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DISCUS PROJECT

Digital Transformation in the Construction Sector: challenges and opportunities

Country Case Studies

Report – Belgium

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LENTIC

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Introduction

Digitalisation and technological changes have specific impacts on the construction sector. They involve new challenges on both organisational and industrial relations' aspects. In order to document these impacts and challenges from a qualitative perspective, we present in this document the results of a case study led in the sister companies Mobic and Scidus. Strongly anchored in the field, it addresses the impacts of the introduction of robotic production lines on the organisational and social dialogue aspects of these construction companies.

Two aspects motivated the selection of these companies. First, Mobic and Scidus dedicate most of their activities to prefabrication in one of the main branches of the construction sector. Indeed, they operate in the wood construction sector, more specifically in the timber frame constructions market. Second, the companies' developments towards digitalisation are considered to be among the most advanced in their sector in Belgium.

Mobic's activities are oriented towards design and sales of the structures; while Scidus takes on the production part (log cutting, panel assembly and house finishing). Both companies are part of a larger Group, whose parent company is IMAX Pro. IMAX Pro activities are dedicated to the research, development and commercialisation of the robotic production lines at large scale. This case study primarily focuses on the impact of the robotic production lines on the reality of work of the Group's production site (Scidus), located in Etalle. It secondly addresses the impacts and the relations with the design office (Mobic), located in another village called Harzé. Because of time and resources constraints, the situation of the IMAX Pro company is not addressed in this case study.

The case study is divided in five chapters, as follows. First, we detail the methodology adopted for data collection and analysis. Second, the main characteristics of the case study are presented in terms of company background as well as the main digitalisation and innovations adopted. Third, we address the impacts of those technologies on three organisational dimensions (work organisation, labour force, working conditions). Fourth, the relation between the technologies and industrial relations is exposed. Fifth and finally, the main drivers and barriers considering digitalisation are listed.

1. Methodology

In order to ensure the validity of the results presented below, we triangulated our data through multiple sources. Preliminary contents were collected during the approval process of the case study given by the company. At the beginning of July 2020, in strict compliance with the sanitary rules, we arranged a 2h30 guided visit of the production halls in Etalle by the Scidus' director. This visit allowed us to grasp the situation in the field and to get an overview of the entire production process. Six semi-structured interviews which form the core element of our approach, were carried out over the period of mid-July – mid-December 2020. Given the COVID-19 pandemic situation at that time and a change in health regulations, they were conducted by phone calls or videoconferences and lasted between 20 and 60 minutes. The table below summarises the interviewees' role. Throughout the writing period, desk research allowed us to confirm or clarify elements given by the interviewees. It mainly consists of the website of the companies, newspaper and online media clippings, as well as videos, and websites of connected organisations such as Digital Wallonia. Following the writing of the main corpus of the document, a last phone call was organised at the beginning of 2021 with the Scidus' director in order to clarify specific points of which we wanted to deepen our understanding.

Table 1 – Interviews summary

Interviewee 1	Mobic's founder and director[1]
Interviewee 2	Design office manager
Interviewee 3	Scidus' director
Interviewee 4	Assistant production manager
Interviewee 5	Joiner
Interviewee 6	Former worker

2. Main characteristics of the case study

2.1. The companies

The technological innovations currently implemented within the production halls originate in 1988 with the creation of IMAX Pro. IMAX Pro initially specialises in automation and fibre optic deployment, far

[1] Mobic was founded by two persons but we only interviewed one of them.

from the wood sector. It operates in those fields for about ten years, capitalising on a strong technical background from the founders (two brothers, both holding engineering degrees). In 1998, when creating Mobic (see next paragraph), they orientate IMAX Pro's activities towards robotic. IMAX Pro researches focus on lowering production costs of the timber frame market by industrialising the production with machines. In 2008, the company succeeds in developing the first robotic production line (V1) for wood framing, based on robots from the automotive industry. Since then, IMAX Pro continues its research activities towards new and more complex robotic solutions, including a V2 of their robotic production line.

As stated above, IMAX Pro founders' create Mobic in 1998. From the start, they dedicate its activities to the construction of timber frame houses. The production hall is located right next to the design office, in Harzé. At the time, production work is manual. Workers (carpenters and joiners) carry out wall manufacturing and panelling. Engineers in the design office already work with 3D files, from which machines files are exported for logs cutting. In 2008, manufacturing and panelling are automated through the implementation of the V1 developed by IMAX Pro. As Mobic expands, the original production hall of Harzé becomes too small to support production capacity and new facilities are built on the same site. In 2015, management decides to take over the Scidus sawmill and its production halls in Etalle (100km away from Harzé). Control over a larger part of the value chain expands. In March 2020, all the Mobic's workshops from Harzé are repatriated to the sawmill site in Etalle, along with a switch to a just-in-time (JIT) production system. As a result of the lasts years' researches of the IMAX Pro team, a new innovative and flexible robotic line (V2) is developed to maximise the industrial potential of timber frame construction in new markets. It is implemented in June 2020 and was expected to be fully operational in January 2021.

All of the woods mounted in production comes from short supply chain (50km^2 around production site). Based on the machine files sent by the design office and optimised by the assistant production manager, they are cut in Scidus' sawmill to the needed sizes. The sawmill also provides connected wooden products such as terraces, siding and parquet flooring. Mobic's premises in Harzé are now entirely dedicated to the design office, site supervision and sales activities.

Mobic has patented eight different technologies related to different parts of the wooden frame construction process (roofing, walls, frameworks, floors). These technologies aim at improving the thermal, acoustic and mechanical qualities of their buildings. Both Mobic and Scidus received several certifications related to wood supplies (such as the "Local Wood" label which guarantees that raw material are supplied within a 150 km radius around the sawmill), energy consumption or sustainable management.

Companies are organised by departments and functions. A few persons assure several functions at the same time. Overall, each of the three company employs between 15 and 20 salaried persons. Scidus also has recourse to a substantial number of subcontractors, which can double or triple its number of workers at a given time. Overall, the ownership structure remains largely a family property, and the turnover tripled over the last year.

Mobic is directed by one of the two founding brothers. One person, who supervises seven drafters, manages the design office department. Sales department is made up of five persons: on the one side, the two founders and the Scidus' director, who are general salespersons; one the other side, two sales representatives specialised in houses selling. The R&D department consists of two people who report directly to the director. Three persons work in the administrative department (one in Harzé, two in Etalle), which services are mutualised for the three companies. Scidus is directed by one person. A manager oversees the entire production department (sawmill, paintings, dry kiln, wood calibration and grooving), accompanied by an assistant manager who has specific responsibility for the three workshops described in the next section. A foreman, who reports to the production manager, coordinates the work of the operators (between 40 and 60 operators, depending on orders' volume). The foreman as well as substantial part of these operators are subcontractors. In the sawmill, six workers are posted along the motorised sawing line to supervise and operate the cut of logs into lumbers. Scidus also includes a maintenance and development department, made up of one manager and four workers (two of them being subcontractors); as well as a sales and purchasing department made up of a single worker. IMAX Pro is directed by one person. The director supervises the work of two departments. On the one hand, the robot & web department in which six developers, engineers and designers work on the development of robotic solutions. On the other hand, the electro-mechanics department comprises an industrial designer, a workshop manager and a team of three workers in charge of the electrical installations.

2.2. Digitalisation and innovations

Main digitalisation and innovations adopted by the companies

As of today, the production halls (now located in Etalle) revolve around three types of workshops.

- The first workshop is a 2D workshop equipped with three workstations. One "Speed-Cut" that machines and cuts wood sections coming from the sawmill, one assembly table and the first robotic line (V1) consisting of three robots. The workshop delivers isolated and closed 2D walls sections. Part of the production is shipped as such directly to on-site constructions. In that case,

the client's contractors perform assembly as well as finishing on-site. The rest of the production is sent to the second workshop.

- The second workshop is a 3D workshop operating as an off-site construction site inside the production halls. It is divided into two segments. One segment deals with single-family dwelling units, the other with series productions of houses for holiday resorts. The outcomes of this workshop consist of finished and equipped 3D sections of houses. A protective cover is placed around the sections, which are shipped by trucks to the customer's construction site to be assembled as whole. All 3D houses' sections are made of the wall sections produced in the 2D workshop.
- The third workshop is equipped with the second robotic line abovementioned (V2). It deals with the direct cutting of logs for industrial production of complex wood sections and structures.

Two different versions of robotic lines equip the workshops of the production hall for assembling timber frames constructions. They constitute the main technological innovations adopted by the companies. The first one (V1) operates at the end of the first workshop. This robotic line consists of three robots anchored to the ground that pick, cut, place and nail the wooden elements to produce large 2D flat elements (average 10 x 2,5m). As no robotic model fitted the needs of the founders, they based the design model on robots from the automotive industry.

> *There were quite a few machines for the industrial production of frames, but none of them corresponded to what we were looking for. So my brother thought we should start from a robot used in the car industry.* (interview excerpt, Mobic's founder)

IMAX Pro engineers and developers worked on the development of programming softwares that could fit the wood construction sector and the specificities of Mobic's architectural projects. This first static robotic line was launched in 2008 within the company and is operating since then. It essentially deals with automated repetitive tasks and gestures for the manufacturing of 2D wooden framed walls.

Based on the experience accumulated with the V1 and with the evolution of robotics, a second version (V2) of robots has been developed. Instead of being anchored to the ground as the V1 is, this version is characterised by its mobility around a workstation. The V2 also offers greater versatility in the type of work it can handle. Thanks to a system of scanners and tags, the robot is capable of recognising the log to be processed, referencing it and drawing conclusions about what type of operation it can perform on it. Therefore, precise imaging of the log can be obtained before cutting starts. Such elements, combined with a movement system, allow the V2 to position itself correctly in relation to the type of work expected on the trunk or piece of wood placed on a trestle. In this work configuration, the robot placed itself in a very precise position in relation to the log to be cut, rather than the other way around. A tool changer on the robot head ensures versatility. The robot is also collaborative in its work with the operators. It evolves around workers by self-correcting, *i.e.* by rectifying its position in relation to the environment in which it operates. In a nutshell, this second version is dynamic, polyvalent, flexible, and collaborative.

In the design office, Mobic's architects and engineers have worked since the creation of the enterprise in 1998 with digitalised 3D plans on computers for every new construction projects, contrary to the classical and almost always used 2D paper plans. Asides from allowing the customers an immediate visualisation of the volumes of the projects ordered, the modelled plans are directly sent for production as order forms to the machines and the operators on the robotic lines.

Relations with internal and external stakeholders

The in-house R&D plays an important role in the digitalisation and innovations implemented and, more generally, in the development of the companies. Each of the three companies (IMAX Pro, Mobic, Scidus) has its own team dedicated to research or maintenance and development focusing on their lines of business. IMAX pro develops robotic solutions for the wood industry, which are used in the production halls. Mobic's R&D team focuses on improving the wooden frames by developing patented innovation technologies. The Mobic's team also develops new constructive systems for large buildings in collaboration with the Scidus maintenance and development team on the sawmill and production site. As an example, the large building used for drying the woods after they have been cut has been designed internally and the development team onsite is familiar with all its operating circuits. Another illustration

regards the software running in the robots that the IMAX Pro teams developed internally.
Collaboration and partnerships with universities and the public sector are sought, for a couple of reasons. First, to contribute to the resolution of the numerous technological and research gaps related to industrialisation of the timber frame sector. Second, to consolidate their market position and keep on being at the forefront of technology. Mobic is an ambassador of Digital Wallonia, a regional action plan setting up objectives to reach a digital transformation in several social and economic key themes, including the working world. A PhD financed by the Walloon public research service has been launched in 2019. The PhD student (working half time in the company and half time at the university) has been hired to develop ways of designing and building structures assembled from tree trunks with robotics.
The companies' developments towards digitalisation are considered to be among the most advanced in their sector in Belgium. They are currently the only enterprise in Belgium that manufactures prefabricated wooden structures with robots. Two explaining factors of this situation emerged from our interviews. First, the strong technical academic background of the founders. Second, the differentiated market positioning adopted by the Mobic ever since its creation.

> *From the beginning, we positioned ourselves as managers of an industrial company and not as craftsmen. We knew that we would not be carpenters creating timber frames, but industrialists producing timber frames with cost-reduction as an objective.* (interview excerpt, Mobic's founder and director)

As regards the relations with the BIM in particular, the Scidus' director considers the digitalisation processes implemented throughout Mobic and Scidus as "*a construction type of BIM*", which not only smooths communication between stakeholders but also guides the entire production process.

> *There is a lot of hype going around the BIM. Sure, it helps building cheaper buildings, but it does not necessarily make the construction process quicker and of better quality. In our company, since we cut the woods based on 3D machine files, we already know the dimensions we need as soon as logs enter the sawmill. So we smooth communication between actors, we limit material losses and we optimise design and construction processes.* (interview excerpt, Scidus' director)

This differentiation strategy and the digitalisation associated result in the selling of wood frame products that are partly competitive and partly complementary with the existing offer on the market. On the one

hand, single-family dwellings or curtain walls compete with the products offered by other manufacturers in the same sector, and are positioned as both cheaper and of better quality. One the other hand, Mobic is the only company that is able to offer complex wood structures produced at industrial scale while meeting profitable production, thanks to the V2 of the robotic lines. These products relates, *inter alia*, to walls and roofs with unique curves and large formats, complex structures such as the very recent construction of 10 ha of carports made of tree trunks.

3. Impacts of the technologies on organisational aspects

3.1. Impacts on work organisation

Coordination between companies along the value chain

According to the director of Scidus, the wood sector is characterised by a closed and poorly integrated value chain. Actors across the value chain are fragmented and they rarely speak to each other. The use of robotic production lines, materialising the founders' desire of industrialising the sector's production, has enabled the company to grow and extend steadily. This has, in turn, enabled the pursuit of a vertical integration strategy, notably through the acquisition of a sawmill. Vertical integration also takes place at the other end of the value chain. As stated by the director, the aim is to proceed "*on the same tree, from the log to the house*" while minimising financial losses related to the various stages of trunk transformation.

Regarding coordination between companies belonging to the value chain, Mobic wishes to dedicate most of its production to the outcomes of the second and third workshops, *i.e.* to the production of finished and equipped 3D houses blocks (for single-family dwellings or holiday homes) and complex structures (in terms of cutting). The company wishes to avoid the coordination required with construction trades on site when sending 2D panels directly to the construction site. This latest option is thus more and more called to act only as a buffer between two 3D production orders.

> *All this management of sub-contractors on site involves a lot of uncertainty. There are many things that we cannot control. It is a nightmare in terms of management when you send a subcontractor to a building site.* (interview excerpt, design office manager)

Logistics and transportation

The vertical integration strategy and the shift to just-in-time production (see "work processes and tasks" section) supported by technological innovations also led to concomitant changes in transportation system. In 2020, the company repatriated all parts of the production chain currently held on the same geographical site in Etalle. In terms of logistics and transportation, the objectives were to eliminate the management of goods transport between the two previously geographically fragmented production sites, to avoid material leakage, and to create links between the different productions.

On-site and off-site productions

The company wishes to concentrate its activities on the off-site productions of wooden structures, which are the outcomes of their second and third workshops. The second workshop relates to the production of finished and equipped 3D houses blocks, the third to wooden elements of complex structures. In the long term, the direct sending of the 2D panels and closed walls from the first workshop to on-site construction sites will be used exclusively to smooth production between two 3D orders within production halls (off-site production related to the second workshop).

