

# **Technological development in the construction industry**

An empirical study on sense-making processes of stakeholders in the  
construction sector

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### **ABSTRACT**

The construction industry is increasingly adopting digital practices to improve processes and efficiency. Although they lack technological development compared to other sectors, they are making efforts towards becoming a more innovative, efficient sector by implementing various technologies onto the construction sites. The ASHVIN project aims to take this one step further through the implementation of sensors across its demonstration sites. Its measurements can, with the help of IoT ('Internet of Things') and digital twin technology, help make the sector more productive and efficient, while reducing costs. However, these technologies also have the potential to impact workers' privacy and freedom within the workplace. Therefore, it becomes important to understand how the various stakeholders within the project make sense of these sensors and technologies to ensure a safe but privacy friendly workplace. This research addressed these issues by holding qualitative, in-depth interviews with various stakeholders within ASHVIN, together with the analysis of meeting minutes consisting of important discussions and decision-making processes. A thematic analysis of the interviews and meeting minutes was conducted. It was found that individuals discuss technologies in their workplace as a positive asset, as well as seeing no inherent issues with it. Technologies were also seen as contributing to an overall promising future with technological innovation at the forefront. Furthermore, sensors and technologies were seen to have surveillant properties in terms of monitoring practices and risks, as well as safety aspects. How employees working among the technologies were (or were not) informed was discussed through a construction worker perspective, as well as an overall level of awareness. Lastly, different contextual values associated with the technologies implemented were discussed, such as privacy and security. Overall, positive attitudes towards technologies and sensors were found and less attention given to its risks and privacy and security implications. Furthermore, privacy is often seen as a 'box to be ticked', rather than seeing the benefits associated with it. More attention should be paid to this, as well as aspects related to safety, privacy, and security in general.

**KEY WORDS:** *Construction industry, technological innovation, workplace surveillance, privacy, security*

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# 1. Introduction

The workplace is increasingly digital. In fact, according to a Forbes' article, 25% of all jobs in North America will be done from home by the end of 2022 (Robinson, 2022). Adopting new technologies for various purposes, many sectors have adapted and benefited from the implementation of innovative technologies. Applications on computers to schedule meetings, keep track of time, or even monitor employees have been accompanied with great benefits for organizations (Cijan et al., 2019). For example, Gerten and colleagues (2018) found that digitalization specifically enables the monitoring of employees more. This process accelerated during the COVID-19 pandemic, where new monitoring techniques were implemented to ensure employees were working productively from home. Since the pandemic has calmed down and working from home is less of a necessity, the workplace for many had been changed drastically. With these options to work from home still available because of these new technologies, many companies are now even more digitalized than before (Amankwah-Amoah et al., 2021).

One sector seemingly lagging in the move toward a more digitalized workplace is the construction industry. It is an old sector, and one that is essential to society. It has developed its own standards, work practices and overall efficiency and safety measures over time through the implementation of better work schedules, safer working conditions and the implementations of new machinery (Kulkarni, 2007). However, although the standards have improved over time and the implementation of machinery has moved to advanced stages, further modernizing and innovating the industry has been slow coming (Aghimien et al., 2018).

This lack of digitalization within the sector caused the start of the ASHVIN project. As a European Commission funded Horizon2020 project, ASHVIN hopes to enable the European construction industry to improve levels of productivity while reducing the cost and guaranteeing employees' safety. A proposal will be provided, containing a wide digital twin standard, meaning "an open-source digital twin platform that integrates IoT ('Internet of Things') and image technologies, alongside a set of tools and demonstrated procedures to apply the platform and the standard proven to guarantee specified productivity, cost, and safety improvements" (ASHVIN 'About' page, n.d.). All these technologies are to be deployed at select 'demo sites', meaning construction sites used to demonstrate the purpose and usefulness of these technologies.

In large scale projects like these, it is important to not only guard aspects such as safety, cost, and productivity, but also consider privacy and security implications of such innovations. Digitalization is encouraged, but only with the right privacy and security measures in place, considering all people working with, or creating these technologies. To

understand thought processes of these various stakeholders, this study adopts an explorative nature. The goal of this thesis is to research the meaning making processes of ASHVIN stakeholders with regard to sensors and technologies (to be) deployed at the demo sites. Gaining an understanding of their thought processes and aspects that they deem important are of great benefit in further exploring and specifying measures to be taken when implementing the technologies on a broader scale. This study therefore answers the following research question:

*How do employees working in the construction sector make sense of the technologies implemented or to be implemented by ASHVIN?*

This research takes an empirical approach in understanding the sense-making processes of technologies (to be) implemented by ASHVIN at construction sites. This serves as a starting point to develop best practices for ASHVIN to consider when deploying the technologies at the sites, as well as in the development of the ASVHIN platform. This is crucial in the further progress of the platform as it becomes a wider used tool within the construction industry. Identifying its risks and best practices early on is essential in this process.

### **1.1 Scientific relevance**

The effects of technologies in the workplace have increasingly been the focus of many studies. For example, during the COVID-19 pandemic, different surveillance techniques within the workplace were implemented due to employees and employers forced to work from home. Blumenfeld and colleagues (2020) have looked at changes particularly evident in employee surveillance as a result of the pandemic, as new technologies were implemented during that timeframe to match the visibility employers had of the work their employees carried out before the pandemic (Blumenfeld et al., 2020).

Although workplace surveillance has been studied within various sectors, such as in airports (Anteby & Chan, 2018) and during checkups of hotels (DiDomenico & Ball, 2011), research on this topic within the construction industry remains limited. Both how employees within this sector make sense of surveillance and what effects this can cause have not been the focus of research. Additionally, although a substantial amount of research explores digital twin technologies and what they are and could be used for, there is less research done on the potential within the construction industry. These are some important points to be addressed, and this research takes part in bridging this gap.

Furthermore, as discussed by Rosenblat and colleagues (2014), literature on surveillance in a more general sense offers descriptive explanations about monitoring in the

workplace, but specific metrics are still missing in attempting to understand how it can change overtime. There is an existing feeling that surveillance is always paired with feelings of invasiveness, but since the discussions still only take place at a descriptive level, real changes are not yet made (Rosenblat, 2014).

This thesis bridges a gap between the more technological adaptations of the sensors and other technologies implemented at construction sites and the effects this has on the stakeholders working with it. Through this a better understanding can be reached on not only the technologies themselves, but also any unintended surveillance practices that they might exert in.

## **1.2 Societal relevance**

Construction workers are currently interacting with these technologies during their daily activities. The reasoning for the employment of these technologies is to ensure their safety and that of others throughout the construction site. However, this may have consequences for how workers navigate their tasks, as well as how they feel. Grasping how the workers make sense of the new technologies can help further understand how employee surveillance affects their work, as well as their wellbeing. Employee monitoring is not new in other industries, it is only being exacerbated by the advent of new technologies, data collection and analysis methods. In the construction industry the correct employment of these sensors and technologies may help avoid life threatening injuries. However, it can also stigmatize employees and be used to make decisions averse to their interests. This is extremely important for the wellbeing of the construction workers, as well as for employees in other fields. As mentioned before, new technologies are implemented within the workplace, but not enough thought has been given to how employees make sense of these surveillance technologies and how this can potentially affect work performance and wellbeing of the employees.

## **1.3 Structure**

This research adopts an inductive qualitative approach through conducting in-depth interviews. The interview guide is constructed based on an extensive theoretical framework, to be found in Chapter 2. Followed by this, Chapter 3 provides an elaborate explanation on the methodology, and in Chapter 4 the results of the data analysis are presented. Lastly, Chapter 5 provides conclusive thoughts based on these results through answering the research question, as well as suggesting potential limitations and opportunities for future research.

## 2. Theoretical Framework

This chapter provides an overview of the theories, concepts and frameworks related to the research question. First an overview of the digitalization in the construction industry is discussed, together with limitations and how this digitalization process could be further improved in the future. After this, the concept of workplace surveillance is tackled. First the definition and origin will be discussed, and then an employee and employer perspective on the topic will be explained. Adopting the perspective of the employee, the impacts and behavioral outcomes of workplace surveillance are explored. The perspective of the employer analyzes the several reasons they may engage in employee monitoring. Following this, various risks of workplace surveillance are stated and explained, as well as how to mitigate these. Lastly, a description of specific privacy issues related to technologies is given through the explanation of two theories: communication privacy management and contextual integrity.

### 2.1 Digitalization in the construction industry

Different industry sectors have digitalized their operations over the years. However, COVID-19 has accelerated this process, forcing more aspects of work towards digitalization (Amankwah-Amoah et al., 2021). The construction industry is lagging in this process in comparison to other sectors, but has been making an effort to change. In Australia, Leviäkangas and colleagues (2017) found that the Australian construction industry has accepted technological developments, but that it does not have the tendency to take a big leap towards it (Leviäkangas et al., 2017). Overall, the scientific literature suggests that some effort is put into digitalizing processes, but more could be done to further improve this. Elghaish and colleagues (2020) state that only recently the construction industry has been more accepting of this, such as through the implementation of information technologies in the sector (Elghaish et al., 2020). Furthermore, Kudryavtseva and Vasileva (2021) also discuss that, whilst the industry is at the economic forefront, digitalization processes on the other hand are met with resistance (Kudryavtseva & Vasileva, 2021).

Aghimien et al., (2018) studied the benefits of digitalization present at construction sites in South Africa. Digitalizing the design and feasibility phase, Aghimien and colleagues (2018) found this to be beneficial for a faster delivery of construction projects because of an increased speed of work, productivity, and simpler working methods. Tanga and colleagues (2021) also investigated the digitalization of the construction industry in South Africa. They found that, when implemented correctly, information and communication technologies lead to improved productivity, work being done faster and diversification (Tanga et al., 2021).



Rogers (2019) has looked at digitalization within the construction industry from a software perspective. Software developers have largely invested in offering digital services to construction industry companies. Although initially slow in accepting this as an option for improvement, a change was seen in the companies' attitudes as technology became the standard in other industries as well (Rogers, 2019). This resulted in a process of change towards using different digital solutions for many issues, such as realizing better time and risk management, among others (Rogers, 2019).

