the added value of their work. In addition, as already mentioned, the introduction of both technologies in Airbus has significantly affected teamwork, via an improvement in communication – both at the horizontal level and between workers and managers.

These circumstances clearly mark the transition in their situation before and after 2018 (after the pilot phase and when the technology was properly introduced), going from a fairly routine activity to one that allows a certain involvement in the manufacturing processes, e.g. in assembly line tasks.

4.3 The impact of technology on job quality

This section analyses the effect of the introduction of digital technologies on job quality. As discussed in the conceptual framework, a multidimensional concept of job quality is used, based on the seven indicators proposed by Eurofound.

Overall, it is worth mentioning that, as we have already seen in section 4.2.4, the technologies introduced reduced manual and routine tasks, which translates into an improvement of the intrinsic job quality in both selected establishments.

4.3.1 Skills and discretion

One of the most important changes brought about by the digital revolution in both establishments is the need for new skills and new training profiles for workers, requiring continuous training.

Managers at TTI-Algeciras state that the move towards digitisation and automation has had a major influence on the profiles to be selected, as well as on the levels of training required, with a significant predominance of technical professions (e.g. engineers), digital skills and abilities, and an English language proficiency (essential for the port sector and for use the technological applications and design files). The qualification requirements are increasing and the significant demands of these skills for some blue-collar positions are striking. In addition, a strong attitude towards teamwork, the ability to learn in process (while working), as well as great flexibility and the ability to adapt to change are in demand.

As already mentioned in section 4.1.1, and 4.1.2., upskilling and re-skilling of workers have been a crucial part of the digitisation strategy in both TTI and Airbus. In the case of TTI-Algeciras, the local workforce needed specific training to be able to use the complex terminal operating system designed by the Korean engineers. The training was provided by the company, either in-house or with the help of their suppliers. In addition, peer-learning or mentoring also proved crucial:

Airbus' HR department shares some of the opinion mentioned in TTI-Algeciras about the new skills required. Airbus distinguishes between the already established staff requirements (technical training at various levels, English and digital skills), versus the emerging ones, strongly conditioned by the implementation of 3D printing. Training in these areas has become a key point, and demands in digital skills and English are increasing.

In the case of Airbus, managers mentioned that the company was in constant need of training in new skills because the digital technology is undergoing rapid change. Innovation managers underline the importance not only of technical training in new technologies but also of the necessary change of mentality and working methods. Airbus also engages in technological mentoring. In this case, young workers with high technological skills advise older workers in the use of new digital tools. The programme takes place in a blended learning format with a predominance of online communication through forums. Apart from the training actions formalised by the company itself, the workforce has developed a culture of intense training activity through informal networks (peer mentoring, on the job learning), according to an Innovation Manager. Much of the learning takes place within the team, and this formula is a key aspect both for boosting the group's performance and for individual professional progress within the company.

The general opinion of the interviewees is very positive towards training, seeing it as an opportunity to improve within the company. For example, one worker mentions the courses offered that allow the worker to obtain the delegation of signature for additive manufacturing (training involving a formal certification to operate the 3D printer), which means a very high increase in the worker's responsibility and autonomy, since he can guarantee and verify that the whole process complies with the appropriate requirements and greatly simplifies the hierarchical chain. However, as in TTI-Algeciras, some workers are very willing to improve their training and skills both inside and outside the company, while others are more reluctant to learn the use of new technologies.

Finally, regarding recruitment, in both case studies HR managers underline a change in the profile of the workers hired, increasingly demanding workers with higher qualifications in industrial and software engineering, programming or data science, which are particularly relevant areas for the digital transformation. But beyond the educational qualifications required, all the actors agree on the importance of the attitude towards learning processes that are necessary in a complex environment with rapid technological change: workers with an innovative attitude, willing to learn things, who have social skills for teamwork, expertise, etc. are required.

4.3.2 Physical environment

In the two case studies analysed, one of the most significant effects of the introduction of new digital technologies is the significant reduction of occupational risks and the improvement in the physical conditions of the workstations (posture-related, ergonomic, vibration, noise, temperature, etc.).

Automation through the IoT system in TTI-Algeciras has allowed a high reduction of work accidents to a minimum, in a sector such as maritime logistics where the rate of work accidents is high. A person in charge of the innovation department explained that the cause of this reduction is the reduced interaction between humans and machines, as the technology implies no workers circulating in the yard, except for those who have explicit permission to carry out repairs and so on. Workers and employee representatives highlight the advantage of eliminating those tasks with higher psychical risk (e.g. stevedores are no longer exposed in the danger area to carry out the twistlock operations[13] manually during the load and discharge process) and the increase in safety regulations along with the increased regulation of all activities caused by the demands of the technology itself. In addition, HR managers mention that the reduction of accidents at work is a differential element that gives the company an advantage over the competition, both because of fewer accidents and system downtimes and because the company now employs fewer workers in the area of health and safety.

In the case of Airbus, the combination of 3D printing and connectivity via IoT has had a positive effect on physical working conditions. IoT connectivity is allowing departments to detect and anticipate problems, breakdowns, etc., reducing occupational risks. In turn, with 3D printing, parts are

[13] Twistlock is a mechanical locking device at the corner of a container.

being manufactured and prototyped that have improved ergonomics, reduced the weight of parts, increased brightness, etc., making manual work easier, minimising errors and improving workers' health. According to the workers, these benefits do not affect flight parts (which require a very rigorous certification process as explained above), but they have affected the prototyping areas and workshop parts. Additionally, 3D printing has made it possible to design bespoke tools that improve ergonomics and reduce occupational hazards. However, new physical risks associated with 3D printing are emerging, for example powders used for 3D printing can be ultrafine and include nano-sized particles that pose health risks for workers. In this respect, management has created specific protocols to compensate for these physical risks as part of the innovation strategy.

In the case of Airbus, there has also been a significant change in the distribution and organisation of the workplaces. On the one hand, 3D printing sites with adequate ventilation have been created in the establishment. In addition, since 2014, ProtoSpace has been created, which is a network of creative spaces whose aim is to encourage innovation and "give shape" to ideas. According to the interviewees, this has conditioned the distribution of physical spaces in the establishment. However, the IoT, although not directly, has changed offices in favour of open and dynamic spaces that allow for the agility and flexibility required by new organisational forms and working methods, based on rapid data exchange, predictive maintenance and data analysis.

Finally, the introduction of 3D printing at Airbus is an improvement in terms of sustainability and environmental care valued by both management and employees. Much less waste is produced which is beneficial for the environment and, also, makes the physical environment of the workplace more comfortable. In addition, new organic materials are constantly being innovated for use in 3D printing as a contribution to the environment.

4.3.3 Social environment

The use of IoT in TTI-Algeciras has meant a relevant change in the forms of communication and social support among workers. The company combines highly advanced IoT-based communications with face-to-face meetings in its day-to-day activities. On the one hand, part of the communication is carried out through digital contacts, with the transmission of orders, instructions, changes or even the execution of operations, done quickly and with very few physical movements. On the other hand, the company insists on maintaining personal contact as a matter of organisational culture: "we have the capacity to fix a machine located miles away from our headquarters, operating remotely. However, management is committed to face-to-face relationships, purely as a cultural issue" (Source: an HR Manager). In this way, an essential part of the coordination of the activity occurs during the meeting that takes place at the beginning of the working day between three key departments: operations, systems and maintenance. The aim is to coordinate the planning of the working day among the three departments and address the possible difficulties that may arise all together. It has traditionally been carried out in person, even though in the last year it has been done virtually (due to pressure from COVID-19, as 20% of the staff have been put to work remotely). So, the data provided by the IoT technology helped to keep activities going during the Covid emergency.