> *Some clients ask us to do closed structural work, and to be able to do the finishing inside the building. But this is not our job. We want to concentrate on prefabrications, on everything that can be done in the workshops* (interview excerpt, design office manager).

As of today, the extent to which the construction project is built on-site or off-site depends on its type. The off-site production is well used for holiday homes, which architectural plans can be mass-produced as they present very little variation from one house to another. For single-family dwellings, the switch is currently being made from closed structural work (2D panels from the first workshop) sent on-site, to off-site production (second workshop). However, the operation requires an individualised approach from the design office for each dwelling, as each customer may expressed different architectural wishes and needs.

Work processes and tasks

The anticipation of assembly processes during the design of the architectural plans by the design office is not new. Indeed, since its creation, Mobic has been working with machine files at the first workshop to produce 2D panels. A prior planning of the positioning of several construction elements is therefore necessary. However, the implementation of the V1 (and later the V2) as well as the increasingly frequent use

of these panels for the off-site assembly of house blocks at the second workshop have required extensive planning by the design office and a more complete transformation of information to the production stations. A thorough reflection is required in order to establish in advance the layout of all the elements (*e.g.* cables, doors, electrical sockets, parquet, furniture, water pipes, etc.) that are going to be assembled off-site, so that the robots can panel the wooden elements accordingly. This way of proceeding has an impact on the timing of the work processes. It increases the design time, in favour of a reduction of the production time needed. Nevertheless, in overall, the time between conception and selling in prefabrication is reduced to several days, compared to on-site building, which can take up several weeks.

Vertical differentiation is increased as work is strongly divided between conception and execution. It also affects negatively the flexibility of these working processes and the related tasks, both in the design office and in production.

> *Once the blocks that make up the house are assembled, things cannot be changed anymore. Everything has to be modelled. Each cable has its own path.* (interview excerpt, design office manager)

> *When assembling the house at the workshop, I have to anticipate by knowing which parts of the wall we will dismantle for taking apart the modules that we will reassemble on site.* […] *If a furniture I build falls on a junction of two modules, I have to think about how I'm going to place it so that it can be dismantled. Before, on the building site, I did not think about all that.* (interview excerpt, joiner)

The tasks undertaken by robotic lines can be characterised in several ways, depending the production line on which the task is undertaken.

- Regarding the V1, the use of robots allows maximum standardisation of repetitive tasks such as nailing or panels assembly. Machines orders are established by the design office. They are sent to the production for optimisation (see next paragraph) and then executed by the machines.
- Regarding the V2, the standardisation of cutting is also sought, but applies to complex, technically demanding tasks. The use of lasers with referenced points in a 3D space aims to avoid cutting errors occurring during manual work by a carpenter. Changes between old and new tasks will be characterised through the impact on professions in part 3.2.

Finally, recent changes in the entire production process system have been established. During 2020, along with the repatriation of the entire production onto the Etalle site, the company decided to switch

to a just-in-time production system. Its aim is to manage production flows based on demand and not on supply. Previously, a stock of standard size wood sections was produced at Scidus and stored partly at Etalle, partly at Scidus. The design office drew its plans based on these standard size sections and wood was cut accordingly, sometimes requesting a large number of offcuts. As of today, the computer files sent by the design office to the production specify the required wood sizes and cuttings. These orders are optimised by the assistant production manager who then informs the sawmill with the corresponding timber production requests (up to the exact number of wood sections requested). The production orders for the speedcut, the assembly table and the V1 are also optimised so that the machining of the wood reduces the number of offcuts. Regarding the orders for the V2, all three companies of the group are involved. In addition to the drawings and machining files provided by the design office, IMAX Pro sends a robot control file (specific to each cutting order). The JIT is supported by the computerisation and digitalisation of processes, which facilitate coordination between the different departments in terms of information transmission, but also in terms of product traceability.

> *Each wood section we place has a digital twin in the machine file.* […] *I can inform the sawmill with the exact number of woods that will be needed for each project. Each wood is numbered in the digital machine file, and we also know where each number will fit in the assembly.* (interview excerpt, assistant production manager).

Coordination between services and between workers

Coordination between the design office and the production halls division is ensured by various means. A phone call is scheduled each week between the design office manager and the assistant production manager so that planning at the design office is adjusted to the actual state of production. Each single-family dwelling project starts with a videoconference between the managers and the drafter in charge in order to have an overview of the project. Calls between production and drafters also happen anytime technical problems emerge such as export of the machines files. During project, should the drafters and architects need expert knowledge on particular techniques (such as heating or electricity), internal meetings can be organised between drafters and workers specialised in those techniques from the production hall. However, most drafters and architects have acquired, throughout the years, a large part of the skills necessary for drawing plans taking into account those techniques (see “training” section in part 3.3).

Work schedule and coordination within workers in the production hall is largely organised by the optimised production orders sent each day to the robotic lines. Workers refer to the files on the machines

in order to operate. At the first workshop (V1), orders specify which and how many woods have to be cut, how to assist the robot with assembly and how to finish the panelling of the walls. At the second workshop (3D), orders are used to build and equip houses' blocks with the appropriate construction techniques. At the third workshop (V2), the operator hired (see “profession” section in part 3.3) refers to orders to place and manipulate the logs for appropriate cutting by the machine.

> *Workers implementing files just need to execute the orders. We provide them with the plans in 3D, they have a look and then can conclude “I have to put a pipe of such a diameter here"».* (interview excerpt, design office manager)

This standardisation of processes sought via computerised production orders is intertwined with direct supervision from the assistant production manager as well as from the foreman. At the beginning of the day, the assistant production manager announces the objectives to be achieved according to the orders received by the design office and optimised. For the 2D and 3D parts, the foreman then allocates workers on the basis of work poles (structural assembly, glassware, carpentry, electricity, etc.). Each work pole then rotates through the various construction projects in progress. The assistant production manager checks on the workshops a couple times a day (right after workers allocation and a couple hours later) to supervise each work group and to solve potential problems. The nature of such problems generally varies from workshop to workshop. At the first workshop, the main problems relate to difficulties in reading the construction plans or to breakdowns of the speedcut. Workers are then invited to refer to the 3D model available to get an overall vision of the project. Breakdowns are reported to the maintenance and development department. At the second workshop, requests generally concern the purchase of materials (glue, screws, etc.) which are passed on to the purchasing department. We cannot provide information on that matter for the third workshop since it was not yet operating at full scale at the time of our interviews.

3.2. Impacts on the labour force

Professions

Firstly, we analyse the impact of technological innovations with regard to the workers that are directly concerned by robotic lines in the enterprise. We can qualify the nature of the human-machine interaction as a substitution one, for both lines. However, this substitution applies to tasks of a very different nature depending on the robotic line. For the V1, the substitution takes place on manual tasks that are

difficult and repetitive. It applies on products that have been the core of the company's production since the beginning. Consequently, factory workers have seen an evolution of their function towards that of machine operator, which includes new tasks (see “coordination” section in part 3.1).

> *When they* [factory workers] *were offered the opportunity to move to robotic production lines as operators, some stayed on the* [assembly] *tables but many preferred to move on as machine operators.* […] *And I'm not sure I would find people who would agree to nail the same nails on the same prefabricated boxes all year round.* (interview excerpt, Mobic's founder)

For the V2, substitution also takes place on manual tasks. These tasks however require a high level of technical expertise, with high cognitive load and offer high added value. Beyond substitution, Mobic is initiating an industrialisation of these technical acts traditionally handled by carpenters, in line with the differentiated market positioning adopted by the founder.

> *The robot for logs* [V2] *enables us to proceed to highly complex technical cuts, to which the only competing profession would be that of a carpenter. But imagine how long it would take a carpenter to produce the volumes we can supply with the machine?* (interview excerpt, Scidus’ director).

As the enterprise has invested in this sector of activity through the implementation of the V2 of the robotic line, this function is new within the enterprise. One machine operator was hired for this position. Secondly, we analyse the impact of technological innovations with regard to the professions indirectly concerned by robotic production lines. As far as the workers at the 3D workshop (second workshop) are concerned, the tasks performed remain similar to the ones performed onsite but vary in terms of working conditions (see part 3.3) and in anticipation of the work processes as stated in part 3.1.

> *The work remains the same because we are still building houses, but the way of working is different because we are building houses that will be dismantled and shipped onsite to be rebuilt.* (interview excerpt, joiner)

As far as the drafters in the design office are concerned, they operate in a minority segment of their profession (3D prefabrication of timber frames). This implies proficiency in specific skills and the recruitment of corresponding profiles, for a profession whose scope of tasks is thus diversified and, according

to the head of the design office, appreciated by the workers. Due to digitalisation of the production processes and the greater vertical differentiation that follows, the number of drafters hired by Mobic tends to increase over the years.

Skills

The company defines three levels of use for robotic lines and, more generally, for production machines (such as the speedcut). Each of these levels corresponds to different requirements in terms of skills, as well as recruitment (see next section) and training (see dedicated section in part 3.2) practices. We also analyse these issues at the design office division.

As far as production is concerned, the first level is that of basic operator. This level of use of robots and machines corresponds to the day-to-day operations that have to be carried out in a functional working environment. The level of qualification required in terms of both technical and cognitive skills is low, and is "*actually excessively accessible, even to those who do not have a joiner's profile"* (interview excerpt, Mobic's founder). Focus is put on basic soft skills, *i.e.* motivation, seriousness, conscientiousness, etc. In that way, versatility in the day-to-day use of the various machines is increased in order to be able to make up for possible absences of workers. The second level is that of expert operator. It is expected from the expert operator to be able to detect problems as well as to analyse those reported by the basic operators. On the basis of this analysis, the expert operator determines if they are capable of direct repair in order to return to a normal production framework, or if the repair order should be passed on to maintenance. Such decision is taken according to the urgency of the situation (*e.g.* problem causes a production shutdown; production shutdown must be planned for fixing the situation; situation can be solved during off periods, etc.). It is therefore important to possess machine programming skills, as well as decision-making and planning skills. The third level corresponds to the maintenance vision. This level involves the R&D/maintenance departments of the three companies, depending on the machine and/or the type of problem encountered. Here, advanced technical skills in terms of programming, mechanics, engineering, etc. are expected.

As far as the design office is concerned, the design office manager considers that 3D prefabrication in the wood frame sector requires the mastery of additional specific skills for drafters. Drafters are required to understand as well as have a basic command of special techniques such as electricity, plumbing or heating. This can be explained by the fact that the production processes used in 3D prefabrication requires placement of these circuits beforehand, at the design stage (see "work processes and tasks" section in part 3.1). Therefore, the company favours architects profiles rather than designers to fulfil these

functions, as the architectural education includes a section dedicated to the understanding of these techniques. As underlined by the design office manager, "*a designer will only draw. You need people who understand the project as a whole"*. Those skills are then improved over the years with experience or *via* specialists' consultation in coordination meetings.

Recruitment

As expected skills and tasks differ depending on workers' profiles, so do the companies' recruitment practices. This is particularly noticeable in the recruitment channel favoured for basic operators, on the one hand, and for the other types of profiles aforementioned, on the other hand. For basic operators, the preferred recruitment channel is through subcontracting. Several former basic operators worked under a salaried contract in Harzé, when part of the production was still located there. The merging of all production activities to Etalle led to the termination of those workers' contracts. Explanations given by the interviewees relate to the geographical distance between Etalle and Harzé that made the daily commute a non-viable option. Currently, the majority of basic operators in production halls work through a subcontracting firm. However, exceptions exist: pre-existing internal contracts (*e.g.* transmission of salaried contracts with the takeover of the sawmill); very specific profiles of workers (such as the joiner we interviewed); commitments to internal employment contracts made with centre of expertise following the development of a training connected to a recruitment campaign. As regards the other types of profile mentioned, they operate as employees either with Scidus or Mobic companies.

Based on our interviews, we distinguish four reasons as to why the company resort to subcontracting for basic operators. Firstly, subcontracting facilitates the company's ability to manage variations in the number of simultaneous customer orders. Typically, the number of workers employed in production varies between 40 and 60 people. Numerical flexibility based on the volume of orders is therefore ensured. Secondly, management feels that subcontractors might show more motivation for getting work done as they are paid on a project basis (the more projects they finish, the more they get paid), in what can be called "*a carrot and stick"* strategy. Thirdly, digitalisation and the use of robotic production lines (V1 and V2) simplify the remaining tasks to be carried out by the workers. Skills associated with these tasks are hence easier to find and more available on the labour market. The company thus uses the market option rather than the salaried contract to acquire these skills. According to the opposite reasoning, the enterprise uses the salaried contract rather than the market option in order to maintain internally specific skills that are difficult to find on the labour market and that bring a high added value to the enterprise. The following excerpt about basic operators illustrates our analysis.

There is no problem in ensuring that sufficient expertise is available. The workers only have to follow the instructions. Machines provide the added value. (interview excerpt, Scidus' director)

Fourthly, subcontracting makes it possible to keep the number of salaried workers below the legal limits for setting up social dialogue organ. We can hypothesize that this organizational choice thus supports management's desire to maintain the current situation in terms of social dialogue (see point 4).

3.3. Impacts on working conditions

Training

The digital technologies implemented within the company levelled down the needs in technical qualifications for basic operator. Expert operators provide the necessary training elements (such as how to read a 3D plan, how to adequately position the trunk for the V2) directly on the field. These are relatively short, one-off training points and not full scheduled days of training. The main objective is the correct use of the machine at its full capacity. Training for expert operators is also given in-house. The initial mastery of machine by the first expert operator is acquired in collaboration with the designers of the robotic lines or external consultants. Subsequently, the expert operator is responsible for training other managers to reach this level, over periods identified and reserved for this purpose. By way of example, during the first week of January 2021, the founder of Mobic (expert operator on the V1) gave a training course to the assistant production manager on that matter.

Workload, work pace, autonomy and control

Digitalisation combined with the just-in-time production system results in a production organisation that seeks to maximise the operational capacity of the machines. The work pace and tasks are driven by standardisation of process through production orders by projects in order to achieve such maximisation. As previously exposed, the enterprise resorts to numerical flexibility via subcontracting in order to adapt the workforce to the amount of workload required. The "*carrot and stick"* strategy might question the workload intensification for workers, but we are unable to provide feedback from the field on that matter. Regarding autonomy, discretionary decision making as regards the speed of the machines cuts is possible by reporting speed adaptation demands to the assistant production manager. However, autonomy in the sense of the establishment of the own workers' rules in the organisational and production

processes is very low. The main form of control lies in the close digital monitoring of work *via* production orders. Workers refer to the files on the machines in order to operate; and their achievements are checked during the day by the foreman and the assistant production manager (see "work processes and tasks" section in part 3.1).

Health and safety

Offsite production makes it possible to lower many risks traditionally encountered on construction sites, whether for the workers themselves or for others. Physical conditions at work are improved. The production halls provide adequate lightening and temperature and are less subject to climatic conditions. Working infrastructures (such as scaffoldings) can be appropriately placed as the ground is perfectly flat, and working tools are available within close range. Workers have access to standard amenities, compared to the often basic ones on construction sites.