The research done gives the overall idea that digitalization within the construction industry brings along many benefits, as well as progressively becoming the standard within the industry. However, Meno (2020), in his book on digitalization of South African construction sites, states that it has only been implemented at a basic level, for example by using phones or computers. More advanced technologies using virtual reality, IoT, and drones or sensors are yet to be implemented. Meno (2020) argues that, if these are introduced, human and financial risks, security-related and legal risks, technological risks, and operational risks are important issues to consider. Among the human risks, Meno (2020) mentions that of psychological issues, where workers may feel uncomfortable because of surveillance technologies on site, which can have negative effects on occupational health (Meno, 2020). Within ASHVIN, the implementation of technologies such as drones, sensors and IoT ('Internet of Things') is currently in process, stressing the importance of a worker perspective on the technological developments within the construction industry.

## **2.2 Workplace surveillance: a complicated and developing concept**

Workplace surveillance has existed long before computers, and the internet. However, it has only been recognized as such since the beginning of the 1980s (Ball, 2010). In the beginning of the 20<sup>th</sup> century, employers were already exploring technologies and structures to help with efficiency and integrity of labor and business. Frederick Winslow Taylor, a mechanical engineer, was one of the first to employ measures of 'performance monitoring' to help meet production targets (Sewell, 2005). The Taylorist way of thinking was "the unobserved worker is an inefficient one" (Rosenblat et al., 2014, p. 2). This raises some ethical concerns, as Introna (2003) argues in his work on employee monitoring. He argues workplace surveillance to be unethical and unfair to employees, and ethics in this case should not simply be considered, but also acted upon when surveilling workers (Introna, 2003).

Introna's point holds true in today's managerial supervision. Technological improvements have made surveillance more palpable, with the increasing variety of monitoring practices available today (Rosenblat et al., 2014). Especially in recent years, concerns around workplace surveillance have increased as a result of the COVID-19 pandemic. Temporary forms of surveillance, used particularly for remote working solutions,

are now being extended and used when people are no longer working remotely (Maalsen & Dowling, 2020). Furthermore, the boundaries between workplace and private space are put into question, which puts the workplace surveillance boundaries in a complicated context. (Rosenblat et al., 2014).

The current, most used, definition of workplace surveillance is that of Ball (2010). She conceptualizes it as management monitoring, tracking, and recording its employees, based on performance, behaviors, and personal characteristics (Ball, 2010).

### **2.3 An employee perspective on workplace surveillance**

As ethical issues become more prevalent, recognizing employee perspectives is crucial to better understand the process of workplace surveillance. Monitoring employees can have varying impacts, depending on the individual and type of surveillance technology. It can result in various responses, such as compliance or resistance, which should in turn be mitigated.

#### *2.3.1 Impacts on the individual*

Differences in individuals affect acceptance of workplace surveillance. White et al. (2020) studied the impacts of various digital monitoring frameworks through a psychological lens to explain individual differences in the responses to these forms of surveillance. They suggest that, while the employer is authorized to monitor its employees, employees have built-in attitudes, beliefs, and expectations on how they should be treated during their work hours (White et al., 2020). For example, Yost et al. (2019) found that individuals with a higher level of trait reactance are more susceptible to threats against their freedoms, leading to often oppose the surveillance they are under (Yost et al., 2019). On the other hand, personality traits such as extraversion and emotional stability are associated with experiencing digital monitoring as more positive (White et al., 2020). Furthermore, Laird et al. (2018) argue that higher levels of self-efficacy also moderate the effects of digital monitoring (Laird et al., 2018).

Differences in surveillance technologies also influence reactions of those monitored. For example, technologies using biometrics, such as scanning of fingerprints or facial expressions, tend to be experienced as more invasive, leading to stronger reactions among employees (Crampton, 2019). Furthermore, newer devices used for emotion monitoring to identify, for example, high levels of stress are also often seen as more invasive by the employees. Moore (2018) critically argues that, although developed and used with the right intentions, these monitoring devices feel personal and invasive to workers (Moore, 2018). Next to the devices themselves, Ball (2021) argues that employee reactions are also depended on data collection processes, as well as how this is used over time. When these

are not clear, employees voice concerns related to potential data breaches, unethical use of data by outsiders and discrimination (Ball, 2021).

### *2.3.2 Behavioral outcomes*

Employees make sense of the type of workplace surveillance they are under differently, causing different sensemaking processes and different behavioral outcomes. These responses are not directly tied to one personality trait or specific monitoring device, but rather a combination of these, as well as other factors. For example, as argued by Sewell et al. (2012), employees' attitudes towards surveillance are as changeable and episodic as the resistance it can result in (Sewell et al., 2012). The main reactions from employees are to either resist, comply, or to try and control or limit the effects of surveillance. Two main reasons determine compliance or resistance: the potential unintended use of technologies, and whether these unintentional effects can be avoided in the future. The specific technological design can also affect employees' decisions to comply or resist, by refusing to accept the surveillance that they are under (Sulzhenko & Holmgren, 2020).

When an employee complies with the surveillance technology they are under, this means they do not exert any resistant behaviors, and often have a positive outlook on the surveillance practices and how it is beneficial for both the employer and themselves (Sulzhenko & Holmgren, 2020). Resistance happens when an employee does not agree with the level of surveillance they are under, because of the technology itself, their personal beliefs, or a combination of these. As abovementioned, individuals with high trait reactance are likely to engage in counterproductive work behaviors as a result of negative feelings towards being monitored (Yost et al., 2019). For example, as researched by Anteby and Chan (2018), employees will avoid CCTV cameras to resist being surveilled (Anteby & Chan, 2018). Overall, resistance is more likely when surveillance technologies are hard-wired, or unavoidable, and when technology is experienced as excessive and punitive (Bradbury, 2019).

Employees can also attempt to control or limit the effects of monitoring. This is a middle way to deal with surveillance experienced as intrusive. DiDomenico and Ball (2011) researched the extent to which bed and breakfast owners tried to manage their identities and exposure through board inspections. For example, when being assessed, the owners verified the evaluation criteria against that of their competitors, as well as checking levels of consistency and fairness (DiDomenico & Ball, 2011). These behaviors do not result in the active resistance of surveillance, but rather slightly alter the results of the monitoring the bed and breakfast owners are subject to.

## **2.4 A managerial perspective**

Employees are an important, and often underexposed, part of workplace surveillance, but it is important to also consider the managerial perspective, as they have different reasons to impose monitoring measures on their employees.

The first of these reasons to engage in workplace surveillance is that of increased productivity. As mentioned by Ciocchetti (2011), both employers and employees have a love hate relationship with technologies in the workplace. Where employees using computers might feel more like checking social media statuses, employers can use technologies to surveil and expose these exact activities in the name of worker productivity (Ciocchetti, 2011). Changes in society such as the COVID-19 pandemic have caused a lot of employees to move from the office to a home office. According to Wang et al. (2021), this has differing effects on worker productivity. Where some feel more productive, others are less productive and overall work performance is harder to oversee by employers. To be aware of productivity levels of employees, managers have opted for more forms of digital monitoring in the name of worker productivity (Wang et al., 2021).

Another reason for employers to engage in workplace surveillance is worker safety. This is also closely linked to new surveillance techniques employed by ASHVIN in the construction sites, where the wearing of helmets and harnesses can be checked. The construction sector in general is one with a high risk and many accidents, due to construction workers operating in a danger zone (Ulang et al., 2014). To minimize the risk and improve worker safety, various surveillance measures are researched and tested. For example, Fang et al. (2018) have investigated the detection of harnesses and hardhats on construction workers through deep learning with the goal of increased worker safety (Fang et al., 2018).

Lastly, employers engage in workplace surveillance to avoid negative publicity and protect themselves against outside sources. As mentioned by McParland and Connolly (2020), abusive or offensive materials circulating within the company can result in negative publicity. Furthermore, outside sources could abuse their technologies, such as email systems or other platforms used, increasing the necessity for them to be monitored. This minimizes opportunities for ill-intended outsiders to abuse the organization's systems (McParland & Connolly, 2020).

## **2.5 Risks surrounding workplace surveillance**

Looking at the abovementioned issues, workplace surveillance has its risks. Two main trends occur here: due to datafication, employees are more visible to their employers and organizations, and the private-public boundary is constantly challenged because of increased visibility. This can lead to psycho-social risks. Identifying these can help avoid issues such as decreased job satisfaction, increased counterproductive work, resistance, and an increase of

stress levels (Ball, 2021). The main risks related to workplace surveillance are that of function creep, lack of transparency and level of invasiveness.

The first risk related to workplace surveillance, and surveillance in general, is function creep. Function creep is defined as extending the use of a system or technology beyond the purposes it was intended for (Koops, 2021). Ravid et al. (2020) concluded that employees' reactions to surveillance are impacted by the purpose for which it is used. Within ASHVIN, safety monitoring is used as a form of surveillance, and Ravid et al. (2020) show that these ways of monitoring are often deemed acceptable by employees. The risk here lies in not providing a recognized purpose for the surveillance, as employees will deem it excessive. This can in turn decrease perceptions of fairness, justice, and satisfaction, as well as trust in the organization and autonomy (Ball, 2021).

The next psycho-social risk factor is the lack of transparency. This occurs when the reasons behind monitoring or surveilling employees in the workplace are not correctly communicated (Ravid et al., 2020). If, as mentioned above, the organization is not able to give the purpose of monitoring or is not transparent about this, this can lead to a decrease in performance among employees, as well as perceiving the monitoring as authoritarian and without a purpose (Ball, 2021).

The level of invasiveness of monitoring employees is also important. As discussed by Ravid et al. (2020), how invasive surveillance is depends on a few aspects. For example, biometric monitoring and movement technologies were experienced with high levels of invasiveness, resulting in stronger emotional responses and higher resistance levels (Ball, 2021). Furthermore, it can damage relationships between the organization and its employees, making employees feel untrustworthy, which then impacts fairness and privacy perceptions (Ball, 2021).

## **2.6 Privacy in the context of technologies, CPM and Contextual Integrity**

As previously discussed, employees raise various types of privacy concerns in response to being surveilled by their employer. Although they stem from various reasons, privacy seems to be a large underlying factor in this process. Especially through increased use of technologies in the workplace, this tension between privacy and technology usage seems to increase existing concerns.