According to the workers interviewed, digitisation has favoured a more detailed access to information in a systematic way, making tasks much easier (e.g. machines maintenance tasks, organisation of ship arrivals, crane movements in the yard, etc.). In addition, this enabled all workers to have knowledge of what is going on in the company's operations before starting their shift. Workers' general opinion is that it is very important to communicate with colleagues and when this communication has failed they have been badly affected. In addition, the improvement in communication, especially related to technological changes, had a positive effect on the level of employee engagement in the workplace. Communication via internal chat or web conferencing is generally viewed positively by employees.

The heads of the HR department at TTI-Algeciras on the other hand stressed that the use of technological tools means that sometimes employees do not see each other, which can weaken the relationship between employees and interdepartmental communication. They therefore underline importance of the quality of team management in organisational change and in stimulating interaction with other employees.

Managers, employees and employee representatives all agree that telework is entirely feasible thanks to the connectivity and automation that had previously been introduced. This has been demonstrated by the measures against Covid-19 which have not weakened the social environment in the workforce. Still, HR managers adopt a cautious approach and value face-to-face working as a way of reinforcing the organisational culture of the company.

At Airbus, the push for IoT, connectivity and 3D printing has meant a radical change in the social environment according to interviewees. The company has always had high levels of communication between departments and between workers, but what these technologies have done is to make this communication more fluid, faster and more constant, to the extent that they have facilitated the exchange of all kinds of data and information. Managers and HR managers point out that the intranet and the sharing of all files on the cloud, albeit a very simple innovation, have radically changed the way of working in recent years. Associated with IoT, the use of communication tools (internal chats, web conferences, exchange of information or collection of comments from colleagues) has generated a positive stimulus in the interaction between employees and has strengthened teamwork (both within establishment and between different establishments in Spain and internationally, something that was unthinkable before). The HR department stresses that the improvement in communication makes it possible to be more effective and to increase employee motivation.

The impact of 3D printing on the social environment deserves a special mention. The HR department values positively that in the production and prototyping phases 3D printing facilitates a few actors and levels involved, which favours involvement and organisation of the staff. Although, as explained in previous sections, the innovation strategy started from the management, the ALM logic has led to horizontal networking, improving employee motivation and the working environment. For instance, the network and *ProtoSpace* (see section 4.3.3) are particularly relevant as they al-lowed workers feeling at the heart of innovation and to start collaborating with colleagues they had not previously known.

According to the interviews, 3D printing also favoured communication between employees and management; according to the employees, management showed a great interest in the innovative ideas coming from them (bottom-up). Employees and innovation managers also report a significant increase in communication and exchanges of interest to employees with outsourced suppliers who joined additive manufacturing, for which mentoring and certificate (delegation of calculation signatures) was necessary.

In Airbus, the benefits of technology on the social environment have been lower for shop-floor workers, due to their involvement in pre-processing and post-processing tasks related to 3D printing. According to the interviews, in these positions, adaptation to technology is not as necessary and attitudes are less receptive, with the worker's own will determining the degree of involvement.

Finally, in the case of Airbus, the prior promotion of digital technologies has facilitated adaptation to the restrictions imposed by Covid-19. On the one hand, all the advances in connectivity and information management via IoT have facilitated work and teleworking during the Covid pandemic. A representative from the HR department mentions that thanks to the technology, virtual workshops have been developed, data exchange has increased, 3D printing processes can be controlled from home, etc. On the other hand, since before 2020, but especially since the pandemic, Airbus has used its 3D printing technology to manufacture healthcare material in collaboration with hospitals in the Madrid region. In the opinion of all interviewees, this has brought extra satisfaction to the workers who dedicated many hours to these solidarity tasks.

4.3.4 Work intensity

In the case of TTI-Algeciras, as explained in the section on the digitalisation strategy (4.1.1), the speed, rhythm and order of the work is determined by the technology and, as it is a low-cost terminal, the tasks are more intense and diverse for the worker. According to interviews with workers, technology determines the work and demands high speed, while at the same time increasing the need for technical qualification. Automation has made it possible to significantly reduce the time it takes for workers to perform many tasks. In addition, digital automation and IoT have reduced physical and manual tasks, which makes work less tiring. The employees emphasise that this has made possible the restructuring of working hours due to the measures against Covid-19 during 2020 to the extent that it was possible to move from six consecutive 8-hour shifts to four consecutive 12-hour shifts (see section 4.3.5). It is linked to more flexibility and fewer days of work and is facilitated by technology that allows longer shifts without reducing task efficiency.

At Airbus, the adoption of 3D printing tended to lead to a decrease in labour intensity (especially prototyping of parts with additive manufacturing in polymers), while increasing the need for qualification and intellectual demands. According to the employees interviewed, this change increased task variation for qualified workers, reduced manufacturing times, and resulted in increased motivation, greater autonomy and more coordination between shifts. However, all interviews point to the slowing down of times due to the verification needs, as part manufactured via 3D printing technology have to pass several tests and abide to standards in order to be considered suitable for eventual aircraft components.

By contrast, workers directly dedicated to 3D printing have seen their workload increase exponentially over the last few years, which has been partly compensated for by an increase in the number of workers in these positions (mainly engineers). However, employments interviewed indicate that the previous establishment organisational structure is maintained, so that the introduction of digital technology translates into more workload and more responsibilities, especially for team coordination positions.

In the case of IoT, its effect on work intensity is somewhat different. HR managers indicate that in intermediate positions (engineers, team leaders, administration managers, etc.) there is a short-term increase in work intensity, as they had to learn to work with data and new skills in Agile organisations. In the discourse of workers, these changes emphasise the disappearance of bureaucratic tasks thanks to connectivity, which allows workers to dedicate themselves a greater extent to tasks with high added value.

Regarding manual workers in the workshop and on the assembly line at Airbus, their work intensity has been slightly changed by the introduction of these digital technologies, since when it comes to IoT for shop floor and assembly line workers, the pace would now be somewhat more determined by IoT-connected machines.

4.3.5 Working time quality and work-life balance

3D printing and IoT can offer greater opportunities to make work more flexible and carried out remotely, which can contribute to greater autonomy and efficiency for workers.

In the case of TTI-Algeciras, for example, automation with IoT has facilitated the adaptation to the measures against Covid-19 by allowing the modification of work shifts (the company is operating 362 days a year, 24 hours a day) to require less physical effort. It has gone from 3 daily shifts of 8 hours, where 6 days are worked in a row and 4 are rested, to two 12 hour shifts per day working 4 days and resting 6. In the general opinion of the workers, workers' representatives and HR managers, these measures have been very well received by the employees as they are a benefit for family reconciliation, minimise occupational and health risks and can even improve the performance of the worker.