> *We don't have to take into account the wind, the cars… We just have to look out for our own safety and that of the people who work with us. We don't have to worry about trespassing, for example…* (interview excerpt, joiner)

According to Scidus' director, these health and safety elements constitute a key advantage for recruiting workers. The proximity of Luxembourg, offering higher wages with which Belgian companies can hardly compete, draws many worker to this country. Improved working conditions act as counterweight to this trend.
With regard to the interaction with the robots themselves, engineers at IMAX Pro have defined two security zones. The robot is notified of the presence of external objects by a series of sensors. If an external element enters its first working area, the robot adapts its working speed by slowing it down. Whenever that element trespasses the second zone, the robot stops, and then resumes work once the zone is secured. This security aspects enhance workers' safety, according to management of the company.

4. Industrial relations and social dialogue

4.1. Within the enterprise

There are currently no structured and formal social dialogues bodies within Scidus or Mobic. Both companies are under the thresholds requirements for establishing a trade union delegation, a health and

safety committee or a work council. Management has expressed during the interviews the desire of maintaining the current situation as long as possible. As underlined by one of our interviewees: "*the boat needs only one captain*". Hence, industrial relations in a broad way take place between direction and workers directly.

Regarding the implementation of the digital technologies, the second robotic production line (V2) has reunited various actors for its conception and implementation: the employers, the knowledge workers from IMAX Pro as well as several university academics in robotics, engineering and wooden structures fields. No other actors such as unions' representatives at regional or national level, civil associations, etc. were involved.

There are no agreements (whether binding or non-binding) regarding the technological innovations and their possible impacts on work organisation, labour force or working conditions. Social dialogue about these topics is then informal and happens through management line. Workers are informed of the implementation and operation of the lines when relevant (e.g. spontaneous talks, first visit of production hall upon hiring, etc.).

On the specific topic of health and safety, prevention of occupational risks in ensured notably by visible placards informing workers of the ways machine works and the appropriate actions to take within its radius, such as which mandatory equipment to wear. Documents given upon hiring also specify by which security rules workers have to comply and which training certification the workers must possess before manipulating some machineries (such as a forklift) or setting up scaffolding.

4.2. Implementation and effects of the technologies on social dialogue in general

We provide one hypothesis as to how new technologies influence industrial relations and social dialogue in general. As we exposed earlier, digitalisation simplifies the remaining tasks to be carried out by the workers. Skills associated with these tasks are hence easier to find and more available on the labour market. This in turns can justify the use of subcontractors rather than salaried contracts as there is no need to keep the related skills internally. Extending this reasoning, we postulate that digitalisation enables a deskilling of tasks, which, in turns, allows the company to resort to different subcontracting methods that it would not otherwise be able to use (without deskilling, the enterprise would face a skill shortage regarding the carpenters and joiners needed, which would therefore be difficult to hire at subcontracting conditions). By having recourse to subcontracting, structured social dialogue bodies are non-mandatory, as the legal thresholds for salaried employees are not met. In that way, the explosion of workers' statuses with digitalisation may pose a threat to social dialogue.

5. Drivers and barriers considering digitalisation

We identify several drivers and barriers considering digitalisation that can apply to the case studied and the sector. In term of drivers, firstly, the culture of innovations brought by the founders profoundly shaped the development of the companies towards digitalisation. As one of our interviewees stated, "*what is really surprising here is the determination and will of* [one of Mobic's founder] *to robotise the wood industry, when we don't necessarily think about robotising it*". Secondly, the strong focus put on internal R&D made it possible to adapt and tailor the digital innovations to the specific needs of the company. Thirdly, the implementation of the robotic production lines can be seen as an answer to the shortage existing for several years in the construction trades (see national report). Fourthly, the additional production costs of wood construction compared to construction in concrete. This situation is caused by the high value losses linked to processing of wood. This pushed the company to turn to the JIT production system as a support to digitalisation, and to establish constructions plans that maximise the use of the wood and limits losses.

> *The sawmill can produce three types of length in the woods: 2m70, 3m30 and 3m70. These are short structural timber. Beyond these lengths, we have to buy KVH* [type of wood available for sale] *of 13m in length. In the sawmill, short structural timber costs 150€ per m3. KVH costs 350 euros per m3. […] So we worked on the planning and the JIT to buy as little KVH as possible, and at the same time to not have to maintain an incredible volume of different woods.* (interview excerpt, assistant production manager)

The greatest barrier in terms of digital industrialisation of the wood construction sector relates to the complete absence of parametric design softwares that have to be uploaded to the robots to carry out the cutting operations. Company therefore collaborates with universities on long-term research projects for the creation of such softwares. For companies in general, and based on the case studied, we consider that a certain size and a related volume of production must be reached in order for the investment in such machines to be profitable. This is a major constraint since most timber operators are small enterprises (in line with the distribution of enterprises in terms of number of employees at national level). However, digitalisation can also be seen as a vector of growth for companies which supports companies' development. The robotic lines offered growth opportunities for the companies in terms of new markets and competitive advantage.

The image associated with robotising industry is often that of multiple layoffs. I think that this is a vector of growth. It is the tool that has enabled our factory to develop. We started with 4 people and now we are almost 150. (interview excerpt, Mobic's founder)

Finally, as the wood sector is strongly fragmented, the necessary collaboration along the required actors supply chain is complex. The vertical integration strategy adopted by Mobic/Scidus may be an inspiring answer to this sectoral particularity.

Conclusion

This case study addressed the impacts of the introduction of robotic production on the organisational and social dialogue aspects of the sister companies Mobic and Scidus.

Regarding direct impacts, changes in terms of tasks handled by the operators is probably the most notable, as they switched from factory operators to machines workers. The substitution relation that happened in both V1 and V2 of the robotic lines simultaneously led to improvement of working conditions in terms of health and safety while increasing a form of deskilling regarding the operators. Entry barriers for hiring workers are then lowered, as they can be trained easily for the jobs. On the contrary, skills of expert operators, maintenance and drafters have been reinforced. As vertical differentiation increased with the production orders being elaborated by the design office, standardisation of process became the norm in the enterprise. The introduction of the V2 also opened up gates to new markets for the company, that would not otherwise have been reachable.

Regarding indirect impacts, we can cite the vertical integration strategy that is pursued by the company and materialised at both ends of the supply chain. On the one hand, via the takeover of the sawmill and, on the other hand, via the focus put on off-site prefabrication. Moreover, we believe that the modification of the production processes towards a just-in-time production system has been facilitated by the digitalisation of the company, and acts as a support to the technological innovations.

Regarding industrial relation, this case study illustrate how digitalisation can be a threat to social dialogue. New technologies seem to favour a deskilling of the labour force, making it more available on the labour market and contributing to less added value. This allows the company to develop sub-contracting chains, thus keeping its employment volume below the thresholds of trade union representation. The

consequence is an apparent weak dynamic of social dialogue, even informal, even though these organisational transformations have a strong impact on working conditions. In this sense, digitalisation calls into question the relevance of the current regulatory framework on this matter.

Future researches on the topic should mainly seek to involve machine operators direct feedback in order to enrich data regarding, for example, wages, possible working hours intensification or relation with the machine. On a larger perspective, at society scale, we raise our concern in this conclusion regarding the impact of the V2 of the robotic line on highly qualified technical professions. Machines are reaching level of precisions and sophistication that now enable them to perform non-routine manual work. Undoubtedly, the deployment of these machines will have an impact on occupations such as carpenters. The question remains as to how and to what extent such jobs will evolve.

Case study B: Colas Group and the "Tram of Liège" Project

Introduction

This case study addresses the impact of BIM technologies on work organization, labor force and working conditions as well as on social dialogue and industrial relations. By focusing on the "tram of Liège project" – conducted by the French construction group Colas – we would like to show how the BIM technologies were used in the project and changed several work habits. Still rather in the conception phase, this gigantic project involves changes at all levels for the city of Liège: mobility, buildings, public spaces, roads, etc. The project also includes a significant number of stakeholders. This is currently one of the largest construction projects in the Liège region. Since BIM technology is used for several parts of the project, this was a particularly suitable case for our study.

BIM is often restrictively seen as a modelling tool, which functionalities are limited to designing through 3D models. The purpose of this study is to show that BIM's impacts on work are cross-cutting. One of our objectives is to show that BIM' effects are not limited to the Colas group but also concern its partners and clients, as it changes the interactions between stakeholders. Although BIM affects many aspects of work, we will show that the technology is poorly known and receives little attention from trade unions.

This case study is divided into six main sections. We first introduce the methodology deployed. In the second section, we describe Colas group and contextualize the tram of Liège project. The third section explores the heart of the subject by introducing the effects of BIM on work organization, on the workforce and on working conditions. The third section deals with social dialogue and industrial relation. The fifth section is a discussion about drivers and barriers considering digitalization processes. In the sixth section, we introduce insights regarding the COVID-19 pandemic issue based on our study. We finally summarize the contribution of this case study in a brief conclusion.

1. Methodology

Within Colas, we have met six key actors to understand how BIM was implemented and how it is managed and used in the Tram of Liège project. We first met someone from the BIM direction at the group level (from Colas Projects). This person was enlisted in the tram of Liège project, as it became one of the top

venture involving BIM at the group level. We then met the global infrastructure manager of the project. Not convinced by the BIM at first, he changed his mind after seeing all the benefits that the technology brought to the project. We then met two workers at a more operational level: a draftsman and an engineer, both specialized in 3D modelling. Their perspectives were very complementary: the draftsman was discovering BIM when the engineer was already familiar with the technology and convinced of its usefulness. Both of them have been appointed "BIM coordinator", which means that they are accountable for the operation of the platform and the training of other workers. The next person we met is a prevention adviser, with whom we discussed issues related to work organization and safety. The last person is an employee of a trade union who is in charge to follow all Colas activities in the area of Liège.

In order to conduct our interviews, we followed a pre-established interview guide, which contained numerous themes including questions about the respondents, their company, but also about their perceptions of BIM and the elements that promote or prevent the digitization of their work context. The interviews were conducted remotely (due to the corona virus crisis), during the months of May and June 2020 and all lasted approximately 1h30'. Interviews were conducted in French and all the extracts that we use in this document come from our translations.

Table 2 – Interviews conducted

INTERVIEW	POSITION	ROLE RELATED TO BIM	REMARKS
Interviewee 1	BIM direction – Colas projects (Paris)	BIM expert: he is the driving force behind the BIM on the project	Important experience in 3D modelling, particularly on colossal projects
Interviewee 2	Head of infrastructure works – Colas Belgium (Tram project)	BIM supervisor	Skeptical about BIM at the beginning, he is now very keen on it
Interviewee 3	Draftsman and 3D modeler – Colas Belgium (Tram project)	BIM coordinator	Currently learning 3D modelling via Revit.
Interviewee 4	BIM engineer – Colas Belgium (Tram project)	BIM coordinator	In training to become the main BIM coordinator of the project.
Interviewee 5	Prevention adviser (Tram project)	None	/
Interviewee 6	Trade union permanent (in charge of monitoring the colas group)	None	Did not know exactly what BIM was before the interview

In addition to these six interviews, we collected several documents, which allow us to contextualize the project but also to understand more deeply the challenges of the BIM and its implications on work or-

ganization. We have also assisted to several demonstrations of the BIM software in action. After gathering these data, we distributed quotes in tables according to different themes that structure the following sections of the document: impacts on work organization, on the labor force, on working conditions and on industrial relation and social dialogue. We then collected verbatim related to the factors that facilitate or hinder the adoption of the BIM technology within an organization. This section also serve as a discussion one in which we compare our observations with the scientific literature, which is still rather scarce on the subject of BIM in view of its novelty.

2. Main characteristics of the case Study

2.1. The company: Colas Group and Colas Belgium

Colas Group2 is part of the French giant multinational Bouygues Group and is one of the world leaders in the construction, servicing and maintenance of transport infrastructures. Colas Group is active on the five continents, in over 50 countries. With a network of 800 works operating units and 3,000 units for the production and recycling of construction materials, the group employs no less than 57,000 people and carries out around 75,000 building sites per year. The group has three main activities split into as many entities:

- Roads (72% of total activity): construction, upkeep and maintenance of all kinds of roads. This branch also includes civil engineering and building activities (new constructions, rehabilitations).
- Materials (18% of total activity): industrial activity of production, distribution, sale and recycling of construction materials. Colas has a dense international network of quarries and gravel pits, emulsion and binder plants, asphalt plants, concrete plants, materials recycling facilities and more.
- Rail (8% of total activity): design and engineering of major projects, construction, renewal and maintenance of rail networks (high-speed HSR lines, conventional lines, tramways, metros), including installation and maintenance, electrification, signaling and safety systems.

In addition to these three main entities, Colas is also involved in water and energy transportation (this fourth entity represent approximately 1% of their activity). For the purpose of this case study, it is also important to mention another (transversal) Colas entity: **Colas Projects**. This fifth entity focuses on colossal projects and aims at ensuring coordination between the different entities and between all partners involved in the project. The purpose of Colas Projects is to carry out the multiple phases of the

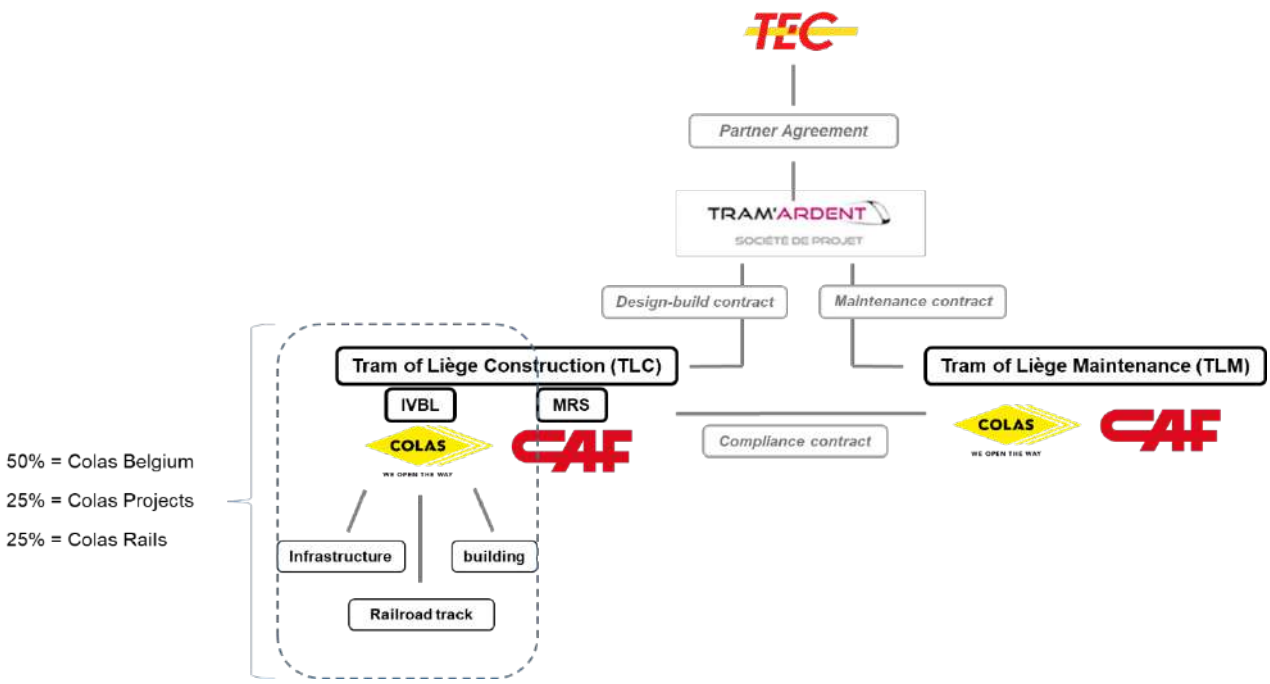
[2] For further information, see https://www.colas.com/en

project, from the elaboration of the offer to the execution of the contract. Colas Projects is a centralized entity (in Paris) that operates at the group level.