New, innovative technologies allow for easier ways of collecting and merging data. As the collection of personal data has become easier, the privacy concerns regarding the gathering and usage of this data have grown (Solove, 2004). Overall, the tension between privacy and technology has increased greatly since first introduced by Mayer-Schonberg in the second half of the 20<sup>th</sup> century. Where back then, only small amounts of data were associated with privacy concerns, nowadays digitalization allows for extensive data collection

(Agre & Rottenberg, 2001). Various online platforms permit extensive data streams to be collected, further complicating the privacy issues associated with it (Solove, 2004). In general, as argued by Morizio (2016), individuals often lack understanding of how and which data is collected on them. Although there are laws and regulations put in place, this lack of understanding causes individuals to easily disclose personal data to obtain various benefits, without thinking of its consequences (Morizio, 2016). In the instance of wearable devices, such as fitness trackers, little information is provided on data collection, usage, and detention period, indicating a clear lack of transparency. Despite this, users will easily provide this data to reap the benefits, suggesting a lack of understanding and awareness of privacy issues related to it (Crossler & Belanger, 2017). Relating this back to employees and workplace surveillance, if they are not aware of the lack of transparency in data collection, they will not understand the privacy issues and therefore won't be able to act on it.

### *2.6.1. Communication Privacy Management*

The relationship between people and the protection of their own information is complex. The theory of Communication Privacy Management (CPM) explains how people are either willing or not willing to share their personal data (Petronio & Durham, 2015). CPM looks at how personal data is treated by people and based on this, suggests their attitudes and feelings towards privacy. It indicates that private personal data are managed effectively based on three factors: Privacy ownership, privacy turbulence and privacy control (Petronio, 2013).

Privacy ownership addresses how the ownership of personal data is dealt with and how it is recognized. Petronio (2013) argues that individuals tend to believe that they are the exclusive owners of their personal information and that they have trust in the idea that they can either protect their data or grant someone or something access to it. This means that the rights to that data can either be restricted or shared. When this 'ownership' is shared, others become co-owners, and the individual perceives this new owner to have honest intentions and responsibilities towards the data. This co-ownership can consist of multiple people or groups and can take up varying amounts of time (Petronio, 2013). According to Petronio (2013) "the notion of co-ownership has made a significant contribution to seeing privacy issues and disclosure as relational in nature" (Petronio, 2013, p. 9).

The next factor is that of privacy control, which represents the engine responsible for granting or denying access to private data. Because individuals believe they own the rights to their information, they also believe they control who has access and who does not, even after assigning specific 'co-owners'. Furthermore, people control their private and personal information by developing and using privacy rules, derived from decision criteria like situational needs, cultural beliefs and motivations. These criteria can be divided into either core or catalyst criteria (Petronio, 2013). When looking at privacy rules, these core criteria

embed the fixed indicators used to make choices about specific rules, such as newlyweds both bringing their own familial privacy views and beliefs into the marriage. Catalyst criteria explain the shifting and merging of those familial, preexisting privacy rules, towards new ones in order to accommodate the needs of your partner (Serewicz & Canary, 2008).

Privacy turbulence is the last factor of CPM, and explains the unpredictability of privacy regulation. This unpredictability can vary from minor disturbances to complete breakdowns. Privacy turbulence has become increasingly interesting, as it puts into question why specific privacy systems break down, which can in turn lead to solutions and prevention. It shows the need for change in privacy management systems with regard to its set out rules and expectations (Petronio, 2013).

Depending on either of these factors, initial privacy ownership, control or turbulence, people's attitudes and beliefs toward privacy can change. This is also a phenomenon present in workplace surveillance, where employees' attitudes toward monitoring can change depending on their personal characteristics, technologies used, and type of data collected. Watkins Allen and colleagues (2007) studied CPM in relation to the workplace. They researched how employees manage their information and its boundaries in terms of what to keep private when electronically monitored. These privacy related boundaries are established when an employee starts working, where these surveillance practices are either described as positive for the employee and/or company, or as a form of coercive control. Boundary turbulence did not appear much, but the boundaries are repeatedly articulated by employees (Watkins Allen et al., 2007).

Smith and Brunner (2017) also researched CPM. They studied decision making processes of employees in terms of which information they would disclose or not disclose at work, and CPM was used to understand the management of their private information. They showed that specific core criteria were motivations for employees to either conceal or reveal in the workplace. Maintaining boundaries based on organizational culture was an important factor, as well as considerations related to relationships, considerations based on risk versus benefit, or a desire to get feedback. Next to this, the employees also used, for example, retaliation to restrict and reply to turbulence (Smith and Brunner, 2017).

### *2.6.2 Contextual integrity*

Contextual integrity takes up an important part in the privacy realm. Nissenbaum (2004) used it to explore privacy implications in various academic fields. Rather than looking at privacy dichotomously, as a contradiction between public and private, it should be seen relationally, considering expectations about suitable information flows where the contextual norms become more critical (Nissenbaum, 2004). The theory of contextual integrity identifies a framework made up of three principles, namely privacy protection against intrusive

government agents, limiting access to confidential, sensitive or intimate information, and restricting invasions into areas deemed private (Nissenbaum, 2004).

These three principles provide an idea as to individual authority over varying levels of shared information, either government or public information and non-sensitive and sensitive information (Nissenbaum, 2004). However, they do not consider how the function of privacy and its management is not always clear, especially involving issues relating to new innovations in technology application for example. Therefore, the theory of contextual integrity emphasizes greatly on information flows, through presenting a framework to understand particular behavioral patterns concerning to the privacy issue (Barth et al., 2006).

The four variables in this framework are appropriateness, roles, informational forms, and principles of transmission. Appropriateness addresses which nature the information of individuals has for it to be seen as appropriate to share. Next, specific roles taken on might influence an individual's decision-making process in seeing something as a violation of privacy. Third, which forms information takes on also affects people's willingness to share or not, for example being either public or private, or sensitive versus non sensitive. Lastly, the principle of transmission places restrictions on the information flows, bases on the form of information shared (Barth et al., 2006). For example, as Nissenbaum argues (2004), within this principle confidentiality is critical, where the information shared is expected to stay between the original owner and its new 'co-owners' (Nissenbaum, 2004).

Contextual integrity has also been used to explain workplace surveillance phenomena, such as during the COVID-19 pandemic. Vitak and Zimmer (2020) researched the disrupted balance between public health concerns and privacy of citizens. Evaluating tracing apps set up to combat the virus and minimize the virus to spread, they state that the process of data sharing should be contextually dependent. Factors such as accessibility and transmission principles should be taken into consideration when discussing data transfer. They furthermore argue that one should be cautious in violating contextual integrity, even for causes such as 'solving' the pandemic, because of long-term related risks such as autonomy loss and function creep (Vitak and Zimmer, 2020).

The theoretical framework presented in this chapter helps understand the restrictions on the perceived privacy issues people have and how critical the protection of specific personal or private information is. Furthermore, contextual integrity in particular offers nuance to reasons for the specific limitations concerning collected data, the notion of public areas, and bases of information flows.



### **3. Methodology**

Based on the theoretical concepts from the previous chapter, the research adapts a qualitative in-depth analysis to understand how various stakeholders within the construction sector make sense of the implementation of new technologies and sensors. In this chapter the methodology is discussed in detail, discussing all aspects of the research design.

First, a general description of the research design is provided, including the sampling method, operationalization, and data collection process. After this, the chosen data analysis procedure is explained, as well as critically reflecting on the research design and, lastly, considering some ethical principles to keep in mind.

#### **3.1 Qualitative approach and in-depth interviews**

The aim of this thesis is to understand how people working with new technologies on construction sites make sense of them, and their surroundings. Next to this, it aims to better understand the position construction workers find themselves in, as they are working in a sector aiming to become more digitalized. These aspects require the finding trends and underlying opinions, as well as gaining a better understanding of the meaning making processes of the participants interviewed. Aligned with the methodological literature by Babbie (2013), a qualitative method is therefore most appropriate for this thesis.

The specific method chosen to reach these research goals is that of in-depth, semi structured interviews. As mentioned by Johnson (2002), in-depth interviews are used to get to 'deep' knowledge about everyday life experiences, events, places or practices of participants. It is a collaborative effort, as both the interviewer and interviewee need to search for this level of deeper understanding. The interview process will result in creating meaning together through a semi structured approach (Johnson, 2002). The semi structured set up allows for diversion to delve more into specific topics or ideas the interviewee might have, whilst keeping structure in terms of main topics needed to be discussed (Gill et al., 2008). In-depth, semi structured interviews here are seen as the best way to come to an understanding of how employees developing and using new surveillance technologies make sense of them.

The sensemaking process is an intricate one. According to Weick (1995), sensemaking is an ongoing process and each new event that is needed to make sense of is prompted by uncertainty and doubtfulness, which results in the creation of meaning (Weick, 1995). Next to it being an ongoing process, sensemaking also includes other aspects: identity construction, it is retrospective, focused on and by extracted signs, plausibility driven, enacted through environment and the social (Mills et al., 2010). The semi structured nature of in-depth interviews helps to consider all these aspects in the sensemaking process, as it is

a flexible approach. Whilst giving some guidance on what to discuss, it allows for the discovery of these different underlying aspects as well (Gill et al., 2008).

Although focus groups could also be considered for this research, interviews were deliberately opted for. Firstly, as stated by Mills et al. (2010), sensemaking is an individual journey. Through the interview process, the employees working in the construction sector can explore these different aspects in-depth more comfortably. Furthermore, as argued by Guest et al. (2017), interviews are considered to be as effective, and sometimes more effective than, focus groups in terms of generating a list of topics within a specific domain (Guest et al., 2017). Furthermore, focus groups collect different types of data in comparison to in-depth interviews. Whilst in focus groups the richness of interaction between its participants is the primary goal, interviews focus more on having an in-depth conversation about a particular topic (Guest et al., 2017). In-depth interviews are most suited for this thesis, as the way the participants navigate themselves around the sensors implemented by ASVHIN differs from individual to individual. As can be seen in the theoretical framework, the effects workplace surveillance has depends on the individual, which in turn influences the type of response to it (Ball, 2021). Therefore, it is through in-depth interviews this individual sensemaking process can best be unraveled and discussed.