As already mentioned in the case of Airbus, the combination of both technologies has favoured teleworking throughout 2020 for the most technical and white collar profiles. Again, manual jobs (e.g. assembly line workers) have been less affected in this respect by the introduction of digital technologies. Previously, many employees in the HR department had voluntarily agreed to a no break in the middle of the working day for a better work-life balance (it should be noted that in Spain the working day is often split into two shifts, with a break of two hours or longer). This is possible in part because of the flexibility of technologies that do not require all non-manual workers to be in the workplace at the same time (e.g. administrative staff or engineers).

However, in both cases study, the introduction of technology has meant in certain positions (especially middle positions) increased responsibility and autonomy which has translated into longer hours and constant connection to work.

In the case of TTI-Algeciras, the constant exchange of information and the speed of tasks together with constant connectivity (for example, the ease of being connected via a mobile device to any new happening in the operation) has had, according to the workers, a negative impact on their work-life balance.

Something similar is happening at Airbus, brought about as much by connectivity and IoT as by 3D printing. The latter has the advantage of having remote control over the printing of parts and prototypes (although it is always necessary to supply the materials to the printer), which means a connection and responsibility outside the workplace, diluting schedules.

So, overall, the impact of digitisation on working time quality and work life balance is unclear, with some changes allowing for more flexibility and better work-life balance (e.g. the change in shift patterns) and some leading to increased time pressure and longer hours, via an increase in responsibility, as well as an intensification in communications.

4.3.6 Prospects

In relation to the employment dimension, beyond wages which is addressed in the next section, it is important to know the effect of technological change on career prospects and job security.

Management in TTI-Algeciras indicated that new technologies always allow career opportunities for employees who are trained to work with them. The innovation management stresses that the specific skills (e.g. on how to operate a sophisticated TOS) that can be gained by working in such a technologically advanced establishment are difficult to acquire in formal education. According to the HR department the training and experience gained meant that some employees have been able to progress and move to companies abroad. An HR manager defines this as a "brain drain": workers who after training and experience in a semi-automated port terminal have been recruited by other international companies. This is a positive effect of technological change on the labour prospects of employees, especially the highly skilled, but it is seen as a drawback by management. The company has not put in place strategies to mitigate this brain drain, because due to the organisational set-up it cannot offer the promotions that would be necessary to retain certain workers, although it does pay workers high wages – especially compared to the average in the region – which is probably one of the ways to limit this problem.

Workers also agree that they have improved their career prospects as a result of the technological changes. Many have been career advancement to middle positions with better conditions, due to the increase in the actual amount of intermediate positions especially for qualified staff, which has made it easier the possibilities for upward mobility. So even though the company offers limited opportunities for workers who already occupy higher levels, it does have career opportunities for those at mid-level positions, mainly as a result of specific skills and experience with digital technologies.

Among the negative aspects, some interviews indirectly mention the possible job losses due to automation. Innovation and HR managers point out that the loss of jobs only affects manual workers and subcontracted workers, as previously mentioned (section 4.1) However, in the interviews they also mention that thanks to digitalisation other jobs requiring more qualified profiles have been created and maintained. Yet, employees and the works council are aware that the current technology would already allow for more automation and further reduction of jobs. In general, there is a division between the subcontracted manual stevedoring jobs that can be replaced more easily but are not being replaced at the moment because of labour agreements and the employees of the establishment itself who have experienced how certain tasks have been downsized as a result of the technology.

The results in the Airbus case study are consistent with a positive effect of technologies on career prospects. Innovation and HR managers point out that employees who get on board with new technologies are more mobile and improve their positions in the company. In the opinion of all interviewees the risk for their career prospects is not having the right skills and knowledge to adapt to the speed of digital change, so there is a relative fear of being left behind.

In the opinion of all interviewees, one of the most important aspects favouring the upward mobility of workers is to have an open and flexible mentality towards new technologies. Personal interests and technological motivation have favoured better positions within the company for workers with medium-high qualifications.

In contrast to what was found in TTI-Algeciras, according to the interviews in the case of Airbus, the downsizing risk is not so much linked to digitalisation but to the loss of business in the aerospace and defence sector, which affects especially manual workers and subcontracted companies. This negative effect is more visible during the last year due to the economic impact of Covid-19 in the sector, which has generated an increase in labour conflict in the company because a reduction in staff numbers is envisaged. Additionally, thanks to innovation 3D printing, the company has reduced its dependence on suppliers, which may have affected the employment levels of these external companies. Finally, workers and employee representatives indicate that, compared to initial reservations about the introduction of technology because of the potential loss of jobs, the positive assessment now predominates because it has improved the quality of work on a day-to-day basis.

4.3.7 Earnings

Even though we cannot provide a direct estimate of the impact of digitisation on earnings, we can assume that it is positive, given that workers who are more proficient or receive more training are more likely to move up to better jobs (internally) or to other companies. Similarly, both companies pay higher wages, but whether this is caused by the introduction of the technologies or whether both companies were able to both pay high wages and introduce more digital innovations because of other factors is hard to say.

In the case of TTI-Algeciras, the HR manager mentions that the company stands out for having high wages compared to the average of the region (Andalusia is one of the poorest regions in Spain) and also compared to similar companies in the country because the establishment matches its wage level to that of the stevedoring sector. This is also emphasised by the workers' representatives, who agree that the gateway to the port is a frontier in terms of wages. According to all interviews the wage level and its uprating are not related to technology, but to the importance of collective bargaining agreements and being a sector with a lot of social protection. This is a plausible explanation given the abundance of cheap labour in the region, however, we should not forget that TTI-Algeciras also invests in specific training, which makes workers more valuable and offers a possible route through which digital technology positively affects wages.

In Airbus, managers indicate that wages are 2.3 times higher than the national average and slightly above the sector average. This is explained by the specificity of the aerospace sector which is particularly high-tech and needs highly skilled workers, so once employees are trained they become especially valuable which translates into higher wages. The interviewees emphasise that the wage policy is well established in the company and is transparent. Managers, workers and employee representatives all agree that technological innovation has no direct impact on the level of wages, which are governed by access to higher positions and collective bargaining. However, access to higher positions is to a large extent determined by the technology as mentioned in section 4.3.6., so it is possible that interviewees (managers, workers and their representatives) underestimate the positive impact of the technology on wages.

4.4 Employee involvement and social dialogue in the deployment of technology

Employee participation in the workplace is essential to ensure awareness of and compliance with organisational strategies and technological change. The literature often indicates that the benefits for job quality and innovation of employee participation and good social dialogue are evident (Van den Berg, 2013; Grande et al. 2020). In this section, we address both indirect participation (referring to the participation of employee representatives, trade unions or works councils) and direct participation (between managers and employees without the need for intermediaries).

Firstly, regarding the role of workers' representatives and social dialogue, one of the main findings of our study is that they have little influence on the introduction and development of new technologies.

In the case of TTI-Algeciras, according to all the interviews, there has been little labour conflict over the last decade and communication between management and workers' representatives has always been fluid. The workers' representative points out that there are no demands related to technology in the negotiation of these agreements and that direct communication between workers and managers has always been used in relation to the introduction, supervision and evaluation of digital innovations. Among managers, it is mentioned that the benefits brought about by technology in terms of improved employee well-being and job satisfaction have meant that there have been no major labour disputes, creating a win-win situation between employees and the company. It is important to point out that thanks to the role of social dialogue and the weight of the trade unions, certain jobs have been maintained or reconverted, jobs that technology would have allowed to eliminate as a result of automation. In other words, workers' representatives and social dialogue are fundamental at times of organisational change in human resources, but they have little involvement in technological changes.