Countries where Colas operates also have their own national organization and direction. Colas Projects works alongside the group' subsidiaries (national directorates) in the design and implementation of gigantic projects. Colas Belgium is an example of national subsidiary. Colas has been active in Belgium for more than 25 years (through a gradual takeover of several Belgian companies). At the national level, the organization is similar to the group organization: there are several entities grouping together the company's main activities. Because the tram project is so significant, it is a separate entity within Colas Belgium. It has its own executive board, finance department, procurement department, etc"*It's a fully-fledged business unit"* (head of infrastructure works, tram of Liège project).

These precisions were essential to understand the structure of the tram of Liège project on which we have focused our case study. The project is a public-private partnership (PPP), which is rather unusual for Colas. As a client, the Transport Operator of Wallonia (OTW – "*Opérateur de Transport de Wallonie"*)[3] has asked a consortium to design the tram of Liège, in addition to carrying the project out. The following figure shows the relationships between the main actors involved in the project[4].

Figure 1 – Structure and main actors of the "tram of Liège" project



[3] The trade name generally used is "TEC" (standing for "*Transport en commun"*, which means public transportation).

[4] For the sake of simplicity, the financial partners of the project do not appear in the representation (figure 1).

As shown in the figure 1, a project company (named "*Tram'ardent*") handles the project for "TEC" and delegates the construction and the maintenance of the tram to a consortium of companies. Two main companies carry out the construction part of the project: Colas and CAF (a Spanish company specialized in rail tracks and trams). Colas is responsible for the design (infrastructure), the construction process, and the laying of the railroad tracks. The percentages on the left show the importance of the various Colas entities involved in the construction part of the project[5]. As we have mentioned, it is such an important project for Colas that it is a fully-fledged entity within Colas Belgium. At the time of our interviews (June 2020), the project was mainly in its conception phase, which means that the infrastructure entity is particularly active.

This case study focus on this infrastructure department, as it is where BIM technologies are particularly used. Initially, the use of BIM technologies was not foreseen in the offer phase. Nevertheless, during the design phase of the project, it quickly became clear that some points were too complex to be realized with traditional 2D plans. That is when BIM technologies came into play, through a BIM engineer from Colas projects, who was seconded on the project. The technology rapidly achieved a great success and entered the project in a more formal way, with increasing importance. In the next section, we will focus on BIM technology, what it changed during project execution and how it affected the tram of Liège project.

2.2. Digitalization and innovations

Colas presents itself as a very innovative group, that pays particular attention to its innovative strength to adapt to customer needs, new uses and the challenges of the energy transition and digital transformation. At the group level, using BIM technologies is part of the strategy. They created a small entity (four persons) labeled "BIM by CO" based in Paris. The aim of this entity is to promote BIM within Colas's huge projects and to support local projects that want to implement BIM technologies. Knowing that Colas is particularly active on issues related to BIM, let us describe what BIM is and how Colas use this technology within the tram of Liège project. The B.I.M. initials stands for three different but complementary definitions. The following box lists these three definitions.

[5] IVBL meaning "*Infrastructure, voies ferrées, bâtiments et lignes électriques*", which can be translated as "Infrastructure, railways, buildings and power lines". As we have mentioned, the scope of the project is very broad: it includes roads, public spaces, electricity and telecom networks, gas, water, public lighting, street furniture, green spaces, etc. MRS stand for "*matériel roulant et système*", which mean "rolling material and system".

*Building information **model***: It is the digital model, the virtual representation of the work. Often, there are several layers containing information about the objects that make up the work.

*Building information **modelling***: The realization of the digital model, where information and geometry connect. In small building sites, the architect sends the models to the companies who only visualize the model. In larger projects, the stability and special engineering offices involved also produce models. They are then compiled by the general contractor to generate a unique and up-to-date, useful coordinated model

*Building information **management***: Management and exchange of information and digital models throughout the project life cycles, through a digital platform.

Most experts stop at the first two definitions and forget that it is primarily a method of coordination and not just a fingerprint model. In a nutshell, BIM is a working method based on a collaborative platform where the latest information is available to several stakeholders. The platform may or may not include 3D models. Modelling in 3D helps to reduce upstream conflicts and to have a better vision on the various structures to be integrated. **BIM does two things: it helps coordinate (through a platform) and design (through 3D modelling).**

In the "tram of Liège" project, the BIM collaborative platform used by Colas is "BIM 360"[6]. BIM 360 is a platform allowing the publication of all kinds of documents: word files, pdf files, 2D plans, 3D plans, etc. Documents cannot be edited on the platform, but collaborators can open them, comment on them or point out defects. BIM 360 is a monitoring platform, which centralizes most of the exchanges regarding the production of documents. This means that all those involved in the design process (Colas staff but also subcontractors and partners) upload their production to the platform. The aim is to centralize the plans in order to ensure that they evolve more effectively. Several crucial points of the Tram route were created in 3D modelling via Revit[7]. The 3D models produced on Revit are also posted on the BIM 360 platform. The two main uses of BIM (design and coordination) can be found in the tram of Liège Project.

Besides BIM 360, there is a formal project platform, which is used to validate plans with the client (called GED, "*gestion électronique des documents*" meaning "electronic document management"). This platform is used to submit finalized plans, so that they can be validated by the client. It is not collaborative and does not allow for coordination as BIM 360 does. The "GED" is the official platform of the project,

[6] "BIM 360" is a program from the company Autodesk, which makes software mainly for designing, drafting and drawing in various sectors. BIM 360 is a unified platform connecting project teams and data in real-time, from design through construction and supporting informed decision-makings.

[7] Revit is a construction design software that allows creation of a 3D model in order to generate various documents necessary for infrastructure works (plan, perspective, etc.). It is a multi-trade BIM software for construction professionals (engineers, architects, draftsmans, contractors, etc.).

the communication interface between the contractors and the client. Once the plans from the project phase have been validated, they can move on to the execution phase.

There are generally two main phases at a construction site: the study phase and the achievement phase. The study phase itself is divided into two sub stages: the project phase (intention, representation with a certain level of detail that enables ideas to be fixed) and the execution phase (the detail is pushed to the limit to make the plan executable). It is only once the client has validated those two steps that the actual site work can begin.

3. Impacts of BIM

3.1. On work organization

"The heart of BIM is not modelling; it's the coordination between the different stakeholders" (BIM engineer and BIM coordinator on the tram of Liège project). Within colossal construction project, coordination is often a key element to project success. As the Tram of Liège project involves a large amount of stakeholders, the need for coordination methods rapidly became a quick discussion points during project elaboration.

To carry out the study phase, Colas is working in partnership with a major French design office, in addition to numerous subcontractors in Belgium. This means that there are multiple stakeholders involved in production of the plans. Confronted with numerous problems of loss and interminable e-mail exchanges, Colas thought of a solution to improve coordination. The idea of using BIM 360 software to coordinate gradually emerged as the optimal solution. BIM affected works organization on many crucial points.

BIM 360's impact on work organization

BIM does not fundamentally change the phases of a project, but it helps to articulate them "*It allows procedures to be put in place, especially where there are not any*" (BIM expert, Colas Projects). BIM helps to comply with rules, such as quality standards. It increases the general quality of the project by facilitating exchanges between the different partners. The BIM execution plan (BEP) defines the whole BIM structure of the site (role of each person, process to be set up etc.). The primary goal in the tram of Liège project was to identify those workers who were willing to integrate the BIM team that was being set up. The result was the assembly of a small structure, very "informal" at first, which was presented to the project management. The project

management validated the structure right away, "*because they noticed that 'the beautiful 3D models' were able to solve many outstanding points"* (BIM expert, Colas Projects). They endorsed the structure and imposed it on all parts of the project. The initially underlying BIM structure became official. This team was in charge of the implementation of the BIM 360 platform. Their role was to ensure that all the staff involve in the study phase deliver their production on the platform. This included the set-up of many procedures and short trainings regarding the basic uses of the platform.

BIM has had a major impact on all the study phase and more specifically on the production of plans. BIM 360 is an enhanced viewer that allows the submission and monitoring of plans (in every conceivable format). There is no drawing functionality on the platform but all those with access can see the plans. Depending on the authorizations, certain employees may also add comments: these are chips marking problematic spots. Each person involved in drawing up the plans (Colas' designers but also subcontractors and external design offices) is required to upload them to the platform. Then, project manager responsible for the verification go through the plans and give their comments. There are also moments of exchange between project managers and draftsman to discuss the most complex remarks. This process makes it possible to limit the many time-consuming exchanges during the drawing up of the plans. This process requires rigor (mainly concerning the chronology and planning of working sessions) yet the results are conclusive as stated by the head of infrastructure works: "*with this method, we have managed to come up with plans that have been accepted by the clients, which was not the case a few months ago"*. The platform has become a critical milestone in the design phase.

The management praises this new working method: "*There are no more unprocessed mails and data: all remarks are centralized. All you have to do is to see each other from time to time and make sure that the chips [remarks] are closed. This solved many problems. Follow-up is much more effective, when the people in charge of verification close the chips, we know it's good"* (Head of infrastructure works, tram of Liège project). This platform-based working method has standardized the coordination process, which previously took place through mutual adjustment. A draftsman gives the same echo: *"It makes a big difference. You do not have to work with the people next to you anymore. It is very positive for the continuity of projects. You can have people who are good at what they do working in continuity, with better coordination*". With BIM, the audit loop has become clearer for both internal and external stakeholders, and the efficiency of plan production has increased.

Eventually, the philosophy of BIM is to get everyone using the technology, "*ultimately, everyone should be involved in BIM*" (BIM expert, Colas Projects). From a handful of people at the beginning, today several hundred people use BIM 360 to coordinate around the tram of Liège project. For the moment, BIM

is only use in the study phase and almost exclusively in the project phase. This point is in line with the observations of Aghimien *et al.* (2018) who argue that the digitization of the construction sector is for the moment mainly limited to the study and design phases, with little impact on the realization phase. While the platform is efficient, it also requires significant resources in terms of planning. As the head of infrastructure works stated:

> *"For the moment, I am making up for the shortcomings in terms of planning. Keeping up with the BIM submission schedule requires a lot of organization. Not all the plans are managed by the design office; there is also a team of 6 draftsmen at Colas. These draftsmans also have to fit into the BIM structure like the external design office. There are also objectives and deadlines for these draftsmans. The project managers control their production in the same way as the plans produced by the sub-contractor-external office. It takes a lot of time to give work and imperatives to these draftsmans, especially as it is in perpetual constant motion. Backlog accumulates and priorities change all the time. People are annoyed because they of change subject abruptly. We need a coordinator, a study production manager, who will use the BIM to coordinate all the teams. This coordination takes a lot of time, especially in a context where priorities change constantly".*

In the case of the Tram of Liège, the BIM team (initially informal, as evoked earlier) gradually became a useful support for the project team. From purely technical at first, their role evolved to more managerial activities. This is in line with some observations made in the scientific literature: the responsibilities of BIM specialists, which were only technical in the past, are evolving towards more managerial responsibilities (Boton & Forgues, 2019). The head of infrastructure did the opposite, moving from a classic managerial role to a role of coordinator of the platform's activities. By setting up a platform as a central gateway for all exchanges, BIM technologies have a strong impact on the coordination of work.

3D modelling and work organization

The 3D modelling aspect of the BIM also affects work organization "*The 3D view allows everyone to understand reality faster. Many problems can be anticipated: this generates significant time savings"* (BIM expert, Colas Projects). Some sections of the tram are so complicated that it is impossible to represent them in 2D. 3D modelling makes it possible to unlock particularly complex technical problems by conceiving the division of work differently. Each special technique obtains the necessary information thanks to the division of the model into several layers. This allows the work sequence and the needed

resources to be better predicted. BIM has not only made work organization more fluid, it has also improved its efficiency.

3.2. On the labor force

Coordination with BIM

Regarding existing workforce, "*engineers and project managers are particularly impacted by BIM… And by extension, all design professions are concerned*" (BIM expert, Colas Projects). As BIM is a working method more than a designing software, it is transversal and it does not concern just one specific job. Almost all the professions involved in the study phase are affected by BIM "*Coordination with BIM does not require special skills, but rather soft skills: drawing up a schedule per week, per day, etc. The reality is that people find it difficult to function methodically, chip by chip. Very often, you get the updated plan and all the chips are still there. Project managers who are responsible for the chips usually have to go and double-check. But they are already satisfied that they can send proper plans*" (Head of infrastructure works, tram of Liège project). BIM mainly has an impact on transversal soft skills concerning design professions. Professions such as drafter must be rigorous and punctual while project manager, accountable for remarks, must be extremely clear and synthetic. Even though the use of the platform asks for very few technical skills, getting to grips with BIM 360 requires some practice and usually a mini-training course (in addition to setting up and assimilation of many procedures).

The training aspects had to be taken into account by the BIM team. The BIM expert from Colas Projects and the rest of the BIM team provide most of the staff involve in the design phase with very short 20-minute familiarization trainings to BIM 360. The BIM team assembled for the Tram of Liège project is also responsible for the training of the subcontractors working on the platform "*I can give the laying of the rails as an example. I accompany and train the teams so that they adopt the project in its BIM version*" (BIM expert, Colas Projects). The BIM team keeps on repeating the same instructions. Even though procedures are available on the platform, in the form of user manuals, some workers need the same explanations repeatedly.

Modelling with BIM

The modelling part of the BIM is obviously more complex and require numerous skills. A solid background as a 2D draftsman is necessary. The draftsman then needs to learn how to use special software for 3D modelling. There is a wide range of software for 3D modelling. At Colas, the most widely used is

Revit. The draftsman we met, who has a traditional 2D background, and who was assigned "BIM coordinator", is currently undergoing training on Revit. It is a four-day full course divided into eight half-days. As Colas did not have all the necessary skills internally when the BIM team became "official" under the impetus of the BIM expert from Colas projects, they recruited a BIM engineer who came in to bring her expertise.

> *"The BIM expert, in his BEP, has designated BIM coordinators by specialty. He has designated several of them. There is someone for modelling. There is also a topographer. In draftsmanship, there is someone too. We saw that it was a somewhat unofficial process. We have detected in some people the skills needed. Except [name of the person] who came from outside Colas, others were designed internally. Some workers did not like to be involved in the process: we had to replace them. Some showed interest and thought that this was the future of Colas, so they 'joined the cause'. But we also had to leave some of them on the side of the road, without it being detrimental to them*" (Head of infrastructure works, tram of Liège project).

It is interesting to note that Colas turned almost exclusively to the in-house staff to set up the BIM team. It is also important to mention that the designation as "BIM coordinator" was not accompanied by a financial re-evaluation of the project. We will come back to this remark in the section on working conditions.

With regard to the skills needed to work with the BIM, the BIM expert from Colas projects gives us an interesting clarification. According to him, "*Many people have BIM certifications but no experience [in construction projects]. Experience is crucial. Knowing about the software is one thing, but professional experience is much more important to do BIM effectively"*. He highlighted the difficulty to recruit workers who have both digital skills and a significant level of experience in the construction industry. He stated that "*In Liege, there are two BIM coordinators but they are not yet able to do modelling. The professions must always come before the software. Learning to model is not the most complicated. People are currently being trained for this. We need people who understand the heart of the builder's job"*. The core competencies for BIM managers remain skills that are highly relevant to the construction sector.