The interviews with stakeholders in the ASHVIN project took place both on- and offline, as COVID-19 has complicated some of the interviews being conducted on site. The participants were selected through a gatekeeper, namely the consortium partners of the project, who helped find participants to interview. All participants interviewed are presented in the table below. In the name of ethics, all names are pseudonymized.

**Table 1**

*List of participants and job descriptions*

Austin <i>Head of team 'reality capturing'</i>	Using drones, 3D laser scanners and pano cams, among others, to gain information from construction sites and develop technologies to assist construction industry.
David <i>PhD candidate civil engineering</i>	Developing the ASHVIN platform, creating and placing sensors at construction sites to collect data and create digital models.
Lindsey <i>Head of research and innovation</i>	Working with industrial researchers with focus areas on digitalization and digital twins within the ASHVIN project.
James <i>Civil engineer</i>	Implementing innovative aspects at construction sites in terms of building structures, strategical building.
Patrick <i>Construction site manager</i>	Contracting construction companies, scheduling work hours and overall time management.

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Chris <i>PhD candidate engineering</i>	Building sensors for the ASHVIN project, collecting and processing sensor data to create digital twin models.
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Additional to the interviews, discussions in ASHVIN meetings (i.e., meeting minutes) were analyzed using the same method as the interview transcripts, to see how the decision-making processes played out, and which aspects in discussions were deemed important by various actors within the project. Data was collected using meeting minutes from eight meetings discussing sensors and other technologies implemented by various partners of the project. This was deemed important to not only understand meaning-making processes at an individual level through interviews, but also at a group or project level. Analyzing these discussions and decision-making processes strengthened the research by adding an additional layer of understandings of the technologies (to be) implemented by ASHVIN. This project level understanding combined with the individual level bettered the quality of collected data, as these two levels greatly supported and strengthened each other.

### *3.1.1 Sampling method*

The sampling method used for this research is that of convenience sampling and snowball sampling for the interviews, and random sampling for the meeting discussions. Although not ideal, convenience and snowball sampling were the only way to reach various contacts related to different ASHVIN demo sites. Gatekeepers of these construction sites were present, providing the participants available to interview. This meant that, for example, a representative of ASHVIN joined the construction site visit, and introduced participants selected by him or her. Next to this, some of the participants also had contacts with other participants relevant to this research. As the research question relates to sensemaking processes of individuals regarding the new technologies implemented on construction sites, getting different opinions from people in varying positions strengthened the data collected. It allowed the ability to create a well-rounded idea on the effects these technologies may have on participants within the project, and in turn the construction workers operating and working among them.

A few criteria were set out for the research participants. First of all, the interviewees had to know ASHVIN and the existence of the sensors and other technologies implemented at the demo sites. This knowledge, depending on the participant, did not have to be in-depth, but rather a general overview of how these operate. Next to this, a requirement was to have some affiliation with the construction industry to fully understand and be able to answer all the questions.

### *3.1.2 Operationalization*

After deciding the general route to be taken to approach the research question, an interview guide was drafted to help achieve its objective of uncovering the sensemaking processes of the participants. All relevant aspects are present in the guide, however, since the interviews are semi-structured, not all topics were always discussed, or discussed in the same order.

After confirming the interviewees' consent, a brief introduction took place, in which their current jobs and the regular workday were discussed. The next topic is the use of technologies in the workplace in a general sense, and how this has made a difference. Then the implemented sensors were discussed, as well as interviewees' expectations of these. After this, data concerns regarding the sensors and the construction workers was emphasized. Security issues with the sensors were also discussed, as well as which information the interviewees received about the technologies before navigating them. Lastly, the future of the technologies and the construction sector were discussed, as well as potential improvements for the technologies in terms of safety, privacy and security.

An interview is deemed successful if an understanding of the interviewee's thoughts and ideas towards the technologies (to be) implemented on the construction site is clear. Also, which aspects are emphasized by the participant is important, whether these align with some aspects originally mentioned in the interview guide or not. For example, although the initial thought was to gain insights on people's perceptions on privacy in relation to these technologies, other ideas or aspects, such as sustainability and worker efficiency, have come up along the way and are also relevant to the research.

### **3.2 Data analysis**

After the interviews were conducted and in-meeting discussions were gathered, the interviews were automatically transcribed by either the auto transcribe feature of Teams itself, or the transcribe function in Word. Although giving a nice overview of some initial thoughts and answers, the transcripts had to be cleaned up, as well as adding the right timestamps and removing the interviewees' names. Once this process was done, the transcripts and meeting notes were analyzed using a thematic analysis, as set out by Braun and Clarke (2006). This form of analysis works well, as it reduces the vast amount of data into a few key arguments, as well as allowing to show differences and similarities in the answers provided by the participants and aspects mentioned in the discussions. Furthermore, the development of themes through the analysis of the transcripts causes unanticipated insights to be found, which are not directly present when initially going over the data (Braun & Clarke, 2006).

As stated by Braun and Clarke (2006), the term thematic analysis is often loosely used and confused with different names for similar analyses, such as qualitative content analysis (Braun & Clarke, 2006). This thesis adopts the steps set out by Braun and Clarke

(2006) and therefore also use the term 'thematic analysis', rather than other similar vocabulary to describe similar analyses. In general, many forms of this type of analysis, such as qualitative content analysis, although not claimed as such, are essentially thematic, as it is based on the deriving of themes through in-depth analysis (Braun & Clarke, 2006).

Braun and Clarke (2006) discuss both semantic and latent themes. Semantic themes are found at a surface level of the analysis, describing exact aspects mentioned by participants and finding themes. The latent level of themes goes beyond the surface and dives deeper into underlying meanings, motivations and ideals present in the answers of the participants (Braun & Clarke, 2006). Although this research finds some semantic themes, latent themes were mostly opted for, as the research question investigates the sensemaking processes of individuals in terms of working with new technologies. The semantic level does not allow the same level of deep understanding these latent themes provide to, in turn, be able to properly answer the research question.

The thematic analysis used in this research consists of six phases: familiarizing yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (Braun & Clarke, 2006). In the familiarization of the data, all interviews were transcribed, which already allowed more familiarization with the data, as well as looking over the meeting notes. After this, the data was read over again, already producing initial ideas and noting these down. Next, in the step of generating the codes, the data was looked through again and the text was systematically coded, picking out interesting and relevant features mentioned by participants, and interesting reasoning behind arguments mentioned in the meetings. After this, the codes were put together and grouped in initial themes, based on first notes and codes found in the texts. The themes initially created were checked with all derived codes, as well as with the overall dataset and initial notes, through which a thematic map of the analysis was generated. Continuing the analysis, the themes were further defined and specified, as well as zooming out and looking at the overall story of the analysis. Lastly, the analysis was finalized, in which a specific selection of quotes was used to explain themes and sub-themes, as well as linking it back to the overarching research question.

### **3.3 Critical reflection**

Reliability and validity will be discussed as part of a critical reflection of this research design. As defined by Babbie (2011), reliability refers to a tool to measure quality, in terms of suggesting the data to consist of repetitive observation of the same trend on several occasions (Babbie, 2011). The data collected in this research, although building on existing data, is mainly new, as the technologies employed by ASHVIN are only recently implemented, and research on the construction site and the implementation of these

technologies is limited. A view on workers and others interacting with these sensors and technologies has not been presented before. This means that, initially, its findings cannot be checked or extensively linked to existing data, which makes checking the reliability more complicated. However, findings similar to research done within other sectors can serve to check its reliability, as well as a test-retest method being possible through a different researcher using the same interview guide in the future. Next to this, other researchers were asked to see how they interpreted the findings, leading to similar results.

Babbie (2011) defines validity as determining if the research design is accurately measuring the concept it is supposed to measure (Babbie, 2011). It could be argued that through the operationalization of all concepts and developing the interview guide based on existing literature validity has been established. However, Cypres (2017) stresses that validity in qualitative research cannot be measured in the same ways as is measured in quantitative research (Cypres, 2017). Keeping this in mind, although validity is seen as an important aspect within the scope of this research, it cannot be unarguably guaranteed.

Lastly, it is important to mention that, in qualitative research, each researcher individually values different aspects within the study they are conducting, to which this study is no exception. As mentioned by Moisander and Valtonen (2006), features that can affect the quality of the data are relevance and understanding, transparency and methodological consistency, and sensitivity towards the specific topic (Moisander & Valtonen, 2006). These criteria were considered throughout the process of conducting this research to ensure its quality, as well as checking with colleagues to ensure a similar understanding of the data throughout the process.

### **3.4 Ethics**

Ethical principles are important to consider, and a few practical steps were taken to ensure this. First, as this research is part of a Horizon2020 project, an Ethics Application was submitted to the EUR Ethics Committee. This procedure consisted of creating a consent form according to EUR guidelines, as well as constructing a Data Management Plan. After multiple rounds of reviewing the proposal by privacy officers, these documents were both submitted to the EUR Ethics Committee, who approved of the research project.

During the interview process, the ethical principles set out by Resnik (2015) provided a guideline during the interviews, namely ensuring honesty, integrity and sincerity (Resnik, 2020). Throughout the interview process, participants were aware of what they were interviewed for, as well as being able to opt out at any point. Furthermore, apart from 'ASHVIN', no real names or company names are present in this research, ensuring the participants anonymity.

In terms of the in-meeting discussions, all people present in the meetings were notified, as well as the coordinator of the ASHVIN project being asked to approve this analysis. All individuals present in these meetings had the opportunity to opt-out, after which discussions in which they were included would not be used for analysis.

## 4. Results

In this chapter the main themes derived from the analysis of the interview and meeting data will be presented. The analysis resulted in five main themes, namely: positive about technologies, technological future, being watched with a subtheme on a construction worker perspective, and technologies put in other contexts. All these themes also consist of various subthemes, also explained below together with quotes from the participants.