In the case of Airbus, social dialogue is in a complicated moment due to the situation in which the aeronautics industry finds itself, aggravated by the Covid-19 crisis. All the interviewees agreed that the introduction of new digital technologies has not been relevant in the social dialogue and that the role of workers' representatives in innovation strategies has been scarce. The only area in which the works council and trade unions have been more closely involved in the process of technological change has been in the area of employee training.

Secondly, the direct participation of workers is very important and is a decisive factor in the successful development of technologies in both case studies.

In TTI-Algeciras, we found that there is direct communication on the introduction and development of technology in which each position that is affected at departmental level can communicate their impressions or improvements. This direct communication on aspects of technology is preferred by both management and the works council. A representative of the HR department mentions how bureaucracy and dealing on a case by case of each individual often slows down the progress of technology. On this topic, there are diverging views among the employees: on the one hand, the information received for each innovation introduced and the fact that feedback is requested on its development is appreciated; on the other hand, this communication risks being limited to reporting faults that are then analysed by the systems team, but there is no in-depth consultation with the employees.

In the case of Airbus, despite following a top-down strategy in the introduction of 3D printing has generated a high level of worker participation in the whole process of change. Some workers in the additive manufacturing areas mention that during the first years there was an exponential growth of projects and many workers were interested in the novelty of the technology. In the last few years, however, the technology has entered a phase of stabilisation, which has led to a decrease in interest. Despite this significant development, both managers and employees agree that this type of innovation has been successful because employees are proactive. In this sense, bottom-up transmission to propose ideas for improvement and new projects is predominant. The role of workers (both manual and white collar) is very important and welcomed by managers and direction.

5 Discussion and Conclusions

Digital technologies have improved the business models of TTI-Algeciras and Airbus, making them more efficient and competitive in their sectors. In both companies, IoT has made it possible to optimise work processes, increase efficiency and reliability through data analysis, predictive maintenance, automation and task planning. 3D printing at Airbus has offered solutions for prototyping parts, tools that improve assembly lines and designing cheaper solutions and materials for manufacturing production.

The pattern of technology implementation has been similar in both companies: first, an initial phase with exponential growth of innovation impacts with high interest from management that has led the strategy and, also, from employees (e.g. during which much of the training takes place); then, the current phase of consolidation of technologies in work processes, but with stagnation in the introduction of innovative elements and with less intensive training. Both technologies can be expected to be used more frequently in the future or even to become standard practice, especially considering the potential of the combination of these technologies (IoT, 3D, AR/VR, etc.). For example, Airbus has already launched pilot projects to introduce the use of AR/VR in its maintenance and testing processes.

It should also be mentioned that in the two case studies in Spain, the implementation of innovation was not directly linked to any form of public support. The drivers of innovation in the two firms are improved competitiveness and increased efficiency, as well as improved work organisation, job quality and environmental sustainability.

Regarding work organisation and job quality the main findings are summarised below:

- In both case studies the innovations have led to an increase in the autonomy and responsibility of the employees affected by the technology. IoT in TTI reduced routine and physical tasks; for example, some manual maintenance tasks, crane driving tasks, manual data collection tasks, etc. disappeared. 3D printing in Airbus, on the other hand, had less influence on reducing physical and routine tasks, but led to an increase in more cognitive tasks and design skills. In addition, this effect of 3D printing tended to be stronger for white-collar workers (especially engineers). Both types of technologies increased the demand for highly qualified and specialised jobs, to the detriment of unskilled employees, which implies a progressive change in the composition of the workforce in terms of education and age.
- The increase in the information available on all processes is noteworthy. In this sense, IoT technology has favoured the exchange of fluid and direct communications, with companies adapting to project-based ways of working and agile methodologies. The adoption of agile project management methodologies facilitated the introduction and development of the technology.
- In both establishments the technology is not used to monitor and control workers. In general, it is recognised that the full potential of big data and the information collected is not being exploited.
- Overall, IoT and 3D printing have had a positive impact on job quality, either by reducing work hazards, improving the physical and social environment, reducing the intensity of physical work or improving career prospects. However, the effects on work life balance are not as clear because the increased responsibility and constant connectivity makes it more

difficult to separate work and personal time. At the same time, in the case of the Spanish port establishment, the technology has also made it easier to telework and to improve working hours in shift work, which according to workers has been very positive.

- While according to the interviewees, the introduction of digital technologies did not have a direct effect on earnings, it raised the demand for a more skilled workforce, and digital innovations seem to have pushed average wages up. In addition, once workers are trained to use a specific technology, they become increasingly valuable in the labour market and may leave the firm, so one way to avoid the potential brain drain or high turnovers is by maintaining wages high.
- In the two case studies, continuous training and courses have played an important role in the strategy for the introduction of new technologies, in parallel to the higher educational level demanded of workers. In this sense, one of the main conclusions is that both HR managers and employees underline the importance of the employee's expertise, attitudes, willingness to innovate and learn constantly. This is as important, if not more so, as educational qualifications. Successful digitisation requires management to lead a clear innovation strategy, and that companies to invest heavily in lifelong learning and technical training for their workers to be able to use technology. So, education and employment policies over the next years must focus on closing the existing gaps within the staff. To this end, a good solution could be some public-private partnerships whereby they provide upskilling (providing employees with training to optimise their performance) and reskilling (training to retrain workers for a new position, including a variety of VET courses).
- Interviewees in both companies agree that the technological developments expected in the coming decades will reduce the workforce. As a counterbalancing effect, there is a turn towards quality, in the sense that new technical profiles will be demanded by increasingly trained personnel and more services will be outsourced. On balance, the managers of both companies assume, on the one hand, that they will continue recruiting highly qualified workers for added value tasks; but, on the other hand, in the future the fall in labour recruitment will be unavoidable.
- Regarding employee participation, in both case studies the introduction of technology has improved the direct involvement of employees in innovation processes, e.g. by creating spaces for employee project proposals. However, the involvement of works councils and trade unions in the introduction, monitoring and evaluation of technology has been minimal, focusing more on the maintenance of employment.
- Finally, the restrictive measures against Covid-19 during 2020 have favoured an acceleration of technological change in the workplace, with previously introduced technologies being of great help in adapting to teleworking, especially IoT.

The findings on digitisation in the workplace in the two Spanish case studies analysed in this report raise some interesting implications that enter into discussion with the literature.

Firstly, in general in both investigated establishments IoT and 3D printing technologies have a positive effect both on business models and on improving work organisation and increasing job quality. It seems that the digitisation technologies introduced actually increased job quality, even according to the workers and their representatives, basically by making communication more fluid, extending autonomy, increasing skill levels, and reducing physical work. These results are more positive than other findings in the literature. This may be due to the peculiarity of the cases studied that exert a certain bias; for example, both establishments are located in sectors with a highly-protected workforce (e.g. importance of trade unions, collective bargaining, high wages in all positions, etc.) and are companies with international ownership so that technological innovation has sometimes come from abroad. Also, a very relevant aspect is that these two companies use outsourcing for some of the worst jobs or worst tasks (e.g. stevedoring), so the downside may not be seen in the establishment itself. Outsourcing is an important thing to discuss because in general it tends to grow with Industry 4.0.