An interesting point raised in the literature is the risk of skills telescoping between BIM managers and project managers (Boton & Forgues, 2019). We have not really observed this in the case of Colas, where the BIM team is rather supportive of the management team. The BIM team mainly ensures the implementation of the BIM 360 software. They are the key persons who ensure that coordination via the

platform runs smoothly. However, we note that the head of infrastructure works plays the role of BIM manager, in particular by managing the planning and workload allocation. This supports the hypothesis of Boton and Forgues (2019) that project managers gradually become the BIM managers within organizations.

From a quantitative standpoint, BIM has little effect on the workforce. With a single recruitment in the tram of Liège project, the impact is marginal. Workers who were assigned tasks related to the BIM and turned out to not be adequate simply got discharged of these tasks, which were re-assigned to other persons. Hence, the real impact is rather qualitative and mainly related to skills issue. Although BIM has a relatively small impact on the core activities of most jobs, it requires taming a new platform, which is not simple for all workers. We will come back to this in the section dedicated to drivers and barriers considering digitalization. For the professions directly concerned by modelling, the effects are more substantial. They need to acquire new skills and understand what is expected of them as active members of the BIM team.

3.3. On working conditions

Improving coordination between workers and different stakeholders has had a direct impact on working conditions"*Everyone was helped. All feedback is positive once people understand how it works*" (BIM expert, Colas projects). If the BIM expert is enthusiastic and convinced that this technology brings efficiency, he also knows that its functioning is based on the implementation of rules and rigor. The draftsman we met stated: "*Plans must be uploaded. There are codes to respect… There are also two different platforms [BIM and GED]… The administrative path of the plans is sometimes a bit complex"*. The BIM platform sets new standards for the publication of plans[8], which has influenced the daily work life of many workers. Some tasks related to the new procedures have been added to workers' activities.

On the positive aspects, it appeared that working through the platform provide the workers with more autonomy and comfort. This has had a direct impact on work-life balance. The centralization of plans on the platform limited physical exchanges and allowed for more remote work. Thus, teleworking, which used to be little present in the organization, was generalized. Of course, this was also reinforced by the health crisis (see the box on page 17 related to COVID-19 health crisis). The platform has changed the daily lives of workers who no longer have to work alongside their colleagues and bosses. Some interviewees consider that they gained comfort by being spared work trips and other distractions in the

[8] These new standards relate to the pace of publishing productions, documents' formats and the scheduling of weekly meetings to discuss plans.

workplace. For certain tasks that require a high level of concentration, it is particularly pleasant, said the draftsman we met.

This comfort and freedom also have flipsides. As it was pointed out during our interviews, this autonomy must be framed, otherwise it is the door open to a lot of overtime"*There is still a risk of no longer having a work hour. This should make life easier for many people, we must be able to do more in less time, it must not become the other way round"* (Draftsman, BIM coordinator). The risk linked to overwork was indeed pointed out several times during our interviews.

When we asked the draftsman if he felt controlled by the platform, he replied that, on the contrary, he found the system more transparent than traditional direct supervision. According to him, the platform makes things objective since "*the comments are visible to several people and it is clearer what changes need to be made"* (Draftsman, BIM coordinator). Even if the procedures bring stress and deadlines, they seem to be defused by the transparency provided by the platform. The platform plays a role in objectifying the work.

4. Industrial relations and social dialogue

As we have discussed with several actors about industrial relations on the project, it appeared that digitalization is not really part of the debates, or at least not directly. There are several reasons for this. As explained above, in the Tram of Liège project, the introduction of BIM has had effects on specific issues regarding the workforce. During our exchanges with trade union delegates, and even with the trade union permanent staff, it was necessary to give a definition of BIM beforehand. Their knowledge of this technology was generally rather vague or even non-existent. The trade union permanent that we met stressed this point*: "currently, I see no bad effects of BIM on working condition, neither on employment. But we'll keep our eyes open for what's next"*. Another reason is that the use of BIM is currently limited to managerial and rather technical functions. BIM has currently little impact on actual construction sites. According to the head of infrastructure works, trade union demands mainly focus on working time, breaks, and pay. If BIM is not yet really a subject to be addressed in social dialogue, "*it is because it is still very theoretical at this stage"* (BIM expert, Colas Projects). At this stage, BIM also has a greater impact on work organization than on working conditions, making it a source of little concern to trade unions compared to issues that are more "traditional", according to our interviewee.

According to our interviews with a trade union permanent, negotiations on the tram of Liège project

focuses mainly on two issues: safety and working time schemes. As a lot of work is carried out in the city center, deadlines must be kept extremely short (to avoid traffic problems), which raises questions in terms of the occupation of workers. In the opinion of the trade union official, the BIM can play a positive role in this problem, since it makes it possible to better prepare the work and thus improve the conditions under which it will be carried out"*The fact that workers can visualize what they need to do is also a good thing"*, he adds.

Nevertheless, a potential risk to employment was raised during our interviews. This is the issue of the internationalization of the workforce. Since the work is centralized through the platform and can easily be carried out remotely, the temptation exists to use foreign cheaper workforce in order to execute certain tasks. This issue was not specifically mentioned in the context of the tram project but rather as a potential problem, which might arise in the future. Trade union officials also raised this risk during our background interviews[9]. The draftsman we met sums up this fear well: "*In some cases, BIM is very convenient because you can have people who are performing well in their field working in continuity, without worrying about geographical borders. But there is a flip side to the coin: to go and look for foreign people who work much cheaper"*. However, it seems that qualified jobs such as engineers and draftsmans have been preserved so far. The phenomenon of internationalization of the workforce in construction is still mostly "limited" to social dumping. For the time being, it is still quite rare to use the technical skills of some emerging countries in the construction industry.

5. Drivers and barriers considering digitalization

Implementing a new technology system such as BIM has a cost and requires the investment of various resources. These resources are of several kinds: financial, human and temporal. In the literature, two most mentioned barriers to BIM implementation are the learning aspect (and lack of skilled staff) and the cost or lack of company investment (Kihong & Motjaba, 2011). The head of infrastructure works points out that the implementation of BIM is time-consuming: "*The flip side of the coin is that coordination is very time-consuming: it's a very good experience so far, but we cannot deny it. It is heavy in terms of functioning. We need more staff. To have the quality of Colas' self-checking and the reliability of the plans via the BIM tool, it requires more staff and rigor in the processes".* The setting of procedures and

[9] Before carrying out this case study, we conducted two interviews with trade union officials in order to understand the issues of digitalization in the construction sector from the point of view of unions.

their respect are time-consuming. Training staff, while basic for the most part, also takes time. Implementing BIM requires the creation of numerous procedures. Those need to be written, updated, explained and then understood by workers. It must then be enforced in order to verified that people apply them. All this requires a lot of energy.

BIM also obviously has a financial cost. Moreover, it is a big hindrance when it comes to convincing management of the usefulness of BIM: "*we know how much it costs but not always how much it pays off*" (Head of infrastructure works, tram of Liège project). The savings achieved with the platform are hardly quantifiable. On the project, the direction closely follows the cost of the BIM team's services in order to evaluate the expenses at the end of the project. According to our sources, the current cost of the BIM on the project is around 700,000 euros, and it continues to increase. When asked if there are refractors among the management, the head of infrastructure works denies but remains moderate*: "there is no real opponents yet, we'll see in a year's time, when we'll be at 2 million spent on the BIM… But for the moment, it's solving problems for us so everyone is happy"*. Costs include dedicated staff but also all licenses (for the BIM 360 and Revit software, among others), which can be extremely expensive. Moreover, identifying the necessary resources and building management teams capable of managing these changes is complex, which sometimes leads to financial losses (Parusheva, 2019).

The BIM platform also requires a personal investment on behalf of each of the workers who will be using it. The benefits of the latter are not obvious to everyone. Like any process of change, the implementation of BIM has its opponents among workers. The newly defined tasks such as the obligation to upload production on the platform present a knowledge deficit among the actors because they had to realign themselves to the new working configuration (Sackey *et al.*, 2015). This leads to a potential redistribution of power, due to the mastery of certain skills, which can cause resistance to change. Some former draftsmen, for example, weren't very keen to the use of a platform, preferring working on paper supported plans. To defuse this reticence, Colas has set up the so-called "BIM breakfasts". These are small 30-minute meetings where issues related to the use of BIM are discussed. Many workers complain about the cumbersome procedures. These meetings serve to convince them that the return on investment (of time) will benefit everyone, including them. Demonstrations are regularly used to do this: showing people how it works appears to be more effective than long theoretical presentations.

The BIM expert from Colas Projects insists on the importance of entrusting the implementation of BIM to people who have strong skills and experience regarding the construction industry. According to him, it is better to entrust this implementation to construction experts rather than BIM experts: "*People with skills in BIM do a lot of damage because change is often poorly managed. You have to convince first,*

before you start the change. You have to be very patient and explain a lot. You have to rely on people with good professional skills, digital skills come in second place" (BIM expert, Colas Projects). Once again, it seems that professional skills are more important than digital skills.

According to Dong *et al.*, "BIM skills will become a basic competency for construction employees in the foreseeable future" (2015: 118). If digital skills will become basic skills in the future of construction, this is not yet the case according to our interviews. We have been told on several occasions that it is very difficult to recruit staff with a high level in both types of skills (professional, related to construction, and digital).

In such a project with many stakeholders, it is also necessary to gather the support of all stakeholders, including subcontractors. If one partner decides not to play the game of the BIM platform, the whole system will be swamped. Lack of investment (and skills) from external stakeholders automatically results in the failure of collaborative working processes, which underlines the need for multidisciplinary efforts to address this problem (Kihong & Motjaba, 2011). Even if relations with subcontractors and in particular with the design office are not a long quiet river, the usefulness and efficiency of the BIM platform was unanimously recognized in the tram of Liège project. Given the deadlocks encountered, BIM has made it possible to find new technical solutions for these particularly complicated points. Every stakeholder was gradually convinced.

During the interviews, it also emerged that the size of the project is a crucial element for the decision whether to implement BIM or not"*Large projects are more suitable for BIM. And financially, it's difficult for a small company to afford it"* (BIM expert, Colas Projects). At Colas, it remains to be determined what is the critical size at which 3D modelling is made and a BIM platform is implemented. According to the head of infrastructure works, this big internal issue for future projects is not decided yet.

While construction companies are aware of the transformative power of certain technologies such as BIM, they do not always know how to implement it within their organization (Parusheva, 2019). Using BIM is also a strategic issue for a company. BIM has been a very fashionable subject in the construction sector for a few years now and "doing a job in BIM" became a marketing edge for a company. Colas is a group that opted very early on for a digital strategy and attaches great importance to being a pioneer in this field. This desire to be a leader in the field has prompted Colas to invest in BIM and play an accelerating role in its implementation on the ground. Colas aims at developing BIM's uses even further, notably by using the 3D model for maintenance by connecting all the technical data sheets to it. The maintainer would thus have the model of the building with all the information he needs.

Opinions on whether BIM uses should advance further are currently divergent. The BIM expert from

Colas projects believes that site managers will also be impacted and that they will use up-to-date plans on mobile devices, on site, and will be able to rectify errors afterwards. The head of infrastructure works is more temperate, he is not convinced that the BIM will make it to execution phases. Nevertheless, he also admits to having underestimated the BIM and more particularly its effectiveness in terms of coordination. The objective of Colas is to wider the scope of the BIM in the project: connections with purchasing, logistics and storage departments are being studied.

If the enthusiasm towards BIM is unquestionable, the head of infrastructure works invites us to be cautious. According to him, certain aspects are not yet really settled with this technology, such as confidentiality, for example:

"Today the project managers have taken up BIM. They are positive about the technology. There is more than one on his smartphone and tablet doing his chips. Maybe it will get down to the guy in the field. However, it will raise other issues: especially that of confidentiality. BIM is open; it is not locked like GED. The site manager will still have to go to the GED to fetch the execution document. We still need the execution documents with the stamp. If even there is a mistake, contractually, we are in agreement".

We can see that even if BIM is gaining in importance in the construction industry, there are still areas of shadow regarding its final scope and limits.

6. Covid impact – the role of digitalization

Through all six interviews, we have noticed that the Covid-19 crisis has favored the adoption of BIM and contributed to changing mentalities. As workers had to stay home, the BIM 360 platform appeared to be the perfect tool for remote coordination. In a context where BIM was already becoming more and more important in the project, the sanitary crisis has further increased its implementation. According to the drafstman we met, the lockdown "*has opened the eyes of many people"*. However, he continues by tempering*: "we still sometimes lack a good exchange based on a sketch on a sheet of paper"*. There is evidence that the Covid crisis has played an important role in the adoption of BIM technologies within the project.

Just before the health crisis, BIM was gaining importance on the project: *"Demand on BIM for this project has increased. From 3 specific locations in the project, they went up to 7 specific locations in BIM"* (BIM expert, Colas Projects). When the first lockdown arrived, the construction site was closed. The design

department, on the other hand, continued to work, especially on particularly complex points of the project. At this point, the BIM platform proved to be indispensable for remote coordination, while the 3D modelling aspect was also gaining momentum. Overall, "*the Covid has given BIM a big boost*" (BIM engineer and BIM coordinator on the project).

Our interviews show that the health crisis has really played an accelerating role in changing mentalities. According to the BIM expert from Colas Projects, there are going to be big changes in the way of building in the very near future. The Covid crisis has brought this deadline closer.

Conclusion

During our investigation of the Tram de Liège construction project, we revealed a process that involved the implementation of the BIM technologies. We first showed how BIM has informally intruded the project and positioned itself as a tool of choice for two problems encountered in the project: the coordination between a multitude of stakeholders and the 3D modelling of particularly complex parts of the project. Coordination and modelling being the two central elements of the BIM, the Tram de Liège project was a particularly interesting case for this study.

By meeting key actors of the project at different levels (management, BIM specialists, but also operational employees such as draftsmans), we showed the impacts of BIM on work coordination, on working conditions, and more globally on the labor force. Among the main results, we have shown that the impacts of BIM are concentrated on the design professions but concern a significant number of them. The impacts are qualitative rather than quantitative, the most affected item being the coordination at work, completely modified by the use of the BIM 360 platform. We have also seen that BIM brings rigor and discipline by introducing numerous procedures into the work processes. Finally, with regard to working conditions, we have seen that BIM allowed for more remoted work, which provides workers with more comfort regarding their work life balance.

We then looked at social dialogue, where we found that BIM is not really at the center of the debates. Nevertheless, the risk of internationalization of the workforce, which has been mentioned several times, is worth emphasizing. Although the issues of training, financial recognition and acquired skills do not yet seem to be at the centre of the social dialogue on the subject of BIM, we can nevertheless speculate that this will happen in the coming years. Then, by discussing more global considerations on the factors enabling (or not enabling) digitalization, we introduced some elements from the scientific literature on

the subject. We thus addressed elements such as the place of digital skills, the importance of the project's size or the particular attention to be paid to resistance to change. We finally proposed a small sidebar on the accelerator role played by the Covid-19 health crisis in the implementation of BIM on the project.

Bibliography

Aghimien, D., Aigbavboa, C., Oke, A., & Koloko, N. (2018). Digitalisation in construction industry: Construction professional's perspective, *Streamlining Information Transfer between Construction and Structural Engineering*.