### 4.1 Technology as a positive asset

This theme discusses positive attitudes toward the technologies employed, or to be employed at the construction sites, or in the construction industry in general. Advantages of various technologies are discussed, such as that of drones and sensors. This positive attitude towards technologies was furthermore evident in the levels of excitement when mentioning the technologies or technological developments. Another reason for this positivity was found in that of sustainability, which was mentioned as one of the main benefits of the technology and its potential. Lastly, often the technologies were mentioned as having no inherent problems, followed by which the positives were focused on.

#### 4.1.1 Advantages technologies

The first subtheme was evident in almost all interviews conducted. When discussing the technologies deployed at the construction site, such as drones, 3D laser scans, pano cams, or various types of sensors, the participants were quick to mention all the advantages the technologies have. For example, one participant stressed on the adaptiveness of the technologies and how this is an important advantage when trying to save time working at the construction site.

Another aspect often mentioned here was how technologies helped automate various processes. As one participant put it “I think that the greatest advantage of using data or sensors is just speeding up processes and automating processes of inspection and security” (Chris). Automating processes were not only seen as beneficial in terms of saving time, but also in terms of accuracy.

We always need people just to check everything. If we know how to check things, whether they are, uh, a bridge or a person, if we can monitor that using machines, the process is much faster and more accurate than with a person doing that work. (Chris)

Furthermore, as mentioned by another participant “technologies overall just make our work much easier” (Patrick), referring to the work conducted as a construction site manager, after



discussing some of the more basic technologies he is currently working with on site, such as a computer and mobile phone to plan and schedule the line of work.

Lastly, another aspect brought up by the participants was that of usefulness of technologies, particularly in relation to the building of digital models. One of the participants mentions the benefits these digital models made with sensors for architects and others involved.

Because when we make a project, it looks perfect, but then here it's a little bit different. It will be very useful for architects, for example, of properties to know if you have the right number of square meters, whereas here, there are already constructed. Or, for example, to have exactly the position of the columns and the pipes. (James)

#### *4.1.2 Excitement*

The next subtheme present was that of expressing general excitement when discussing the technologies the participants were working with or developing. This was expressed through either feeling proud or happy when talking about, for example, sensors or drones. One participant straight up mentioned “we are really happy with the laser scanners, and also the drones” (Austin). Next to this, he also mentioned feelings of sadness when asked if he was currently working with the technologies.

Sadly I haven't had a chance to go outside and use a drone or laser scanner. So that's hard for me. Uhm, it would be really great to do it, but I have no time for this ... maybe I can plan something with robots in other construction sites, or I take time for this, but for the service scanning and flight rounds, I don't think so. (Austin)

Some other participants showed their excitement not directly through words, but simply by giving very elaborate responses when asked which technologies they currently work with. One participant spent a long time explaining exactly what each type of device or sensor measures, as well as the process of installing these and collecting the data. They also showed feelings of proudness, through phrases like “we were one of the first structural offices to implement beam systems, and nowadays we only use these kind of methods” (James). They furthermore stress their proud feelings in terms of innovation.

And the thing is, despite the fact that maybe nowadays this type of post tension slab is a more widespread technology, when we have started applying it around 15 years ago, it wasn't common at all. It was rare. And this is where the innovation takes part. (James)

Lastly, excitement was shown through daily work processes in terms of the development of technologies. For example, when asked how they work with technologies on a daily basis, one participant corrected the way the question was asked in his answer.

Yeah, well, my work is basically working with computers and sensors. So, what I do is I build sensors, connect them into the web then I get data from them through the web, then I process the data in my computer. So, technology is my work, I don't use technology, I develop technology. (Chris)

#### *4.1.3 Sustainability*

Talks about sustainability were also evident within the positive attitudes displayed towards technology and their development. As stated above, innovation was part of the reason for excitement among participants. Sustainability in particular was present in many answers given, for example in terms of being aware of sustainability and contribution to a more sustainable construction site and buildings. "We are quite engaged with sustainability right now. We are aware of the global concern, and we share the global concern for the climate crisis in which the construction sector also contributes" (James). The participants then offered further explanations as to their solutions, and how they are contributing to a more sustainable future.

We are trying to make all of our structures more sustainable, and one of the ways that we apply technology on that is in the design and project stages of a building. We try to make calculations and estimations of the of the material consumption, CO2 emissions and so on and try to optimize that. (James)

They furthermore explain using various measuring devices for the construction site itself.

There are different devices doing the on-site measuring. We would look at that material consumption, so we can see how much concrete we use, how much water, and the transport of trucks on site and off site. Yeah, there are many indicators that we can that we can use to optimize the process. (James)

#### *4.1.4 Technologies: no inherent problems*

Lastly, participants were quick to dismiss any potential inherent problems of the technologies they were working with. For example, when asked about data concerns, participants would often not see any. "Yeah, the data, you could use it for other things. But we have contracts and rules, so right now we have no issues with that" (Austin). Other participants would give

some technological aspects in which improvements could be useful, instead of answering with data concerns that could result from that technology use. They furthermore mentioned that, since there is no obligation to be part of the data collection process if you do not want to, for example potential construction workers not wanting to appear on drone footage. Another participant mentioned “when they fly the drones there were no workers in this area” (Patrick), which to him eliminated potential data concerns.

Lastly, another participant also mentioned that, since no data is taken from participants, there are no inherent problems with the technologies they develop and use. He then proceeded to explain what he does measure, as to make clear that no human data is collected.

I collected data. Basically, to get an accurate description of the real state of the site. Through specific parameters or data points, for example in a bridge, I need to know how it moves, how it behaves when something is going over it, so I need to get this data to know. After processing the data, I know how the state of the bridge is and if it is working well. (Chris)

This once again shows the overarching idea most of the participants had, namely that, since most of the measurements or use of technologies at the construction site do not include humans, this means no inherent concerns or issues are found within the technologies.

## **4.2 Technology: a promising future**

This theme encompasses the many ideas and overall view of the participants of the future, and how technologies will shape this future. As most participants make or work with these technologies directly, asking about what the future can bring in terms of technological development and its benefits sparked great answers. This theme is divided into two subthemes, namely discussions about all the improvements it brings employees working with these sensors, as well as a general view on having more technologies and how this will take shape in the future.

### *4.2.1 Improvements for employees*

Participants often mentioned the various ways in which a technologically oriented future in the construction industry would be inherently beneficial for the employees working with them, naming various reasons to support this argument. For example, when asked about the future and its use of technologies, one participant mentioned that “maybe this will lead to better working timetables, and better conditions for the workers” (Chris). Other participants also

mentioned how the use of especially planning technologies could be beneficial for the workers in terms of not being over or understaffed, as well as knowing exactly when to be where.

Another participant stated that, in the future, these technologies could help the communications both between workers and between different construction companies: “Maybe we should create programs for the computer to make it easy to be in contact with other companies that are in the construction site” (Patrick). These types of answers were often paired with a conclusive thought on how this could improve not only workers’ experiences, but the construction site as a whole. As one participant stated: “yeah, they can just help improve the whole environment of the construction site” (Chris).

#### *4.2.2 More technologies*

The other idea mentioned most by participants is how the future should always contain more technologies. As many mentioned, the construction industry is an old sector and needs these technological advancements in order to improve. One of the participants mentioned how this is absolutely necessary in order to innovate.

We are focusing on trying to implement different innovative aspects in construction sites, mainly, but not limited to, in the field of trainability we are trying to report every innovative thing that we do, everything related to innovation. Then we try to report all of this and maybe publish a summary. (James)

Furthermore, the automation of processes was mentioned by almost all participants, where more technologies are used to automate many aspects of the construction process. They mentioned many examples of this, such as using drones: “So, we are looking for autonomous drones right now, we have a little garage for all the construction sites that run inside. You don't need a pilot. That's the focus for this year and next year for us” (Austin). Next to this, this participant also mentioned examples on how to automate the picture taking process, which is now part of the work of a construction site manager. “Right now, he takes a picture, puts it on a slide, and adds some words in the slide. So, we think about how we can also do this process more autonomously” (Austin). Lastly, he mentioned how the monitoring process of workers can also be automatized: “For example, how many people today are on the construction site, the technologies can count on the picture six people. ‘OK, right now you can go to work’ “ (Austin). This participant, who works with these technologies daily, also stated how these technologies are increasingly pushed to be used on construction sites, which he argued to be a big step forward in the industry.

The companies these participants work for are in line in with the ideas of the future of the participants. For example, they mentioned various ideas in which they are working towards the future with new ideas for innovative use of technologies.

We take pictures from a drone, import it automatically on a platform, like a cloud platform and then after that we create daily or weekly progress reports on that basis. So that's what's in our future right now, something we think about. (Austin)

Other, more technical ideas, especially in relation to the creation of digital models, were also mentioned in terms of what participants expect from the future. "My expectation is that with this information we can process this information and create digital models that respond to the information of the sensors" (David).

Lastly, a very interesting aspect was mentioned by one of the participants in terms of how useful these technologies are in the future. Offering a slightly different perspective, she mentioned that, although a more technological future should be strived for, which technology is useful for which purpose is important to keep in mind.

You also need to think about how will this new technology, or whatever it is, processes everything, and so on. How will it be used and by whom? Why do we introduce the new technology, like how will it support for example the site management team? (Lindsey)

Although the aim is to digitalize and implement new and more technologies, this aspect showed the importance of still asking these questions whilst doing so, instead of blindly aiming for technological optimization and development without considering other aspects.

This view was also emphasized in the ASHVIN meetings, in which general risk assessments were proposed to further analyze potential issues with technologies implemented, as well as to create a risk mitigation strategy.

#### **4.3 Technology as Big Brother**

The next theme present in the interviews was feelings of being watched, in which the participants shared their perspective on how and to which extent sensors and other technologies monitor structures, people or other aspects of the construction site. Some general information about how these monitoring practices take place were shared, as well as some monitoring concerns and reasons behind the process. Most of them argued that, from a safety perspective, monitoring, for example, workers makes sense.

#### 4.3.1 Monitoring

This first subtheme mainly consists of the participants explaining what is monitored and how this is done. One of the participants explained how the monitoring could be paired with AI, to avoid any issues on the construction site.