Second, we also find some negative effects, and these results are consistent with some findings in the literature on the impact of digital technologies on the quality of work (Fernández-Macias et al., 2014; Antón et al. 2021). In particular, as suggested by this previous research, we observe an increase in work intensity and a blurring of work and non-work time. In addition, different impact of digital technologies can be observed with a bias in the positive towards white collar and professional workers, as mentioned above. But which is not so positive for blue-collar workers, whose jobs are also more likely to be replaced by machines in the future.

Thirdly, one of the striking findings of this research is the limited role of industrial relations in the introduction of new technologies and the negotiation of its effects. The particularity of the cases studied with high unionisation and tradition of social dialogue, on the one hand, generates a labour context where the positive effects of digital technologies outweigh the negative ones, although for example trade unions are not directly involved in the development of technology in these cases. On the other hand, a lack of social dialogue and trade union involvement in the introduction of technology can have a negative effect on employees in other establishments, for example in terms of data protection linked to the IoT or new risks such as micro-powder from 3D printers. In conclusion, as a policy recommendation, the involvement of unions in the process of technical change is likely to be good to ensure the effects are also positive for all employees.

Fourthly, this research brings further evidence suggesting a need to update or create (national and European) labour legislation adapted to the new contexts arising from digitalisation. For example, regulating high-intensity work to avoid burnout; deepening work-life balance measures or regulating teleworking so that it really translates into an improvement in job quality (mitigating its negative effects), etc. For example, digital technology can be a "window of opportunity" for the possibility of reduced working hours to improve productivity and job quality.

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Annex 1. Company profiles

Annex 1.1. Case study 1: TTI-Algeciras profile

Type of entity and ownership structure

Total Terminal International (TTI) is a company in the maritime transport sector (stowage and container terminal) established in 2008, thanks to a concession from Puerto Bahía de Algeciras (Cádiz, Spain) for the expansion of its activity. It was funded by the Korean Hanjin Shipping and after a brief period of preparation of the facilities and installation of the new automated systems (2008-2010), the terminal began its activity in 2010. Thanks to its innovative technological development, it become the first semi-automatic terminal in Southern Europe and Mediterranean.

Hanjin Shipping needed to resort to partner support to maintain its commitment, so in 2015 it merged with the consortium formed by IBK Securities and Korean Investments Partners (75% of the shares for 25% of Hanjin Shipping). Even so, the Korean company ends up going bankrupt in 2017, and is then acquired by the shipping company Hyundai Merchant Marine (South Korea), which controls 100% of the shares since then (source: company). Since March 2021 TTI ALGECIRAS is owned by the Korean shipping line HMM (50% +1 share) and Isla Verde Algeciras Terminal Holding, SL (50% -1 share), the latter 51% owned by CMA Terminals Espagne (CMA CGM) and 49% by the DIF Capital Partners Group. [14]

TTI terminal is located in the Phase A of the Bahía de Algeciras Port, a privileged position in geographical and strategic terms: The strait of Gibraltar is a Geostrategic node for international trade and logistics where most of the world maritime transport network converge. The port of Algeciras stands out as the leader in the Mediterranean and ranking 4th at European level in total throughput and has been established as southern gateway port in Europe for the main commercial trades thanks to its maritime connectivity to more than 200 ports.

Activities and geographic location

The company provides services in the maritime transport sector (activity in stevedoring and logistics). The entire activity takes place in Bahía de Algeciras Port, in a large container terminal for public use. The concession area exceeds 300,000 square meters on Isla Verde Exterior Quay. The Terminals has a 57,271-square-metre public manoeuvring zone, and two quay lines: a 650-metre-long quay to the East and a 550-metre-long quay to the North, with 18.5 and 17.5 metre drafts respectively. The terminal is equipped with eight Ship-to-Shore cranes, 32 Automatic Stacking Cranes (ASC) on rails and 21 Shuttle Carriers that allow the terminal to service the newest generation of 18,000 TEU-plus megaships.[15]

We describe below the machinery with which it operates, characterized by a high level of automation and digitisation:

- 8 Ship-to-Shore cranes (Portainers): electric machines for loading and unloading containers from ships.
- 38 yard automatic stacking cranes (ASC): these are cranes working on rails, fully automatic- thanks to the use of advanced IoT technology applications, such as the Crane Information Management System (CIMS), the Load Control System (LPS) and the Target Position System (TPS).

[14] Source: interviews plus company website The Company - TTI Algeciras.

[15] Source: company website, plus Port of Algeciras - Port Technology International.

- 21 Shuttle Carriers: machines that carry out the loading and unloading of trucks. They currently run on a diesel engine, which will be replaced, in a very short time, by an advanced system that will reduce maintenance cost, as well as the breakdowns.

Size and composition of the workforce

The company has 95 employees in total. Most of its members are engineers who develop technical and supervisory positions, as well as other managers and administrators from various specialties. To complete its activity, the company avails itself of 21 subcontracted workers through Randstad (Employment Agency), always in assistant roles. In total, the company has 116 workers in its nuclear activities: stevedoring and logistics.

The company hires workers assigned to the stevedoring tasks (loading or unloading of ships) from the Local Coordinating Committee: CEPE (Coordinadora de Estibadores Portuarios del Estrecho), an entity in which TTI has 20% of the shareholding and which manages 30% of the workforce of the entire port Bahía de Algeciras. The stevedores carry out tasks of driving shuttles, handling cranes, etc.

Port stevedoring work is organised in "hands". A hand is defined as a coordinated group of workers who attend to the stevedoring of ships for a full shift. TTI activity ranges between 84 workers (6 hands), and a maximum of 98 (7 hands). In this way, the company reaches 214 workers -between contracted and subcontracted (CEPE and Randstad)- at peak workload hours. Among the essential characteristics of the core workforce (95 workers) we must emphasize that they are generally highly qualified employees, predominantly men -in the tradition of the port sector-, and relatively young (38-year-old on average).

The company structures its activity on the basis of 5 departments (see organisation chart in Figure 3). Responsible for all of them is the CEO of the company, who supervises the General Manager. At the next level, the operations department is the largest (44 employees). From here, all operations in the large container yard is coordinated and executed. Under the control of the Operations Director, the department has 3 Operations Coordinators, 6 Shift Supervisors, 5 Controllers, 10 Shift Planners, 11 Real Time, 7 Process Engineers, a Yard Planner, an administrative assistant, as well as 8 Randstad subcontractors from various qualifications.

The maintenance department consists of 27 employees. In addition to the Director, it has an Assistant Maintenance Manager, an Acting Technical Coordinator, an EQM Shift Supervisor, 5 EQM ShIft, 4 electromechanical, 5 Shifts and a General Affairs EQM. The department is completed by 9 contracted Randstad (6 EQM electromechanics and 3 EQM assistants).

The financial department has 8 workers. Under the control of the Financial Director are the Legal Responsible -who has an assistant-, the Purchasing Controller and the Accounting Controller, who has 5 assistants (3 from the staff and 2 subcontracted).

The systems department –which has 6 employees- has an essential role in the automation of the terminal. Under the control of the Systems Director, the Automation & Development Responsible works, which is supported by 2 automation & Development Engineers and the IT Infra-Coordinator, who is assisted by a subcontracted worker.

The Department of Human Relations, Human Resources and Security has 5 employees. The Director supervises the HR Responsible and the Safety & Security Responsible. Both managers have an assistant (subcontracted in the case of HR Responsible).