Boton, C., & Forgues, D. (2019). Comprendre l'impact du numérique sur la gestion de projet en construction. *Lien social et Politiques*, *81*, 41-60. https://doi.org/10.7202/1056303ar

Dong Zhao, Andrew P. McCoy, Tanyel Bulbul, Christine Fiori & Parisa Nikkhoo (2015) Building Collaborative Construction Skills through BIM-integrated Learning Environment, *International Journal of Construction Education and Research*, 11:2, 97-120

Kihong Ku DDES & Mojtaba Taiebat M.SC. (2011) BIM Experiences and Expectations: The Constructors' Perspective, *International Journal of Construction Education and Research*, 7:3, 175-197

Parusheva, S. (2019). Digitalization and Digital Transformation in Construction-Benefits and Challenges. I*nformation and Communication Technologies in Business and Education*, 126-134.

Sackey, E., Tuuli, M., & Dainty, A. (2015). Sociotechnical Systems Approach to BIM Implementation in a Multidisciplinary Construction Context. *Journal of Management in Engineering*, *31*(1). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000303

Case C: Picard Construct

Introduction

This paper constitutes a case study. Its aim is to describe the concrete impacts of digitalisation on the organization of work and social dialogue within a targeted construction company. Such an approach is part of a broader perspective of understanding digitalisation processes and their consequences on the construction sector in Europe. As part of this study, we looked at the case of Picard Construct, a Belgian general construction company. The choice of this firm was relevant for our research topic, as two new digital technologies have recently been implemented there.

Our research is divided into six main sections. The first one allows us to describe our methodology. The second is devoted to the presentation of the studied company and the technological innovations on which we have focused. Then, the third and fourth parts concern the different impacts of these digital tools. The third section deals with organizational consequences while the fourth looks at the effects of these new devices on social dialogue. After that, a fifth part is dedicated to the analysis of the levers and obstacles to digitalization within the company. Finally, due to the health crisis in which we are currently, a final section has been necessary in order to deal with the role that digitization can play in this particular context.

1. Methodology

In order to gather the information necessary for our research, we conducted semi-structured interviews with six members of the company: two team leaders, the manager in charge of the company's development, the HR in charge of blue-collars workers, the manager of the logistics and purchasing department, and the assistant of the purchasing department. These people are all concerned, in a way or another, by the digital tools recently developed (we will come back to this point in the next sections). Indeed, our contact person within the company designated them to us as the best able to inform us. Then we also interviewed the former prevention advisor. Although he is no longer employed in the company, he was the one who implemented the two last technologies. He was therefore a key player to be interviewed to try to understand the digitalisation process within Picard Construct.

Interviewee 1	Manager in charge of company's development
Interviewee 2	HR in charge of blue-collar workers
Interviewee 3	Team leader 1
Interviewee 4	Purchasing assistant
Interviewee 5	Purchasing and logistics manager
Interviewee 6	Team leader 2
Interviewee 7	Former prevention advisor

The vast majority of the data presented in this paper come from these interviews. Due to the health crisis, these were conducted in the form of video conferences and phone calls between November 2020 and January 2021. Each of them lasted about an hour. As mentioned above, these were semi-structured interviews. We therefore relied on an interview guide drawn up beforehand, which grouped the various themes to be addressed: company presentation, innovations and digitization, impacts on work organization, on social dialogue, etc. However, we made sure to let the various interviewees speak freely on each dimension. In addition to these interviews, we also collected some data on the firm's website as well as on the various pages it has on social networks.

2. Main characteristics of the case study

2.1. The company

Picard Construct is a general construction company located in Tenneville, in the province of Luxembourg in Belgium. It is literally a family business. Indeed, originally owned by the Picard family, it was bought in 1999 by a couple, both managing directors, several of whose children have now joined the adventure. However, the company has experienced a relatively significant expansion in recent years: 10 people in 1999 against more than 60 blue-collar workers and around 25 white-collar employees today. In addition, around 500 subcontractors and trades support it in its various projects. On the white-collars side, there are different departments in each of which one to three individuals are employed: HR, purchasing and logistics, finance and accounting, development, prevention, quotes and tenders, and site management. In terms of blue-collar workers, Picard employs three main trades, namely masons, formers and finishers. All other professions are subcontracted. Workers occupying the same function are grouped into small teams of two to four individuals. In each of these, there is always a team leader. In total, the company has about 25 teams of workers.

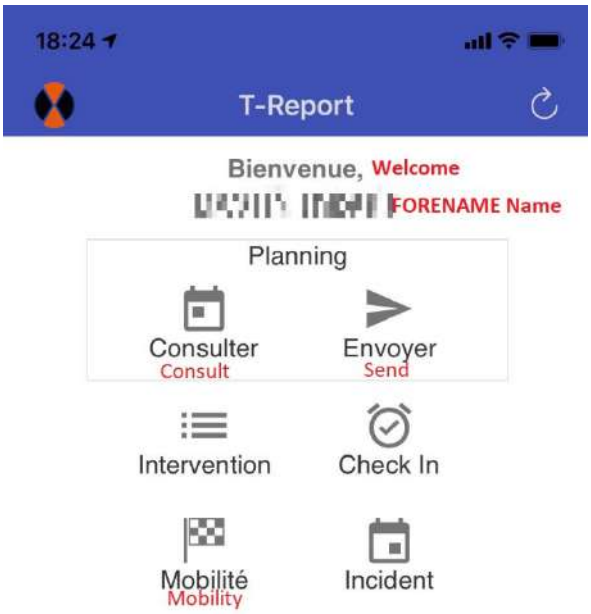
Concerning its activities, the organization carries out the structural work and is also specialized in techniques specific to certain types of building sites. Indeed, it performed various kinds of constructions: commercial spaces for brands such as Delhaize, McDonald's, etc., nursing homes, hotels, industrial halls, etc. Although 80% of its contracts are with private investors, it is also present in public markets for the realization of projects such as schools, football pitches, etc. On the other hand, the firm focuses less on the construction of homes for individuals given the presence of a major competitor in this field (Thomas & Piron). It should also be noted that the company does not use BIM. The manager responsible for the development of the company justifies this by the fact that the tool is too rigid. According to her, the organization needs tools that are more flexible.

Regarding turnover, it is relatively high among blue-collar workers while it is non-existent for white-collar employees. According to the manager in charge of development, this can be explained by multiple factors. First, there are shortages in blue-collar occupations and workers can therefore change from organization very easily. One of the potential causes of this could be that Picard Construct is close to Luxembourg. Thus, many workers cross the border in order to obtain a higher wage than in Belgium. However, this does not explain the difference in turnover with white-collar employees who might also be tempted to work in Luxembourg, especially as the manager confirms that some of the jobs they hold are also in short supply (mainly in technical positions: engineers, site managers, etc.). According to the latter, the distinction stems from the fact that blue-collar workers tend to exaggerate their professional skills and experience when they present themselves in a company because they know that these are difficult to verify during a job interview. Thus, given that the situation is favourable to them, workers do not hesitate to go and see if the grass is greener elsewhere. Conversely, skills and experience of white-collar employees are easier to assess (diploma, discussion with the technical director, etc.). Nevertheless, since the beginning of the health crisis, this situation has stabilized. Indeed workers tends to hold on to their actual job given the present economic difficulties. It must be said that the company has taken the decision not to lay off anyone and instead bet on reducing working hours.

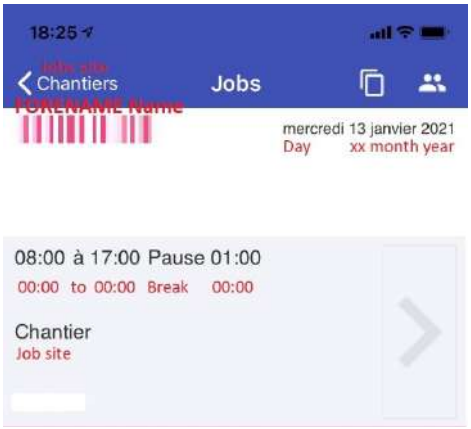
2.2. Digitalisation and innovations

In this study, we will focus on the last two technological innovations implemented within the company, namely tablets (and the new software that goes with them) and a stock management software called Hilti ON! Track. In this section, we will only briefly mention the features presented by these new tools. Then we will describe these in more detail in the next section.

Tablets



Tablets have been used in the company since January 2020 by team leaders only because the tasks that this tool allows to achieve concern uniquely their work (and that of the HR but who does not need a tablet since she already has a computer at her workstation). The main objective of this new technology is to facilitate the processes within the HR department and to improve the coordination of this last with workers. To achieve this goal, the tool is accompanied by an application called T-Report. This software is also installed on the HR computer. This is a program developed by a private IT company specializing in the construction industry. Concretely, it has various functionalities, each of which aims at making easier to carry out a specific task. First, when a construction site reaches an amount of more than 500,000 euros, the workers present on the site must be declared to the NSSO (National Social Security Office) on a daily basis. The first functionality of the application thus enables team leaders to quickly check in workers when they arrive on site and this is then directly transmitted to the NSSO platform. Then, a second possibility offered by the application consists of validating the working hours performed. Finally, the software also makes it easy to declare work trips and obtain the exact calculation of the resulting costs. In addition to this program, Picard also took advantage of the arrival of tablets to create an email address for each team leader in order to fluidify their communications (between them and with the rest of the organization). The T-Report app and Gmail are therefore the two main tools used on tablets.



Hilti ON!Track

The aim of this tool is to simplify the processes within the purchasing and logistics department and to optimize the coordination of this last with workers, as well as to improve stock management. It is a programme used for tracking large machines and managing inventory. It was implemented in the company at the end of June 2020. The application comes from a company named Hilti. Originally, it was a firm that sold tools and machinery for the construction sector. Having realized the problem of locating equipment on building sites, it developed its own software. Picard Construct intends to use this for one or two year(s) to spot negative points and think about opportunities for improvement. The company's goal, after year(s) of testing, is to create its own in-house application tailored to its specific needs.

3. Impacts of the technologies

The particularity of this case study is that the two technologies implemented have each a very strong impact on the organization and working conditions of a specific department (HR and purchasing and logistics). In direct contact with these departments, blue-collar workers, and more particularly team leaders, are also concerned by these innovations.

3.1. On work organization

Tablets

Regarding tablets and the T-Report program, it is before all the HR department and team leaders that have been impacted. The best way to report on this is to describe the way tasks were performed before the implementation of the software and to compare this with the functionalities now available for carrying out the same tasks. We will thus be able to emphasize the impact on the work of each of the two

actors as well as on the coordination between them. We will also see whether the implementation of this tool opens the way to new possibilities that are not part of the initial objectives.

Comparison between old and new practices

In the previous section, we saw that T-Report allows performing three specific activities. Let us review each of them.

- The first activity concerns the declaration of hours worked. Before, the encoding of working hours represented an important part of the HR function. Indeed, at the end of every week, the HR received from each team leader, a paper version of the declaration of hours worked by each member of their group. This had to be entered manually into the computer. From now, she pre-encodes the schedules in the application, which takes her much less time per week, and the team leaders only have to validate or modify the hours worked. This information is automatically sent to the HR computer. Therefore, the encoding activity is strongly reduced. We specify that the verification of the hours worked is carried out via a different tool that was put in place some time ago. As this is not the subject of our study, we do not detail this part of the HR work.
- The second is the check-in of workers for the NSSO on construction sites at more than 500,000 euros. Previously, the HR carried out this check-in. She was supposed to do it the day before. Concretely, she had to encode, on the platform of the NSSO, the schedules of the following day for the workers present on important sites. It was not possible to carry out this operation on the same day because some teams start working very early in the morning. Therefore, if the NSSO decided to control one of the sites before the HR arrived at the office, the workers who had not yet been declared could have been suspected of working illegally. However, there can always be last minute changes such as workers being sick or being sent to other sites. When arriving in the morning, the HR therefore had to call all the team leaders working on major sites to check whether the schedules encoded the previous day still corresponded to reality. Such a situation no longer exists at present since the list of workers likely to be on the site is pre-encoded in T-Report. Team leaders simply need to check a box next to the name of the workers to validate their presence in the morning and the information is directly transmitted to the NSSO plateform. The only part of the job that still falls to the HR is to compare provisional schedules with the team leaders' check-in to make sure that there have been no omissions in the workers' declarations. It should be noted that this also allows her to know directly when someone is absent.

- The last task performed using T-Report is calculating travel expenses. Previously, it was necessary to search on Google Maps how many kilometers represented the various journeys of the workers and to calculate the resulting costs. However, the new software contains a "mobility" tab in which workers can enter their movements using the GPS coordinates of the different locations. The calculation of the exact costs is then carried out by the application.

Impact on the HR department

The description of these activities makes it possible to observe to what extent work processes have evolved within the HR department. Previously, these different operations occupied the HR in charge of workers for two full days a week. Now, these tasks only take her three days a month. Thus, the main advantage of this new system is that it saves a lot of time, which is now used for other activities. Indeed, as the HR explained to us: "*The time that was paid fort encoding sheets is now paid for doing a real HR job, with more soft dimensions: assessment interviews, mobility management, listening and problem solving of workers, etc. Before, when a worker came to see me, I did not have time to devote to him and that is not normal for an HR department*".We therefore observe that a second positive change resulting from the implementation of the tablets is a diversification of activities, some of them allowing her more freedom to proceed within her work than in the previous tasks of encoding.

Impact on the work of team leaders

In general, the impact on the work of team leaders is more limited. Those with whom we spoke indeed believe that there is no great change in their daily lives. The information they used to put down on paper or to give by phone is now to be encoded in a tablet; it does not go further. Although they consider this innovation positive and admit that the software T-Report makes things a little simpler, they do not estimate that this constitutes a major evolution. However, HR told us that some workers felt relieved because the tablets take a small administrative burden off their shoulders: "*They no longer have to think about writing the information and returning the sheets, which they sometimes forgot to do*". This is also the opinion of the former prevention advisor who was in contact with all team leaders as part of his job. In addition, according to one of our interviewee, the ease with tablets expressed by the two team leaders with whom we spoke could be explained in particular by their high level of skills. That is why they do not feel strongly impacted by this change. However, the same is not necessarily true for the others. Then, the former prevention advisor adds that another advantage of tablets for team leaders is that it gives them new possibilities for communication: "*They can send workforce changes directly to the tablet,*

through the app, and avoid phone calls that are not always conducive to the construction environment. They also have the possibility to communicate by e-mail. It is very practical for ordering material. They can send an e-mail to the purchasing department with a picture of the tool they want and a detailed description found on Internet. It is easier for them than writing their demand on a piece of paper".

Impact on the coordination between HR department and team leaders

For the HR in charge of workers, the new software also allows a clearer vision of the schedules. She actually says that thanks to her overview on them, she more easily detects potential mistakes, which can now be rectified very quickly. Consequently, it ensures better daily monitoring of work on sites and a greater responsiveness to the vagaries of everyday life. Obviously, this requires more communication with team leaders, but it is more fluid. In the past, when the HR called them, it was more to clarify inconsistencies in the papers received than to ensure the smooth running of the day.