Yeah, so basically to get hints from the AI. Like, 'oh, you have a problem' or, 'we're at 80% chance that something could go wrong in this situation and after that we have an issue, so please do something to avoid this issue.' That way we save money. (Austin)

This participant also stressed the importance of wanting more technology, such as drones, for monitoring purposes. "So I think it's also possible with this technology and drones to get more information from any situation on the construction site and any place" (Austin).

Another point brought up by a participant was in relation to monitoring targets. He stated that there are simply no concerns in doing what he does because he does not monitor the workers or managers.

Uh, what I've done there in the construction site has been just monitoring things with my sensors, I was monitoring things, not people. ... The data I'm collecting, I'm not worried about people getting it because they wouldn't understand what it is, it needs to be processed with a previous understanding of what we are measuring in the case of my sensors, since we are not monitoring people. (Chris)

Some ideas for monitoring people were mentioned, in terms of using drones for example. One participant mentioned that using drones or cameras to monitor people at the construction sites could be useful.

But I think it might help as some assistance, maybe just with a camera to see if the people that have to be there are there, but then not showing faces but just using numbers. The occupancy, just counting people, this is useful. (Chris)

Another participant talked about a research collection process that had already taken place using drones, but using consent forms to make sure the workers agreed. "I think they also have drones outside now. Yeah, and they take pictures and videos of the construction site and there where people working, so at the project we prepared a document like this one to reaffirm them as well" (James). Monitoring was also considered to be useful in the aspect of going through the correct procedures. "If something happens, you have this data collected

that can help you. If something happens and you have the data to prove that your procedure was a correct.”

Furthermore, during one of the discussions during the ASHVIN meeting various ideas were brought up to see how low scale tracking could further be implemented on the construction demo sites to track its progress. Suggestions in terms of various forms of video tracking were mentioned, as well as some other ideas to track and monitor progress. Next to the overall progress on construction sites, ideas to track the workflow on the construction sites were also presented.

#### *4.3.2 Monitoring concerns*

Concerns surrounding monitoring practices were way less mentioned than its benefits. Overall, even when asked about potential concerns, the participants did not go into too much detail in comparison to how monitoring things or people could help them. However, one participant seemed to be more aware of some potential risks, as she mentioned people who could potentially be afraid or uncomfortable with being under surveillance. She stated that, while monitoring could have some benefits to it, its concerns and risks are not to be dismissed and should be carefully considered.

One other participant mentioned, specifically in relation to video footage, that this could have some concerns. “With a camera, yeah I mean a video is always something people are concerned about so, this might lead to some security issues for people or for the company.”

#### *4.3.3 Safety*

One of the main reasons for the participants to see ‘being watched’ as inherently good, is because of how it can improve safety. Technologies can help the construction industry to avoid incidents from happening, as many participants stressed that this is a big problem at the construction sites today. With many big machinery and objects present, something often goes wrong somewhere, for which technologies could serve as the solution.

One of the participants talked about the development of an app to report incidents and near misses.

This is regarding health and safety, we have an app and a system called Synergy. It's an external provider of the tool. We are using it to report incidents, accidents and near misses. Everyone is encouraged to use it if they see something that's unsafe for and so on, because otherwise it's quite impossible to manage whether there is an accident somewhere. If the app shows a notification the site managers must report it and then the app says ‘it's been brought to the attention that on this level a lot of

accidents happen' for example, then we can help stop it from happening again.  
(Lindsey)

Next to this, this participant also mentioned how, in the name of health and safety, a lot more is possible than just for productivity reasons. "I think for us the respect of the person is extremely important. And that it helps with safety, something that is really stressed. So if you if you do something for health and safety purpose, you can do a lot" (Lindsey). In terms of productivity, she mentioned that, although it is important, privacy and integrity are not jeopardized for 'simple' aspects such as how efficient or productive someone is.

Other participants also mentioned the importance of monitoring to improve safety. One recalled a project currently in progress in the US.

Maybe you can also use some artificial intelligence. If they wear a helmet or something like that, that is possible, but we don't do it in Germany. I know there are some startups in the US for these safety issues, but in Germany right now it's not allowed because of privacy issues. (Austin)

He then also mentioned how technologies in general could be used to improve safety, and how he would envision this.

I think it's also possible that these technologies, like drones or robots, make life safer on construction site, so maybe unhandy work or heavy weights you push up maybe can be done by robots in the future, so maybe that's also making life easier and safer on construction sites. (Austin)

This was also mentioned by another participant, who stressed how a robot could, potentially, help in reducing the amount of structures that fail.

Another aspect mentioned here was the importance to receive real-time monitoring data to gather information on structures, work flows, and other areas of the construction site to improve its safety.

One of the parts that we are working on is just raising alarms, with information. With data that is flowing in real time we can develop some programs that can inform when something is deviated from what it should be. This can be applied to everything, for example if something is falling, deforming, getting close to some danger area, we can get informed and react. That's the one of the biggest advantages of using real time data. (Chris)



When asked about potential concerns of monitoring this in real-time and collecting this data, no real issues were mentioned.

During one of the discussions during ASHVIN meetings the aspect of health and safety was also mentioned as an important focus point in terms of the usage of sensors and other technologies, for the construction workers and other employees present at the construction site.

#### **4.4 A construction worker perspective**

Linked to the theme above, being watched, a construction worker perspective is important to mention. When asking questions about concerns of workers, awareness of workers and asked consent, various answers were given. Although not a large portion of the interview was spent on this, and overall short answers were given, it is important to mention, as this group seems often most unaware of what is happening and how this might affect them. This theme is divided into two subthemes, consent and the informed-uninformed dilemma, as different answers were given to these questions.

##### *4.4.1 Consent*

Various follow up questions were asked as a result of explaining how technologies are used and who or what is monitored, especially in relation to consent being asked from the workers. These questions resulted in various responses. One participant mentioned consent forms being handed out when collecting some of the data, but only to management. Others mentioned that the workers gave consent and were excited to learn more about the data collection of the sensors.

One participant thought of solutions for when workers would not consent.

But maybe someone doesn't give consent. If that happened, there are other buildings even here, this one and this other one which are not being measured or recorded. So maybe the ones that didn't give consent work in other constructions. (James)

Other than these brief ideas and explanations, most of the participants saw no privacy issues or related concerns for the workers, so therefore also stated there is no need for giving consent. As one participant put it "If I was a worker, I think I wouldn't mind if there are sensors or not as far as they do not interact with my work or decrease my production (Patrick). Another participant mentioned how they steer clear of making video streams to avoid this issue of having to ask for consent. "We make no video streams. We take only

pictures or point clouds from the construction site, because of the privacy issues with the workers on site and having to ask consent” (Austin).

In line with this, another participant mentioned how, because the workers were so excited they automatically complied with the collection of data.

In this construction site the workers were very collaborative with us so we don't have any issues with that. Like they were really interested. Interested in the videos of the drone, and they were really excited to see the videos. (David)

#### *4.4.2 Informed vs uninformed*

This subtheme is an interesting one, as the answers to questions asked about the workers being informed about the technologies and sensors resulted in varying answers. In some cases workers seemed fully informed, and in other instances somewhat informed or not informed at all, depending on which technology was used.

Various participants mentioned that the construction site manager was aware of the technologies deployed at the construction site. “Yes, the chief of the workers, he knew about it” (David). When asked about the construction workers themselves, one participant explained how they put up a sign with some explanations. “We have an information sign on the construction site. So there's information: ‘we use the webcams, we use drones, we take pictures, and if you have any problems, please write an email to our Privacy Officer.’ “ (Austin). Furthermore, another participant also mentioned that, in their case, the workers were fully informed.

Yes, yeah. Yes, yes, they were informed, and they allowed us in the spaces and they helped clean. For example, for the 3D radar they have to clean all the slabs to have a correct measuring so, they were informed, of course. We informed them with the companies together and we always informed the property manager for that as well. (James)

Although some participants stressed how workers were informed, others also brought up instances in which they were not, because there was either no need, or someone else had already been informed. In one case, the participant himself was not informed of any data collection.

So, I just came here one day and I found that these guys were here. And then my boss told me that these people had to collect some data. Yeah, I was in here and I just saw other people there. I saw him and he is not from any company that we hired

so I went to him. I talked to him and then I realized that he was here doing our research. And he told me that he would come more times. (Patrick)

When directly asked about the construction workers, some participants also mentioned that they were not informed and not addressed about the work they were doing to collect data. One of the participants raised an interesting aspect, mentioning that the workers shouldn't be informed about that there is data collected, but also why this is collected so they can better understand the process.

We have a problem of information in general, when people are not informed on how the sector is evolving, if we inform them we can work better. And then, of course we need to develop still, this is still in a young age, it will not happen in the next years. We're talking about 10 years ahead. (Chris)

Another participant also mentioned an interesting aspect of working with drones to collect footage of the construction site. The workers were very excited and engaged, showing interest in the research they were doing, allowing to be filmed by the drone. Because of this excitement they wanted to see the drone footage, but, according to one participant, "it was not allowed by the rules of the project" (David).

Lastly, this participant added, "They are not very aware of their privacy issues, like you mentioned earlier, their faces appearing in a video. But uh, but maybe someone else should be yeah" (David).

#### **4.5 Technology put in other contexts**

This last theme gives a more nuanced view on the technologies used in the construction industry, looking at various other aspects to consider from different angles. Issues such as risks surrounding the collected data were shared, as well as various rules and regulations present surrounding the use of technologies at the construction site. Furthermore, privacy was also an important subtheme within the context of technologies, as well as security. Although less mentioned than other themes, such as having positive attitudes towards technologies as well as thinking about a technological future, these subthemes were mentioned by the participants in some instances and are an important part of the discussion.

##### *4.5.1 Data risks*

Data risks is the first subtheme mentioned by the participants when discussing technologies being deployed at the construction site or developed in a lab. As one of the participants mentioned, the data that is being collected and described as anonymous might not always be

fully anonymous. She questioned: “Will there be some IT person who knows what I've done and how will this be used? Yeah, you say this is not that you say that this is all anonymous but maybe they will create things that will eventually reflect on my daily work in in a negative way” (Lindsey).

The same participant also raised some issues with the potential collection of biased data and how it is important to be aware of this.