Finally, the commercial department –the smallest one– has just 3 employees. The Commercial Director supervises the Claims & Customer Service and the Customer Service Assistant.

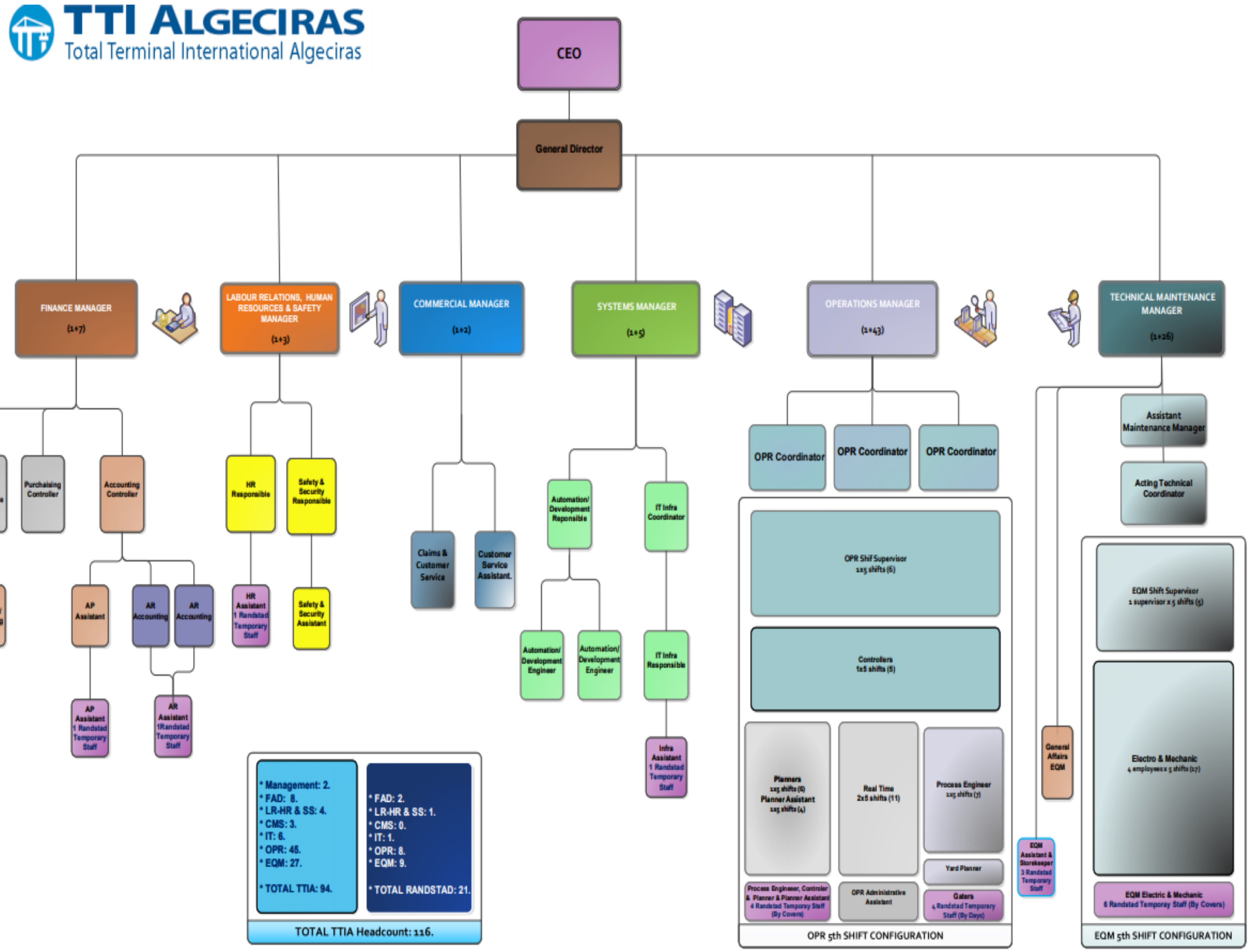
Employee representation

The unionisation of the company's workers does not refer to a single union. Most of the employees are supported by one of the two large majority unions in Spain: Unión General de Trabajadores (UGT) or Comisiones Obreras (CC.OO.), in addition to having the support of the Stevedores Coordinator (CEPE), which has a great political weight in the labour negotiation processes, being key to defending the interests of the stevedoring professionals: “they are the ones that can stop a port” (Manager1_TTI). The Works Council is made up of 5 members, with representation of employees of different positions, qualifications and professions. At present -both the directors of the company and the Chairman of the Council- have defined their labour relations as stable in recent years.

TTI's short history has led to overcoming some difficulties in the workplace. At the beginning (2010), given the creation of a highly technological terminal, highly qualified young workers (technicians, engineers, etc.) were incorporated. Growth was rapid in the first 3 years due to technological development and the continuous creation of new positions. Afterward, both wages and promotion opportunities stagnated within the terminal. TTI-Algeciras has an organization chart (see figure 3) with short trajectories, and a large part of the contracted profiles reach their potential limit during the past 10 years. Given that the TTI trajectory is limited to activity in the Bay of Algeciras itself, some professional aspirations are frustrated, so a promotion can only be achieved through a change of enterprise. This context has generated some tensions, with a Company Committee pressuring management to rush for the promotion options that respond to the progression in qualification and experience of the workers. In this regard, the company's management has indicated that - although the company belongs to a large group - it manages only one establishment in the Strait of Gibraltar with a specific function, and therefore does not offer the possibility of promotion to other areas. Furthermore, the Works Council's possibilities for salary increases are somewhat limited, considering that the average wage of workers is currently more than double the average wage in Spain, thus restricting the scope for bargaining.

In any case, in 2020 a new collective agreement has been approved and, after the negotiations, both parties (TTI Management and Works Council) point out the good atmosphere after the signing of a “win-win” agreement: workers enjoy good working conditions and the company maintains its productivity. The HR Manager highlights two strengths for the workforce: (1) good salary progression, which places them above the industry average and (2) good working conditions supported by automation and digitisation, which are also at the forefront of the sector in this matter.

Figure 4: Total Terminal International: organisation chart (2020, December)