Additional impact

As explained above, the main objective of implementing tablets was to improve the organization of work in the HR department and its coordination with team leaders. The preceding paragraphs demonstrate that this goal has largely been achieved. Little by little, however, Picard Construct is discovering other uses for these tablets. A simple example that illustrates this concerns the ordering of work clothes. Previously, a complete pack of work clothes was automatically provided to every worker twice a year. It was therefore necessary to collect the sizes of each worker (which could vary from year to year), which took some time. Orders are now placed via tablets, on the internal website recently created by the manager in charge of developement. According to the latter, these new tools allow new opportunities: "*Since we decided to digitise, we have become more and more innovative. For work clothes, the idea was really to make the link between the new digital tools (tablets and internal website). Looks like it has changed quite a lot. There is more variety in the clothes offered and workers can choose clothes that meet their needs. They will not necessarily take a full pack if some of their old clothes are still in good condition. It is more economical and ecological too. With tablets, there really are more opportunities."*

Hilti ON!Track

For its part, the Hilti ON!Track program mainly impacts the purchasing and logistics department, in relation with workers. In order to see how important its influence on the organization of work is, we propose to compare again the former functioning of the department with the current situation (following

the implementation of the tool). We will then be able to report on the respective consequences for the actors concerned by this innovation.

Comparison between old and new practices

Originally, the head of the logistics and purchasing department was alone to manage the stock of material in the company's warehouse. This responsibility includes three main activities: inventory tracking, the supply of tools to the workers and ordering equipment. The last operation is carried out via specific software that is not the subject of our case study. Therefore, we will focus on the other two tasks.

- For the inventory, there was no real process in place at the origin. The company was still a small familial structure so it was done from memory on Excel tables. As the business grew, it became unmanageable. The Excel file kept growing and it was getting harder and harder to navigate. At the end of the year, in order to keep a view of all the available material, everything was recounted and manually encoded. No one except the manager was able to have a vision of what was available in terms of materials, which constitutes a problem every time he was away. When he was asked after a tool, he had to look in the repository. He had reached a point where he was doing 30 to 40 times a day back and forth between his office and the depot.
- Regarding the supply of materials to the workers, the procedure in place was rather laborious. In fact, the manager created purchase orders that he sent to the storekeeper by email or paper. The storekeeper supplied the material and wrote down any changes to the basic order on the sheet. This paper was returned to the manager, who gave it to his assistant, who then encoded it into a program. Then the manager checked to see if there was no mistake and, at the end of the month his assistant and himself controlled the entire listing a second time. Of course, with this system, the manager and the storekeeper did not have time to note detailed information such as the brand of the tool, its model, its serial number, etc., on their piece of paper. All the department could know was: a worker had taken a tool (with no more precision). This information was insufficient to optimally manage the logistics and the stock of a company the size of Picard. The latter had become too large for it to be possible to check whether each loan of equipment was properly returned. In fact, once a machine was taken out of stock to go to a building site, the manager had no view of it anymore. Therefore, it was not always easy to ensure it was returned to the warehouse. Suppose a worker did not bring back a tool and nobody else needed to use it for a few months, then it was not possible to realize that the tool was missing. In addition, in the construction sector, tools can be declined in a variety of very specific models that

meet different needs. With the old system, it was not possible to know which models were on site and which were available in stock, which was very problematic.

Now all material is labelled with a barcode, which is unique, and encoded in a database. The latter contains all detailed information about each tool and material movements can also be seen within it. Therefore, it constitutes a very precise inventory. When a machine leaves the warehouse to go to a building site, the storekeeper scan it and the site reference as well as a due date are encoded. If the tool has not been returned to the warehouse by the due date, the program sends an alert message to the manager. His assistant is then responsible for contacting people who did not return the equipment. If it turns out that workers need the machine longer, the period during which they can dispose of it is extended. If it is an oversight, workers notify the date on which they can proceed to the deposit and this is encoded as the new due date. Thus, the software allows better monitoring of the stock. We observe that the process is now standardized, whereas before it was governed by a deficient direct supervision mechanism. It is now possible to know "in real time" where the equipment is located. However, it is not a question of geolocation: there are no chips on material (except on the most expensive machines and on vans, but it is not the object of this paper as this device has been in place for some years now). If the staff knows where the tools are situated, it is only because they are scanned when they leave the depot and because the name of the site on which they are going as well as the name of the workers who operate there and who wish to borrow material are encoded. This system therefore assumes that workers do not move tools without warning the purchasing and logistics department. The manager has the program on his computer and the application on his phone. This allows him to check the inventory wherever he is.

Impact on the purchasing and logistics department

The changes resulting from the use of Hilti software are significant for the purchasing and logistics department. As in the case of tablets, the time saving is enormous, which allows the nature of the tasks performed by employees to evolve. Indeed, the manager explains that thanks to this new system, he can delegate the logistical part of his work to the storekeeper and the purchasing assistant: "*The warehouse starts to run by itself so they can manage without me. I just have to supervise and be available when there is a problem or a question, but that is where it ends*". Thus, he is now only concerned with program supervision and exceptions handling. He adds that the time he no longer has to spend on this activity allows him to focus more on the real work he is supposed to do in his function, namely, negotiating to buy at the best price and managing problems on building sites.

For her part, the purchasing assistant has therefore obtained new responsibilities. The encoding work,

which used to take her at least 30 minutes a day, is now completely replaced by software. Likewise, for the monthly billing, she had to devote a full day compared to 1 hour to 1:30 today. Thanks to this time saving she is available for the new tasks entrusted to her. When we interviewed her, she was busy training herself on different functionalities so that she could take over the management of purchase orders and the invoicing of part of the deposit. She was delighted with the evolution of her role. This allows her to refocus her activities on the purchasing department only, which has not really been the case lately, according to her explanation: "*Initially, I was hired as assistant to the manager in the purchasing department. My main occupation was checking all the bills. Then I was asked to take care of the workers' work clothes, which had nothing to do with my initial role. After that, I was asked to manage construction and vehicle claims. However, I found those tasks less interesting. Here, I took advantage of Hilti's arrival to talk about it and asked to stay in the purchasing department, as originally planned. We discussed this and I will have more tasks related to purchasing so the fact that I only work in this department is justified*". She therefore benefited from the implementation of the program in the form of a refocusing on her areas of interests and skills and a greater horizontal division of her work (more diversity in her tasks). Moreover, in the future, it is planned that another additional task will be entrusted to her: the ordering of consumables for which a minimum stock is to be kept in the warehouse. If this activity will allow her more contact with suppliers, it will also give her a better view of the entire ordering process. Indeed, the assistant is already in charge of checking invoices and it will be easier to carry out this operation for orders that she has placed herself. There will therefore be more link between her tasks, which should allow her a better view as well as more control over the entire process.

Then, in general, the tool allows better management of the department. The assistant says: "*It is less messy. It is now possible to be much more precise in terms of stock, with almost no error. At any time, down to the second, we can know where we are in the stock*". In addition, as she explained to us, some tools have several names. As a result, when the storekeeper wrote down what he provided to the workers, he sometimes used names different from those she knew, which created confusion when encoding. Now, everyone uses a single name: the one that is encoded in the database. The program therefore allowed a certain degree of standardization, which makes things clearer. In addition to this standardization, the database allows the centralization of information, which also simplifies the work of employees. Suppose the manager is away and an order has to be placed urgently, the information is available to enable the correct action to be taken. Similarly, all the data of the company's vehicles are encoded there. Thus, if a document needs to be completed for insurance, for example, it is no longer necessary to search for information from various places in Excel tables. It should also be added that this uniformity in the

way of working suppresses certain conflicts with workers. Indeed, previously, there were sometimes complaints from workers who claimed to have received a specific machine and that it was not the same that was subsequently returned to them. This kind of discussion is no longer necessary today since each tool has a unique code. Therefore, Hilti has solved many problems. According to the development manager, the programme really improves the department's performance and simplifies the work of the entire production chain.

Impact on workers

One of the main consequences of the Hilti program for workers is the strengthening of control over the use of equipment. We will come back to this point later. However, another change can be noted in the organization of their work. In fact, under the old system, the workers themselves loaded the goods into the vehicles at the depot. This meant they had to pick up their tools during the opening hours of the warehouse, i.e. during regular daytime hours, even if they were working shift schedules. Now they are no longer allowed to collect their equipment from the depot. Team leaders must place their tool orders by email 24 hours in advance. The storekeeper prepares them in a storage area that is accessible 24 hours a day. In this way, workers can pick up their equipment at a time that suits them. It should also be added that in the future, it is expected that site operators will have the Hilti app on their phone or tablet so they can consult the stock catalogue on their own. This would be a simplified version of the program that cannot be modified in any way. The aim is simply that workers can see what is available in stock when they place their orders. According to the former prevention advisor, these changes should make their life easier, especially since there were previously many complaints from them about the poor management of logistics at Picard.

Impact on coordination

As previously mentioned, within the logistics and purchasing department, information is now centralized. If this facilitates the work of employees, according to the manager, it also strengthens coordination with workers. As an example, he cites the case of vehicle breakdowns, a situation that occurs relatively often in a company the size of Picard. When this happens, the worker needs specific information such as tires size, etc., in order to communicate it to the repairer. This information was previously stocked in Excel tables or on paper and was not always easily found, forcing workers to wait. In addition, some breakdowns obviously occur outside office hours, which was very problematic in the past. Now, thanks to the database and the fact that it is an application available on smartphones; the manager can directly

find the information and transmit it. As team leaders are now equipped with tablets, the communication can even be made to them by email.

Additional impact

Currently, the impacts of Hilti software are limited to the logistics and purchasing department and workers. It must be said that the program has only been operational since September 2020 and that we are in a particular situation of health crisis. It will certainly be necessary to reassess this in the longer term. Especially since the tool is not yet used at 100% of its capacity and its designers continue to improve it. According to the manager, at Picard, it is slowly starting to be used for quantitative analyses (profitability of machines, quality of vehicles, etc.) but this is only the beginning. Some improvements are already planned, such as the placement of Bluetooth chips on some of the machines.

3.2. On the labour force (employment)

Professions

In the previous section, we saw how the nature of activities carried out in the HR and logistics and purchasing departments have evolved following the implementation of new technologies. However, what is particular about Picard is that the employees impacted by these changes are not taking on a new profession but finally seem to be performing the tasks originally devoted to them. In the case of HR, the encoding activity and the heavy administrative burden prevented her from performing activities related to other areas of HR (than the administrative one) such as development, training, skills management, etc. The HR function was stuck in a bureaucratic model, in which the emphasis was more on the administrative side than on human development. This is evidenced by the fact that, in our interviews, one of the workers spontaneously referred to her as a secretary rather than HR. Therefore, digitization has enabled her to step out of this role in practice. Likewise, the manager of the purchasing and logistics department explained to us how the lighter administrative operations, now supported by Hilti software, allows him to focus on activities that really matters in his job. Finally, because of the help and processes simplification provided by the program, the purchasing assistant can take on new responsibilities and work 100% in the department for which she was initially hired. Ultimately, we cannot speak of old professions evolving or disappearing, nor of the emergence of new professions. We are rather in a case where the management of administrative aspects by new technologies allows everyone to refocus on the fundamentals of their profession.

Regarding workers, who are the second to be impacted by technological innovations, the changes remain too minimal to be able to speak of an evolution of the profession. Of course, they have to deal with these novelties and sometimes take on some additional responsibilities, but this does not change anything fundamental in their manual profession.

Skills, recruitment and training

At Picard Construct, it is now necessary to deal with the new software recently implemented. However, whether it is T-Report or Hilti ON!Track, all interviewees have one unequivocal opinion: programs are intuitive. Indeed, all of them state that it is not necessary to have computer skills to be able to work with these tools. In the case of tablets, it is true that we have received information that some older team leaders struggled a bit more than others at the start. Nevertheless, based on feedback from our interviews, at no point was this a real problem. These people simply received additional help, whether from the former prevention counsellor, the HR, or colleagues. This ties in with what we observed in the previous section: innovations do not fundamentally change the professions they concern. Consequently, nothing changes in terms of recruitments. According to the development manager, there is no need to require additional skills from future recruits: "*The company's philosophy is that everything can be learned. Here, changes remain limited. There is no need to hire workers or employees with advanced computer skills. The programs are quite simple so they can learn when they arrive*". Thus, training in new tools is done internally. In some cases this is quite formal while in other circumstances it is more a matter of "on the job" training. For example, when the tablets arrived, the team leaders were gathered in a meeting room for a collective learning moment. On the other hand, in the purchasing and logistics department where there are few employees, familiarization with the tool is done gradually, depending on the time available.

3.3. On working conditions

Autonomy vs control

In this study, the question of autonomy and control mainly concerns blue-collar workers. First, tablets generate a certain ambivalence, as the manager in charge of development explained to us: "*On the one hand, tablets allow more autonomy because workers are no longer obliged to go through administrative staff to obtain information. On the other hand, controls are carried out to ensure that they are not used for private purposes"*. Moreover, team leaders have to sign a charter to confirm that they are committed

to pay attention to them and to respect the measures taken to avoid theft, etc. Therefore, workers clearly do not whatever they want with them. Then, even if the team leaders are now responsible for the check-in, as we saw earlier, the HR still checks on the NSSO platform that it is correct. Nevertheless, she does not see this as a control, but rather as a follow-up to avoid errors. It should be noted that, as mentioned above, a check is carried out via another tool for the validation of hours worked and trips. This consists of a geolocation system placed on the vans. However, this device has already been in place for a few years and the arrival of tablets has not brought any changes to it. It is therefore not part of the scope of our case study.

The situation is less mitigated about the Hilti software. All of the interviewees agree that the tool strengthens workers' control. The manager of the logistics and purchasing department confirms: "*It is now possible to have a very clear vision of who owns which tool. Therefore, there is better follow-up. As soon as the workers do not return the equipment, they are questioned*". What is surprising is that all of our interlocutors, including the two workers, consider this change to be positive. Here, the discourses are aligned with the fact that previously there was too much freedom and therefore too much abuse, theft, etc., which justifies the strengthening of control. These discourses will however be nuanced in a subsequent section. Finally, it is interesting to point out that, still according to the manager, the Hilti program offers the possibility of going really far in control. However, this is not what the company desires, as it would prefer, to some extent, to maintain a functioning based on trust.

For their part, white-collar employees affected by the latest technological innovations gain autonomy. In the logistics and purchasing department, the assistant and the storekeeper are delegated all the logistics side, without constant verification by the manager as was the case previously. The latter also acquires autonomy in the sense that the activities to which he now devotes himself seem, a priori, less procedural: price negotiation and management of daily problems on construction sites against verification of encodings, creation of purchase orders and monitoring of the inventory previously. The same goes for the HR, who is no longer confined to purely administrative and encoding tasks.

Wage

On the subject of wage, we could think that the potential impacts would mainly concern white-collar employees whose activities are significantly modified because of technological developments. However, for the purchasing assistant and for the HR, no changes are planned in this area. They agree that a salary increase is not necessarily justified in their case. Simply, they will now be paid to do the real work they are supposed to do in their job. The development manager confirms that there are no major changes in

working time or otherwise which would justify a salary review. According to her, it is just a matter of making a few small adjustments in the job description. On the other hand, the manager of the logistics and purchasing department believes that the changes that have occurred in his profession should lead to review his remuneration as well as his job description. At the time of interviewing him, however, that negotiation had not yet taken place.

For blue-collar workers, the T-Report app affects wages in another way. Indeed, the change does not take place in terms of the amount but in terms of the time of receipt. In the past, due to the time consuming encoding of working hours, it took a certain amount of time before workers were paid, sometimes with delays.From now on, the deadline is two working days. There are also far fewer errors, both in remuneration and in travel costs, as this is now accurately calculated by a computer.