We have to be aware that we might collect bias data as our crew or our workforce are mainly male. We only have like 3% females in our workforce on the sites. So, in that respect the data we collect could be a little bit biased and thus we need to take that into account when we analyze the data using algorithms and so on. (Lindsey)

Interestingly, the only female interviewed for this research was the only one to bring up the data biases in terms of gender.

Next to this, another data risk mentioned by participants was that of the quality of the data, as this could influence the analysis and later affect a grander scope of the project. One of the participants explains that it can have some mistakes, deeming it no longer useful.

The quality of the data is important, cause sometimes you take data and then when you are processing the data it has like some mistakes or maybe it's not useful for your purpose. So, I think that's my principal concern. (David)

Issues surrounding data storage were also mentioned by participants and considered an important data risk to take into account. Some participants gave some explanation as to how many backups their collected data has, as well as how they make sure it stays protected.

In one of the discussions held during internal meetings in the early stages of the ASHVIN project, data risks regarding internal communication and data storage were also addressed. This resulted in a platform chosen to store important documents based on it being the most secure and persistent option. On the other hand, the platform used for back and forth communication was not chosen based on these criteria, as messages here were not persisted.

#### *4.5.2 Laws and regulations*

This subtheme was very much present within one of the interviews conducted, as the laws and regulations in Sweden, the country where the participant works, are different from its surrounding countries, affecting what can be done with the collected data, with whom it can

be shared as well as how people can be monitored. In the interview, she explains it as a countrywide issue.

What I do think is an issue for Sweden and the way our whole system works. When you're working, it's connected to a lots of agreements between the labor and management unions or leader unions. You are not allowed to break integrity, personal integrity, in order to achieve a higher productivity. So, if you go to Finland for example, this is a completely different situation. There they are happy to take videos or have cameras without any issues. (Lindsey)

Next to this, she also mentioned how the laws are dependent on the European country, which can in turn influence the construction site culture. "Yeah, I think that it's depending on where you are in Europe, the laws and the unions and if they are strong or weak. Who they are representing will of course create a culture and then environment on the construction site is different because of this" (Lindsey). She also touched upon data sharing processes, stating that this is also legally regulated. "The reason why we cannot do it is because it's against the agreements we have made. So I would break a law and, while you know the research project may enjoy it, it's not something I'm willing to do" (Lindsey). As mentioned above, she also stressed the strong labor union of Sweden, stressing how the country wants to avoid a 'surveillance-like state' at all costs.

It's very easy to theoretically say that yes, this is how we should do it. We should always have, you know, cameras which could record everything, and we can make everything more efficient and so on. In theory, yes. But then we are moving towards the sort of surveillance state and that is a super sensitive issue, at least in in Sweden. (Lindsey)

She also mentions, that in terms of Sweden, the labor union has created fixed times on how long the building process of various parts takes, to avoid this strive towards efficiency over privacy.

For example, can this work be done more efficiently? The labor union and the management of the Construction Federation have made agreements on how long certain activities take, so this is really agreed in the agreements. Like to put up a gypsum wall we'll take this many hours per square meter of this certain trade, so this is agreed before the project starts. (Lindsey)

Another participant also mentioned some legal aspects to the use of technologies in terms of, for example, flying drones at the construction sites.

We decide what can we do and what is not allowed right now from a legal point. I think you have to do a lot of law-work to do the right things. We have to keep distance from, roads, from railways. So, it's not so easy. (Austin)

Another participant also mentioned “in Barcelona we are not allowed to fly drones outside legally, so we can’t do that” (Patrick). Other participants also mentioned legal aspects of flying drones, especially when they are to be operated in a city. When flying drones in more remote areas, the legal concerns were much less.

#### *4.5.3 Privacy*

Already briefly mentioned above, privacy aspects were also discussed in the interview, in terms of issues, concerns, mitigations, the importance of a privacy officer, and the health vs. privacy debate.

Some participants mentioned how the early mitigation of issues that could potentially be privacy sensitive can help. For example, when filming at the construction sites, beforehand people were already instructed to leave to avoid being present on the video footage. One participant mentioned that the only ones visible on the footage were the researchers, having previously given their consent. Blurring faces and information in pictures taken on the construction site was also a mitigation used by some of the participants, before putting it up on the cloud for everyone to see. Another participant also mentioned how technologies should be more privacy oriented in the future, and said that “in the future, license plates will be automatically work, it’s an issue for us now, but we are working on this” (Austin), as well as stating how these privacy concerns are of great importance to them. Next to this, he also mentioned the involvement of a privacy officer on all their projects.

So we work together with our privacy protection manager for this topic also, we discuss every system, every process, every workflow with him. We invest a lot of time to figure out what drones we use, what pictures they make and how much information we get from the from the pictures, and we discuss all those topics with the privacy officer. (Austin)

More general concerns are also mentioned with regards to digital twins and privacy. “Even more so now when we are discussing digital twins, where we incorporate sensors where we incorporate using analytics like AI, making sure that we are respecting people's

privacy” (Lindsey). Furthermore, the discussion between health, safety and privacy is also touched upon, as one participant mentions:

Since the focus of the project is also health and safety on site, we all want the number of accidents to decrease drastically. So, I think that's sort of a not so sensitive question among the workers and management, but we cannot simply introduce every level of surveillance. (Lindsey)

Privacy was also specifically mentioned in the context of Sweden, where the participant argued that privacy is valued above productivity in Sweden, as well as above the safety of the workers. Furthermore, she discussed how there are potential privacy concerns for the workers to take into consideration as well.

You know one part is the workers: Their management could keep track of how many times they have forgotten to do this and so on and so forth. I think that is not a large problem, but some people might feel like ‘okay, you are just checking me, no one should check what I’m doing’. (Lindsey)

During one of the ASHVIN meetings privacy was also discussed in general terms. The main takeaways here were that, when the partners set up the sensors at the construction sites, EUR (responsible for guaranteeing privacy and security throughout the project) needs to be kept in the loop and involved in this process in order to make the right decisions and recommendations. In another meeting privacy implications were mentioned as an important and interesting aspect to explore when developing a more generalized platform.

During meetings at later stages questions of data integration procedures were asked, related to privacy issues, from which another meeting followed to further discuss privacy implications and how to proactively regulate the potential related issues.

#### *4.5.4 Security*

The last aspect mentioned within the development and deployment of these technologies is that of security. Discussions of the effects of automated processes were mentioned, as well as how the technologies pose, or do not pose, any security issues. The future of the security of these technologies was also mentioned, as well as how they could potentially help improve toward a more secure construction site in general.

When discussing the security of the construction site in general, participants mentioned how the use of technologies, such as cameras, could improve this.

Sometimes some pieces are left the construction site and therefore we have to check if it's still there or already removed. Also, anybody who's not allowed to go on the construction site could be checked by a camera or something. (Austin)

Interestingly, another participant had an opposing view to this, as a simple camera might not be able to help much. "I don't see how a simple camera can help to do that, counting people and see who is not supposed to be there, because security is very broad and I don't know how people would do that." (Chris).

This participant also went further to discuss the sensors built and implemented on the construction site.

I don't know, in terms of security, cameras can be hacked. For example, or if you attach something to a crane or a moving thing that can fall down and like, either it does or it doesn't. There are no security issues, the sensors don't bring anything new to the security aspect, only more informatics. (Chris)

One participant also elaborated on his view of the future to improve security aspects of the construction site, going back to the example of using a camera to spot people that are not supposed to be at that site with the help of AI.

Yeah, I think pictures are very good to use for such security issues. If there are people are not allowed to go on the construction site to get this information, maybe you can also use some artificial intelligence. (Austin)

Interestingly not many concerns were mentioned in terms of the security of the data, or the cybersecurity when processing and the storing the data. Either it was not mentioned by participants, or they stated that they did not see any (cyber) security issues.

However, in the ASHVIN meetings analyzed various aspects surrounding security were discussed, especially in terms of the development of a more general platform to put together the various different project types and stages, where cybersecurity was mentioned as an essential part of the discussion, especially when looking at data security implications. When discussing the ASHVIN IoT platform in particular, data collection, data storage and the ability to send information to other devices were discussed, and how these processes will operate in a secure manner. More practically, passwords to this platform could only be requested through one of the partners to ensure a more secure process.



## 5. Discussion & conclusion

This final chapter of the research provides a discussion on the themes and links these back to the theory. It furthermore offers an answer to the research question as posed in the initial chapter. After this, some limitations of this study will be discussed, as well as giving some suggestions for future research.

### 5.1 Discussion: themes and theory

As previously discussed, five main themes were derived from the thematic analysis: technology as a positive asset, technology: a promising future, technology as big brother, technology through a construction worker lens, and technology in other contexts.

The first theme, technology as a positive asset, discusses the overall positive attitudes toward technologies and sensors as implemented by ASHVIN. Going through some existing literature, statements are made about the construction industry often being behind in innovation in terms of digitalization (Leviäkangas et al., 2017). Furthermore, some academics expressed seeing some resistance from the construction sector in terms of feeling the need to digitalize (Kudryavtseva & Vasileva, 2021). Relating this to the findings, the participants and meeting discussions on the (to be) implemented technologies were of a positive nature and met with excitement. Technologies were seen as advantageous, promoting sustainability and carried with them no inherent problems. Although this contrasts with the existing literature, it comes at no surprise. As the ASHVIN project aims to digitalize the construction industry, it makes sense that its stakeholders have a positive attitude toward construction industry digitalization.

The next theme, technology: a promising future, builds upon this idea that technologies are inherently good and that there should be more. Although seemingly contrasting with some of the existing literature mentioned in the previous paragraph, it also draws upon some parallels. One of the benefits for the future mentioned by participants is how it improves the employee experience in terms of workflow and communication. Ciocchetti (2011) also states this, specifically on the use of surveillance technologies, as they can help better productivity and therefore have positive effects on the employees, improving their workflow (Ciocchetti, 2011).

In the third theme, technology as big brother, monitoring practices are discussed as well as why these are carried out. Some monitoring concerns are touched upon, as well as safety in relation to this aspect. Various ideas on how this monitoring could be carried out were considered, such as combining it with AI and letting workers know they are in an unsafe area. Safety was the most used explanation as to why monitoring could be beneficial. This aligns with some existing research, as employees are more likely to accept monitoring

measures when a 'valid' reason for this is presented. Reasons related to productivity tend to be met with more resistance, but safety is often seen as more positive (Sulzhenko & Holmgren, 2020).