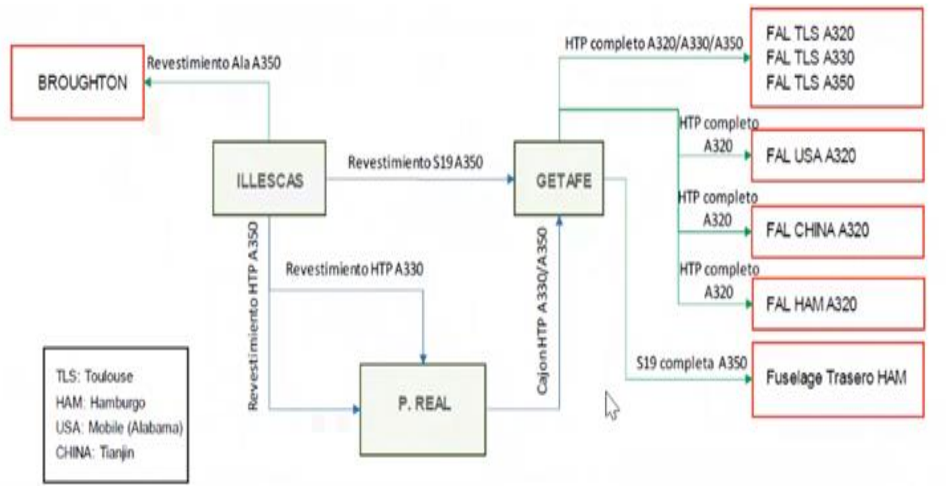
Source: Company

Appendix 1.2. Case study 1: Airbus profile

Type of entity and ownership structure

Airbus is a French aerospace company with extensive military capabilities and, currently, the world's leading aircraft manufacturer. The entity was founded in 1970 through a consortium of several French institutions. The project was undertaken with the clear aim of countering the dominance of the sector, at that stage, held by the United States through competitors such as Boeing and McDonell Douglas. Three decades later, the company experienced an important turning point (2001), when it was acquired by EADS -European Aeronautic Defence & Space- (80% of the shares) and BAE Systems (20%). Five years later (2006), BAE Systems sold its shares to EADS itself, which became the sole owner of the airline. The entity is renamed Airbus in 2014 for purely commercial reasons and, following various agreements, its shareholding will be distributed as 95.78% Airbus SE and 4.22% Airbus Defence & Space (2021 data). The company has a total of seven subsidiaries: Airbus Group, Airbus Military, Airbus Executive and Private Aviation, Navblue, Stelia Aerospace and Testla.

Figure 5: Diagram of production relations between Airbus Spanish sites and other locations in Europe



Source: Company

Airbus has a broad presence around the world, although its activity is particularly strong in Europe, with France, Germany and Spain - in that order - being the countries with the strongest presence. In the case of Spain, Airbus was introduced through its merger with the local entity CASA (Construcciones Aeronáuticas S.A.) in 2000.

The company employs more than 134,000 workers worldwide, of which almost half are located in Europe (63,000). Among them, 12,700 work in Spain, distributed in seven sites, located in different parts of the centre and south of the Iberian Peninsula. Production processes are closely linked to the rest of Europe. The head office is located in Getafe (Madrid), where about half of the multinational's employees in Spain (6,030) work. Getafe also has representation from all departments and areas of the company, and most of the managers are located there. This case study focuses mainly on this establishment, from which the rest of the activities in Spain are coordinated.

Activities and geographic location

Airbus' activities in Spain focus on three main products: commercial aircraft, helicopters and military and aerospace aircraft. The geographic distribution of the activity has its most important nucleus in the vicinity of Madrid, where the sites of Getafe, Illescas, Barajas and Tres Cantos are grouped. The rest of the activity is distributed in different points in the south of the peninsula: San Pablo-Seville, Tablada-Seville, Puerto Real (all of them in Andalusia), as well as Albacete (in the southeast of Castilla-La Mancha).

Company size and workforce composition

The workforce at the main Airbus establishment (Getafe) –with 6030 employees– is distributed as follows:

- Commercial aircraft: stabilisers are assembled for all Airbus series, as well as other major components (2100 workers).
- Military and aerospace aircraft: aircraft for defence and space activity are also manufactured, constituting the strongest sector in terms of workforce: 3800 workers.
- Helicopters: airframes for the complete Airbus series are produced (130 workers).

The activity is complemented at the other sites by: (1) the assembly of some commercial aircraft components in Illescas (900 workers) and Puerto Real (500); (2) specific phases of Military and aerospace aircraft, with the Andalusia sites for the military division (Seville: 2800) and Puerto Real (390), while Barajas and Tres Cantos (440) are mainly involved in aerospace aircraft; finally, (3) the Albacete site (370) is involved in the manufacture of helicopters.

In short, we are talking about a large workforce of more than 12,700 employees in Spain, to which we must add some 57,000 indirect jobs. In addition to the figures, we should highlight the quality of employment: Airbus has a high proportion of permanent contracts (84%) and a very high rate of youth employment (41%). Staff salaries are particularly high, with an average 2.3 times higher than the average Spanish salary.

Considering the three technologies that are the focus of this study (IoT, Augmented Reality and 3D printing), Airbus' contribution is restricted to 3D. Actually, this technology has only recently started to be used in the Spanish sites (2018), arriving relatively late to the market in comparison with other competitors in the sector. This is due to the difficulties faced by the company in introducing relevant changes, which company managers summarise in two: (1) bureaucratic procedures and lengthy protocols, which are necessarily complex when providing services in the field of Defence (military world), (2) in addition to the need to make extensive changes in the set of processes to adapt to such a new technology.

- Employee representation
- Employee representation in the company is based on four main levels:
- Local works councils (headquarters).
- Works councils at national level.
- Inter-company committee (Spain).
- Inter-company committee (Europe).

Getafe has its own Works Council for the establishment itself (local level: headquarters), with a broad representation of workers of different levels, qualifications and professions. Trade union participation is very diverse, as required by the complexity of the sector and the size of the company. Comisiones Obreras (CC.OO.) has become the dominant mass union in Airbus (also Getafe site), although the representations are quite spread out. The current Works Council (2021) was formed after the 2019 elections, as follows:

- Comisiones Obreras (CC.OO.): 38% of representatives (made up of workers of various profiles and levels).
- Association of Technicians and Professionals (ATP): 20.8% (Cadres and technical staff).
- General Confederation of Workers (CGT): 13.8% of representatives (predominantly blue collar workers).
- Unión General de Trabajadores-Aire (UGT-Aire): 6.9% of representatives (Merge of traditional trade union and newly created Cadres and technical staff).
- In general terms, the unions have active participation and strong influence on company policy, with relevance for blue collar workers, while the white collars are mainly organised around the internal splits. Their bargaining clout is based on their shown potential to stop production. The main lines of conflict are fear of job destruction and the age gap generated in both segments (blue and white collar).

Annex 2. Master interview guidelines of first phase

COMPANY/ *EMPRESA:*

CITY OR TOWN/ *LOCALIDAD:*

INTERVIEW LANGUAGE/ *IDIOMA EN QUE SE REALIZA LA ENTREVISTA:*

1. Name and structural characteristics of the company (Country/geographic location; company age, company size, sector, activity, wether stand-alone Company or belonging to an international group, etc. Nombre y características estructurales de la compañía/ localización, antigüedad, tamaño, sector, actividades, carácter independiente o pertenencia a un grupo internacional, etc.

2. Forms of employee representation within the Company (direct or indirect employee representation), trade unions. Tipo de representación de los trabajadores en la compañía (representación directa o indirecta de los trabajadores), comité de empresa y representación sindical.

3. Type of digital technology introduced in the Company and when/why, with details on the work settings, tasks and processes to which the technology is applied and occupations most concerned. Tipo de tecnología digital introducida en la compañía ¿Cuándo? ¿Por qué? Aportación de detalles sobre los equipamientos de trabajo, tareas y procesos en los que se aplica la tecnología, así como las ocupaciones más afectadas por todo ello.

4. A description of the main (expected) changes in work organisation and employment and working conditions effects of the digital technology or technologies adopted. A mix of positive and negative effects. Descripción de los principales cambios (esperados) en la organización del trabajo y el empleo, así como los efectos sobre las condiciones de trabajo de la tecnología digital u otras tecnologías adaptadas. Realizar un balance de efectos positivos y negativos.