Relationships and cooperation with colleagues and management

We have already explained above how the latest digitalization impulses have strengthened coordination between workers and several departments. We also mentioned that different actors provided support to team leaders who met more difficulties with tablets. According to the manager in charge of development, the desire to become familiar with these new technologies leads to a lot of informal sharing of information and mutual help between colleagues, whether they belong to the same department or not. Cooperation is therefore both stronger at the two levels. Moreover, Picard is keen to continue its digitization work by linking several programs in order to create more connections between departments. Finally, with regard to the relational aspect, it should also be stressed that workers now have a HR department to which they can turn in case of problem.

4. Industrial relations and social dialogue

There is no union within Picard Construct. All the workers are unionized but those we interviewed explained that it was rather by "tradition" and as a precaution: "*That is how everyone does it, just in case there is a problem one day"*. Thus, no trade union activity is carried out within the company. The workers justify this by the fact that relations with management are going well, without major conflicts. The interviewees actually described their bosses to us as "*very human and conciliatory*", "*fair*" people. In the absence of trade union activity, we are therefore interested in how the social dialogue, in its broad acceptance (between workers and management) takes place. Social dialogue brings together information,

consultation and negotiation activities between stakeholders. We will now look at how these have been achieved when implementing the latest technologies.

Tablets

The desire to implement a new system for workers and the HR department came from both management and the HR itself. The latter initially made a request to the management because she wanted to develop her service but was unable to do so due to the time it took her to encode working hours. She therefore asked her directors to find a solution. For their part, they realized that, following the expansion of the company, the encoding of sheets of paper was becoming unmanageable. They therefore agreed to review the system and selected software that was offered to them by an external with whom they collaborated. It was then necessary to decide on the tool with which the team leaders would use the program. At that time, the latter only had classic mobile phones and they were already asking for smartphones for efficiency reasons. Management made a different choice from their request by providing them with tablets. The prevention counsellor was responsible for choosing the model. In fact, management knew that he had very good computer skills. It therefore allowed him to familiarize himself with the program and to freely choose the most suitable tablet model. There was therefore no negotiation on this subject, especially since the prevention advisor was able to reduce the costs initially foreseen.

It should be noted that before purchasing all of the tablets, the company started by buying only one so that a team leader could test the system. Therefore, while the others continued to report work hours on paper, this team leader began to doing so through the T-Report app, using a tablet. This way he could report any problems he encountered and major flaws could be rectified before all of the team leaders started using the tool. This worker therefore had the right to make modification requests, which were accepted if they were deemed legitimate. This is still the case today: team leaders can make requests, for example to install additional applications, and these are usually granted as long as they are justified. For his part, the prevention advisor quickly identified the need to secure the tablet. Indeed, initially, it was possible to do everything with it, to install any application, just like a tablet for private use. The prevention counsellor did not wait to see if this would cause problems. It has directly installed parameters similar to child safety devices. Thus, team leaders do not have the ability to download apps on their own or to modify anything on tablets. In addition, it is possible to know how much time they spend on the applications they use, although it is not of great interest in this case. We add that we have not heard of any dissatisfaction from the team leaders with this situation. It must be said that except for the one

who performed the test with the first tablet, they all experienced the secure version directly.

Following the test phase carried out with a single worker, as already mentioned, all of the team leaders underwent collective training. The HR has also received a little training on her side. According to interviewees' feedback, there has been no strong resistance to the change. It is true that some were reluctant at the start because they were afraid of not succeed. According to the HR, this mainly concerned the older ones. Our interviewees confirmed that some team leaders encountered technical difficulties at the beginning. The former prevention counsellor even told us that a few had asked to go back to the old system, which was not accepted. Overall, however, there was no strong protest. It must be said that, thanks to the advantages of the new program, strong arguments could be used to convince the most reluctant: fewer errors in payslips and travel expenses, as well as wages paid more quickly. Recently, the development manager conducted a survey via the internal website newsletter to get feedback on tablet usage. The results are encouraging: 86% of team leaders participated in the survey and the opinions are mostly positive.

Hilti ON!Track

Regarding Hili, the initiative came from the manager of the purchasing and logistics department. As with HR, as the company grew, its workload with old processes was becoming unmanageable. So he looked for a solution and discovered Hilti software. However, at first, management refused to acquire the program due to the cost involved. It was the arrival of the prevention advisor within the company that unblocked the situation. Indeed, the latter was using the system in his former position. He was therefore able to give more explanations to the manager on its operation in practice. Following this discussion, the two actors were fully convinced of the need to implement the tool at Picard. The prevention advisor then set about convincing the directors. Eventually, they realized that while the software was expensive to acquire, it paid off in the long term. They therefore gave their agreement. So unlike the case of tablets, Hilti's implementation required negotiation.

Following this, the prevention advisor and the logistics and purchasing manager worked together to implement the tool. With the health crisis and the slowdown in activities, they were able to put everything in place in a matter of months. During this period, the purchasing assistant was on maternity leave. However, she already knew, before she left, that these changes would take place. She had inquired about this before her discharge in order to understand what was planned. When she returned, the implementation was complete and she immediately started learning about the new program. Soon, she and her manager will be meeting with the Hilti designers to submit requests for changes (for example,

to the layouts) and see if there is room for further improvement. She explained to us that management approval was not required in this kind of situation. Once the software acquisition was validated, the department was able to manage the implementation independently.

By contrast, even if technological innovation affects the working conditions of workers, their opinion was not sought. They were simply informed of the new way of working with the logistics and purchasing department. The two workers we interviewed believe the new system is better. However, according to one of our interviewees, this is not everyone's opinion. As mentioned above, that person considers that the team leaders we spoke with are workers who are doing well. Other workers, they said, are upset because they do not appreciate being more controlled over the use of equipment: "*Some people show ill will towards the new system because they don't like it. It bothers them that we can have a view of what they are doing. They would prefer that we let them do what they want in their corner but this is no longer the case so they complain, they do not make any effort to make everything going well*". Nevertheless, one of the team leaders told us that this was quite a taboo subject: "*Before, there was a lot of abuse with equipment, thefts, etc. Now this is not possible anymore because there is more control. Generally speaking, no one says anything. It must be said that if there are some who complain, we will suspect that it was they who took advantage of the old system, who stole, etc. Therefore, those who are not happy are not going to say it too much*". Thus, although the adoption of Hilti generates discontent among some because of the increased control it implies, abuses and thefts were so numerous previously (they were moreover mentioned by all the interviewees) that its legitimacy is not the subject of a strong and general contestation. Even if some complain, the use of the tool is no seriously questioned. It should also be added that previously, the workers deplored Picard's poor logistics. On this point, the improvements made by Hilti can hardly be called into question, which, in our opinion, also contributes to limit contestation.

If we go back to the three activities of social dialogue, we see that in the case of tablets, negotiation was not necessary. The demands expressed by workers and HR were heard by management, who made decisions aligned with them. However, the manager of the logistics and purchasing department and the prevention advisor had to negotiate to obtain the Hilti software. Regarding consultation, the manager in charge of development considers that workers were all consulted in the case of the two technological innovations. Nevertheless, we believe that this statement needs to be put in perspective. With regard to tablets, for example, management alone made the choice of software. It did not consult the HR, the prevention advisor, or the team leaders on this matter. On the other hand, it is true that the general

opinion of these different actors has been taken into account since the decisions contracted have responded to their requests. Then, the prevention advisor was more than consulted in the choice of the tablet model since he did so independently. However, the team leaders, who are still the end users of the tool, were not involved in this initiative. Nonetheless, their views have been taken into account during the testing phase and continue to be so as they may request generally accepted modifications and improvements to the system. On the Hilti side, the manager of the logistics and purchasing department and the prevention advisor are themselves at the origin of the implementation of the program. The workers, on the other hand, were not in this case. Finally, all the actors seem to have been informed in a very transparent way about technological innovations.

5. Drivers and barriers considering digitalisation

It is interesting to note that actors interviewed identify more obstacles than drivers considering digitalization. Therefore, this is where we are going to start.

Barriers

Barriers to digitalization are multiple and so interrelated that it is difficult to account for them individually. In this part, we therefore try to group together the explanatory elements provided by our various interlocutors, since they are similar.

The first obstacle to digitization concerns financial resources. Implementing new technologies is far from cheap. We have seen that this was a problem for the implementation of the Hilti software. In addition, according to the manager in charge of development, there are few financial aid granted by the Sate linked to the implementation of these technologies: "*At Picard, we were entitled to a single bonus from Forem in connection with one of the programs we use. But honestly, there is too much paperwork to be done to get it. We did it, but when I see how long it took and all that had to be done, I understand that some companies can give up. Not everyone has the time to devote themselves to such procedures"*. In this sense, public policies would also constitute a barrier rather than a lever for digitalization.

In connection with financial resources, the question of short, medium and long term profitability also arises. In this regard, a tool such as a tablet is not a very long-term investment because, given the rapid development of technology, it will be necessary to renew them relatively quickly. Thus, digitization is progressing so fast that it is difficult to expect long-term profitability from certain devices, which may

make management hesitant to acquire them. The development manager even thinks that in the future it will be necessary to hire an in-house IT developer. Then, another fear related to tools such as tablets concerns the placement of these on building sites. Indeed, it is not the most favourable environment for relatively fragile devices. The HR explained to us that at this time it is difficult to know if the workers are taking care of them. For her part, the development manager thinks this is the case but that we have to be aware of the fact that damage can quickly happen. Anyway, as already mentioned, workers have to sign a charter to confirm that they are committed to pay attention to them, to respect the measures taken to avoid theft, etc. The team leaders we interviewed reported that they left their tablets inside a box in the van. Thus, they consider that they minimize risks and it seems to have worked well as far as there has never been a loss.

Finally, a last obstacle mentioned by several interviewees concerns the time taken to implement a technological innovation in a highly competitive sector. Indeed, when getting into this process, it is necessary to train people, to overcome resistance to change, to adapt programs, which is usually done by trials and errors, etc., and it all takes a while. The purchasing assistant gave us a very concrete example to illustrate this situation: "*The first time I had to do the monthly invoicing with Hilti, it took me two days. Normally it should take me 1 to 1:30. But that is in the long run. Now, I am still learning so it takes me longer. The second time, it took me one day so it is still a lot compared to what it should be, but the gap is already decreasing"*. The manager of the logistics and purchasing department explains that this state of affairs generates resistance from the bosses regarding the implementation of new systems. According to him, in the construction industry, staff is in a permanent "rush" due to constant change. This is a highly competitive environment and therefore attention is focused on production. Thus, the pace of work is sustained and life on the site takes priority over the development of tools whose implementation is known to require a certain amount of time that is not always available.

Drivers

Compared to the obstacles, our interlocutors encountered more difficulties in identifying the drivers of digitalization within their company. According to the development manager, this is a necessity in order to remain competitive: "*I realize that there is really a technological evolution taking place in our sector and we have to follow it. You have to get out of your comfort zone so as not to be left behind. I have heard that soon material will be delivered by drones or that sort of thing. For the good health of the business, it is important to go with the flow"*. Thus, digitization would almost be an obligation to survive. Due to the significant progress it allows, it is no longer possible for Picard Construct to continue working

with its old processes while other companies are increasing their performance thanks to new technologies. However, the actors do not see this as a constraint. The manager in charge of development explained to us that the encouraging results generated by the implementation of the latest technological tools made her want to go even further in innovation. We have also seen above that, in general, the new devices have been well received as they facilitate work processes and strengthen coordination. Therefore, the fact that digitization becomes essential is not a problem in the sense that it is well experienced by the majority of the staff.

6. Covid impact – the role of digitalisation

Due to the health crisis we are currently going through, like many companies, Picard Construct's activities have slowed down significantly. Faced with this situation, digitization has nevertheless made it possible to make certain adaptations. For example, some of the employees found themselves teleworking for the first time. Although this is not usually done, this arrangement has enabled some of the staff to continue working. Then, as we have explained, since the implementation of the Hilti program, workers are no longer allowed to pick up their materials from the warehouse. Everything is deposited in advance by the storekeeper in a storage area. An unexpected consequence of this system is that it has made it possible to comply with the rules of distancing during confinement. In fact, the workers, who could sometimes work alone on site during this period, did not have to meet other people when collecting their equipment. Finally, the former prevention advisor explained that thanks to the tablets, the health instructions to be observed could be sent on the professional email addresses of team leaders. If there had not been this tool, these should have been given orally or on paper. The advantage of the electronic system is that it allows the prevention advisor to keep a record that he can mobilize, in the event of a problem, to justify that he has done his job well.

Thus, in certain aspects, digitization has helped to cope with the health crisis. It is also interesting to note that, conversely, at Picard, the slowdown in activities generated by the pandemic has also enabled certain digitization processes to move forward. First, the employees took advantage of this quieter time to reorganize the computer files, which are completely scattered before. However, it was especially in the logistics and purchasing department that the off period made the difference. Indeed, it was in this context of slowdown that the implementation of the Hilti program took place and it was therefore completed much faster than expected. In order to use the tool, it was necessary to label all of the material with a unique

barcode and to encode everything in the software to create an inventory. According to the department manager, under normal circumstances, this activity would have taken a year since there is always some material on site. However, since the majority of operations were at a standstill at that time, most of the tools were in the warehouse and the manager and the prevention advisor completed the labelling and encoding work within two and a half months. Therefore, although it is an exaggeration to say that it has been beneficial, the health crisis has nonetheless made it possible to shift the attention usually focused on production to other activities. In a way, it has therefore temporarily helped to overcome one of the obstacles to digitization mentioned above: the lack of time in a highly competitive sector.

Conclusion

If we review the main elements of this case study, we can see that Picard Construct has, in a short period of time, implemented two new technological devices within the company. The objectives of these initiatives were to facilitate work processes and improve the efficiency of certain departments in order to remain competitive in a sector where concurrence is fierce and where changes are constant. In terms of organisational consequences, we have seen that the new tools each strongly affected a specific department (HR for tablets and the T-Report software, and purchasing and logistics for the Hilti software), and always in relation to workers. At the level of social dialogue, generally speaking, the introduction of these new features did not give rise to strong contestation from the workers, on whom these technologies have nevertheless been imposed. Then, we saw that the various actors identified more obstacles than levers to digitalisation in their sector. Finally, a last interesting element was to note that if digitalisation helped to face certain aspects of the health crisis, on the contrary, at Picard Construct, the consequences of the pandemic also contributed to the progress of certain digitisation processes.

To conclude, it seems necessary to mention the limits of this case study. First, this research was carried out between November 2020 and January 2021. However, the end of the year is a busy time for the construction industry. The time that our interlocutors could grant us was therefore limited. Thus, we have made sure to gather the necessary information in order to fully understand the impact of the latest technological innovations within the company, but some details may not have been mentioned. This is all the more true since, due to the health crisis, we had to conduct the interviews by telephone. As a result, we did not have the opportunity to visualise the working environment and the technological tools. Another consequence of the pandemic is that Picard Construct's sales revenue has decreased. In

this particular context, it is difficult to assess the impact of new technologies in financial terms. It would therefore be interesting to look into this aspect in the future, when the situation will be somewhat restored. In any case, it would be useful to review the impacts of these tools in the longer term given that their implementation is recent: around a year for tablets and a few months for Hilti software.