The fourth theme, technology through a construction worker lens, discusses an employee perspective. Issues of consent and the workers being informed were mentioned in relation to (potential) surveillance they were, or would be, under. In some instances, participants did not know if workers were informed or not. The research of Ravid and colleagues (2020) specifically focus on how the lack of transparency qualifies as a monitoring risk. Adopting a transparency principle here can make a large difference in how monitoring is perceived by the employees subject to this (Ravid et al., 2020).

The last theme, technology put in other contexts, mentions the other aspects related to technologies and sensors implemented by ASHVIN. Data risks, laws and regulations, privacy and security were discussed in this theme, and their relation to the technological developments. Data protection was deemed important, as evident from both the interviews and the analysis of meeting minutes, but there were not always clear data retention or protection rules in place. Ball (2021) discusses the risk of function creep, and how this should be avoided especially when monitoring persons (Ball, 2021). Privacy issues, mitigations and measures were also discussed by interviewees and evident in meeting discussions. Especially interesting in this context is the privacy vs. health debate as briefly mentioned above. Depending on what the emphasis of the data collection was, in the name of safety or productivity, participants responded differently, placing more value on health and safety. Linking this back to Nissenbaum's (2004) contextual integrity theory, participants made sense of their privacy 'contextually', depending on what they considered to be more important.

## **5.1 Conclusion**

The research question,

*How do employees working in the construction sector make sense of the technologies implemented or to be implemented by ASHVIN?*

was tackled using qualitative methods, interviewing participants in an in-depth manner, and analyzing the discussions held in various ASHVIN meetings. Employees working in the construction sector make sense of technologies, such as laser scans, drones, and various sensors in different ways, but tend to all have a technological viewpoint on these. By stressing the advantages of technology, showing excitement and its sustainable aspects and seeing no inherent problems, the technologies are seen as positive. This is also seen in their

view of the future, where technologies can have great benefits to employees. Being watched by these technologies is discussed as mostly positive, because it can improve aspects like safety, security and efficiency. When putting the technologies in other contexts, privacy and security related aspects are mentioned, as well as laws and regulations and potential data risks.

Overall, the attitudes toward technology are positive, but more can be done about the attitudes towards these technologies in relation to the aspect of those working under monitoring or surveillance technologies in particular. The sensemaking processes of, for example, 'being watched' mainly took place on a managerial level, as technologies were mainly understood as being beneficial to the development of the construction industry and, therefore, its workers. It is therefore important to take a worker perspective into account to understand their attitudes towards them, as well as any privacy implications this may have. It is only in this way that the risks mentioned by, for example, Ball (2021), such as resistance of these technologies can be avoided. This means ensuring purposes of data collection to avoid function creep, raising awareness among construction workers through the principle of transparency, and ensuring technologies not to be experienced as too invasive by the workers.

## **5.2 Limitations**

In order to critically review this research, any limiting factors should be explored. In social sciences in general, there is a subjectivity of the researcher studying a topic of interest to further understand and explore (Babbie, 2011). In this case, working for the ASHVIN project an interest was developed, paired with an existing curiosity on privacy and security implications of surveillance measures, to better understand ASHVIN's technologies, sensors and practices and how these affect various people. This interest can have an influence during the conduction of interviews and analysis of the data. However, upholding a self-reflective attitude during the research process helped in staying as objective as possible throughout.

Related to the study itself a few limitations should be mentioned. First, the lack of participants and hard access to get to them limited the ability to select only the participants needed to answer the original research question, related to specific experiences of construction workers working with technologies on site. Various gatekeepers made it hard to reach the right people, because of which the decision was made to analyze additional materials by looking at interesting discussions and decisions that were made in ASHVIN meetings. However, in spite of these limitations regarding participants, this research resulted in interesting results with various aspects valued by other people working with, or developing the technologies (to be) implemented by ASHVIN. This allowed the understanding of what is

seen as important, but also what yet needs to be stressed in terms of technological development and monitoring practices.

### **5.3 Future research**

As mentioned in the previous section, this study offers great opportunities for further research. The first, most important next step is research done in direct contact with the construction workers, or those effectively working alongside these technologies after they are all implemented. Addressing workers directly will give great insight into their perceptions, understandings and meaning making processes of technologies and their potential concerns when working alongside, or with them.

Furthermore, when looking at the research done in the digitalization of the construction industry in general, especially in relation to its privacy implications, there is a large gap to be filled. Fang et al. (2018) mention this in their research, as they research the possibilities for technologies detecting harnesses on workers. Although the technologies are developing, its privacy and security implications are often briefly mentioned, instead of intensively studying its concerns and issues to be addressed and mitigated.

Lastly, an interesting perspective to further investigate was brought up during one of the interviews with a participant. He mentioned that, as an engineer, he notices that a lot of others involved simply do not understand what he and his colleagues are doing. He stated that others believe that they are collecting potentially dangerous data without knowing which data they actually collect. On the other hand, he mentioned that he might not be aware of which implications certain processes can have in terms of privacy and security. In conclusion, more research should be done to bridge this gap between engineers, which data they collect and how this can or cannot be considered sensitive data. There seems to be a lack of understanding coming from both sides, and although this study takes a good initial step, more needs to be done to fully understand, and therefore build, on each other and their expertise to reach more interesting findings and create further reaching conclusions.

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# Appendix 1: Interview guide

## Ethics / Verbal Consent

1. Any questions about the consent form?
2. [In case 'haven't read it'] – Please go over the important info of the Consent Form
3. Do you agree to it? [Get clear verbal consent]

## Introductions / Rapport

1. Hello, my name is Carola and I am a researcher from Erasmus University Rotterdam doing research for ASHVIN, a project promoting the digitalization of the construction industry.
2. Can you tell me a bit more about your work with the company, how long you have been with the company, in this line of work and what your current role is?

## Technology in work context

1. Tell me about your work and how technologies are a daily part of this – what does a typical day look like? Where and how is this aided or monitored by technology?
2. How has this made a difference in your work? In what ways does it complicate your work? How has it made it easier?

## Implemented sensors

1. Which sensors were implemented at your workplace?
2. What were your expectations of these sensors?
3. How have the present sensors in the workplace changed your job experience?

## Data concerns

1. What concerns do you have regarding the data collected through these sensors? What could be issues for boss/client/partners outside the organization?
2. How do you think these sensors could concern the construction workers? What behavior could that result in? Do you have any experiences with this happening?

## Security issues

1. How do you feel these implemented sensors can cause security issues for the construction site?
2. How do you feel these sensors could cause security issues for the data itself?

## Training

1. What sort of information did you have given to you about the technologies being used at the construction site?

#### Future work

1. What is your perspective on the purposes and potentials of technologies such as [name what they have named] in the future of your work?
2. How do you feel these technologies contribute to improved safety and security on site? What should be improved? What should be removed or eliminated?

## Appendix 2: Coding tree

Themes, subthemes, and examples of open codes

Theme	Subtheme	Ex. open codes
Technology as a positive asset	Advantages technologies	Adaptiveness technologies
		Advantage sensors: automating processes
		Drones used for 3D modelling
		Improvements: internet connection everywhere
		Technologies make work easier
		Use of technologies construction site
		Usefulness digital model of building
		Usefulness new technologies
	Excitement technologies	Excited about technologies
		Explanation implemented sensors
		'First company to implement these technologies'
		Not working with technology, but creating technology
		Proud of work technological innovation
	No issues technologies	Amounts of data collected
		Just counting numbers, not counting faces
		No data concerns
		No obligation to be captured by drone
		No workers present when flying drone
		No workers present when measuring
		Sensors to measure movement or structures
	Sustainability	Sustainable awareness
		Contributing to sustainability
		Environmental sensors
		Fighting climate change
		Optimizing processes for sustainability
		Measure estimate energy consumption construction site
	Technology: a promising future	Improvement employees
Future: technologies for improved communication		
Future: overall improvement construction site		
More technologies		Work focused on innovation
		Future: automating processes
		More technologies needed
		Future technologies
Technology as Big Brother	Monitoring	Technological monitoring
		Monitoring things, not people

		Drones to monitoring work
		Monitoring worker presence
		Technologies to monitor correct procedures
	Monitoring concerns	New technologies: surveillance fear
		Video footage might lead to concern
		Avoiding recording people cause it leads to problems
	Safety	App reporting incidents and near misses
		Emphasis on the person and safety
		Future technologies for safety
		Productivity not as important as safety
		Real time data for safety purposes
	Safety of technologies	
A construction worker perspective	Consent	Consent form only given to managers
		Ideas for workers not giving consent
		Workers shouldn't be bothered with sensors as long as it doesn't hinder their work directly
		No (privacy) concerns workers
		Privacy concerns workers
		Workers complying
	Informed	Informed construction workers
		Informed construction site manager
		Somewhat informed construction workers
	Uninformed	Interviewee not informed of data collection
		People need to be informed of the technology
		Workers not addressed
		Workers uninformed
		No compliance transparency principle
		Privacy concerns workers are something for the future
	Workers unaware privacy concerns	
Technology put in other contexts	Data risks	Anonymous data not always fully anonymous
		Concern collection biased data
		Data concern: quality
		Data storage
	Laws and regulations	Countrywide issue: legal aspects
		Data sharing depending on laws and regulations
		Legal aspect technologies
		Legal restrictions flying drones
		Legally not possible to share all collected data
		Strong labor union in Sweden
Sweden avoiding surveillance state at all costs		

		Sweden: fixed times on how long construction activities take
	Privacy	Early mitigation privacy issues
		Future technologies for privacy
		Importance privacy concerns
		Involvement privacy officer
		Privacy concerns technologies
		Privacy vs. health and safety workers
		Solutions privacy issues/concerns
		Sweden: privacy above productivity
		Sweden: privacy above safety workers
		Potential privacy concerns workers
	Security	Automating processes for security
		Future technologies for security
		Technologies for security
		No security issues with a sensor measuring things
		A simple camera might not be worth much for security purposes
		Sensors don't add to security now, only help collect information