Additional topics will be explored in the company interviews relate to the effects of the adoption and use of digital technologies in the workplace on the following dimensions. Algunas cuestiones adicionales serán analizadas en las entrevistas en las empresas, relativas a los efectos de la adaptación a las tecnología digitales en el lugar de trabajo en las siguientes dimensiones:

- Occupacional composition, job profiles and task content, based on concepts illustrated in the JRC Eurofound's task framework. *Composición ocupacional, perfiles de los puestos y contenidos de las tareas, basándonos en el marco de las tareas asignadas al JRC de Eurofound.*
- Work organisation, workflows and processes. *Organización del trabajo, flujo del trabajo y procesos.*
- Employment and working conditions as defined in Eurofound's job quality framework. *Empleo y condiciones de trabajo tal y como se definen en el marco de la calidad del trabajo en Eurofound.*
- Workplace design and changes in the physical workspace. *Lugar de trabajo y cambios físicos en el espacio utilizado.*
- Industrial relations and social dialogue (including information and consultation before, during and after the introduction of the technology). *Relaciones laborales y diálogo social (incluyendo la información y el asesoramiento antes y después de introducir la tecnología).*
- Other potential effects on the Company and the workers. *Otros efectos potenciales sobre la compañía y los trabajadores.*

Annex 3. Master interview guidelines of second phase

Annex 3.1. Interview guideline for HR or Innovation management

1. Characteristics of the firm and its work structure. Características de la empresa y de su estructura laboral

    1.1. Main characteristics of the establishment. Principales características del establecimiento:

2. Incorporating new technologies. Incorporación de nuevas tecnologías

    2.1. Incorporation of new technologies (IoT, 3D printing, VR/AR) in the company. Incorporación de nuevas tecnologías (IoT, impresión 3D, VR/AR) en la empresa.

    2.2. Objectives of the introduction of new technologies. Objetivos de la introducción de nuevas tecnologías

3. Work organisation. Organización de los procesos de trabajo

    3.1. Changes in work tasks and processes due to new technology. Cambios en las tareas y procesos de trabajo a partir de la nueva tecnología

    3.2. The company's approach to technology deployment. Enfoque de la gestión de la compañía ante el despliegue de la tecnología

    3.3. Adaptation or new digital control systems. Adaptación o nuevos sistemas de control digital

    3.4. Occupations and profiles affected by technological change. Ocupaciones y perfiles afectados por el cambio tecnológico

    3.5 Business approaches and strategies in human resource management. Enfoques y estrategias de la empresa en la gestión de los recursos humanos

4. Job Quality. *Calidad del empleo*

    4.1. Organisation of working time in the establishment and changes following the deployment of technology. Organización del tiempo de trabajo en el establecimiento y los cambios que se han producido tras el despliegue de la tecnología

    4.2. Effects on labour risks. Efectos en los riesgos laborales

    4.3. Social dialogue and employee participation in the introduction of technology. Dialogo social y participación de los empleados en la introducción de tecnología

    4.4. Involvement of employees representatives in monitoring the impact of technological change. Participación de los representantes de los trabajadores la supervisión del impacto del cambio tecnológico

5. Conclusions. Conclusión

    Effects of the Covid-19 pandemic. Efecto de la pandemia por Covid-19

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Thank you for your time! ¡Gracias por la entrevista y por su tiempo!

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Annex 3.2. Interview guideline for employee representation

1. Firm profile and employee representation. Características de la empresa y representación de los trabajadores

2. Incorporating new technologies. *Incorporación de nuevas tecnologías*

    2.1. Incorporating new technologies. Incorporación de nuevas tecnologías en la empresa.

    2.2. Objectives of the introduction of new technologies. Objetivos de la introducción de nuevas tecnologías

3. Organisation of work processes. Organización de los procesos de trabajo

    3.1. Changes in work tasks and processes due to new technology. Cambios en las tareas y procesos de trabajo a partir de la nueva tecnología

    3.2. Company approach to technology deployment. Enfoque de la gestión de la compañía ante el despliegue de la tecnología

    3.3. Adaptation or new digital control systems using the technology. Adaptación o nuevos sistemas de control digital con la tecnología

    3.4. Occupations and profiles affected by technology. Ocupaciones y perfiles afectados por la tecnología

    3.5. Business approaches and strategies in human resources management. Enfoques y estrategias de la empresa en la gestión de los recursos humanos

4. Job Quality. *Calidad del empleo*

    4.1. Organisation of working time in the establishment and changes following the deployment of technology. Organización del tiempo de trabajo en el establecimiento y los cambios que se han producido tras el despliegue de la tecnología

    4.2. Effects on labour risks. Efectos en los riesgos laborales.

5. Employee participation and trade union representation. Participación de los empleados y representación sindical

    5.1. Involvement of workers' representatives in the introduction, monitoring and evaluation of new technologies. Participación de los representantes de los trabajadores en la introducción, supervisión y evaluación de nuevas tecnologías

    5.2. Describe the main milestones of collective bargaining and the most important labour disputes. Describir los principales hitos de la negociación colectiva y los conflictos laborales más importantes

6. Conclusions. Conclusión

    Effects of the Covid-19 pandemic. Efecto de la pandemia por Covid-19

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Thank you for your time! ¡Gracias por la entrevista y por su tiempo!

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Annex 3.3. Interview guideline for workers

1. Main characteristics of the worker. Principales características del trabajador

2. Incorporating new technologies and work organisation. Incorporación de nuevas tecnologías y organización del trabajo

    2.1. Incorporating new technologies. Incorporación de nuevas tecnologías en la empresa.

    2.2. Objectives of the introduction of new technologies. Objetivos de la introducción de nuevas tecnologías

    2.3. Changes in the tasks and work processes of your job due to new technology. Cambios en las tareas y procesos de trabajo de su puesto a partir de la nueva tecnología

3. Job Quality. Calidad del empleo

    3.1. Responsibility and Autonomy to carry out assigned tasks. Responsabilidades y Autonomía para llevar a cabo las tareas asignadas

    3.2. Pace of work at your job and change after the introduction of technology. Ritmo de trabajo en su puesto y cambio tras la introducción de la tecnología

    3.3. Skills required in their work and change in skill requirements after the deployment of the technology. Habilidades requeridas en su trabajo y cambio en los requisitos de habilidades después del despliegue de la tecnología

    3.4. Time and workload organisation. Organización del tiempo y de la carga de trabajo

    3.5. Teamwork, relationship with peers and the changes that have taken place following the deployment of technology. Trabajo en equipo, relación con sus compañeros y los cambios que se han producido tras el despliegue de la tecnología

    3.6. Data analysis and aspects of their work that are monitored. Análisis de datos y aspectos de su trabajo que se supervisan

    3.7. In general, describe the benefits and risks derived from the use of technology from their point of view. En general, describir los beneficios y riesgos derivados del uso de la tecnología desde su punto de vista

4. Employee participation and social dialogue. Participación de los empleados y diálogo social

    4.1. Involvement of workers' representatives in the introduction, monitoring and evaluation of new technologies. Participación de los representantes de los trabajadores en la introducción, supervisión y evaluación de nuevas tecnologías

    4.2. Describe the main milestones of collective bargaining and the most important labour disputes. Describir los principales hitos de la negociación colectiva y los conflictos laborales más importantes

5. Conclusions. Conclusión

    Effects of the Covid-19 pandemic. Efecto de la pandemia por Covid-19

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