Everything We Do, Everything We Press: Data-Driven Remote Performance Management in a Mobile Workplace

Lyndsey L. Bakewell[1], Konstantina Vasileiou[2], Kiel S. Long[3], Mark Atkinson[4], Helen Rice[5], Manuela Barreto[4], Julie Barnett[2], Mike Wilson[1], Shaun Lawson[3], John Vines[3]

[1] Loughborough University, Loughborough, UK, {l.l.bakewell, m.wilson2}@lboro.ac.uk

[2] University of Bath, Bath, UK, {k.vasileiou, j.c.barnett}@bath.ac.uk

[3] Northumbria University, Newcastle upon Tyne, UK {firstname.surname}@northumbria.ac.uk

[4] University of Exeter, Exeter, UK,{m.m.atkinson, m.barreto}@exeter.ac.uk

[5]Independent Researcher, helenrice@work-4-me.co.uk

ABSTRACT

This paper examines how data-driven performance monitoring technologies affect the work of telecommunications field engineers. As a mobile workforce, this occupational group rely on an array of smartphone applications to plan, manage and report on their jobs, and to liaise remotely with managers and colleagues. These technologies intend to help field engineers be more productive and have greater control over their work; however they also gather data related to the quantity and effectiveness of their labor. We conducted a qualitative study examining engineers' experiences of these systems. Our findings suggest they simultaneously enhance worker autonomy, support co-ordination with and monitoring of colleagues, but promote anxieties around productivity and the interpretation of data by management. We discuss the implications of data-driven performance management technologies on worker agency, and examine the consequences of such systems in an era of quantified workplaces.

Author Keywords

Remote monitoring; performance management; occupational health; quantified workplace; qualitative study.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g. HCI): Miscellaneous;

INTRODUCTION

The field of HCI has been increasingly interested in the implications of data-driven lives. Studies of personal informatics have explored how the tracking of data might support people to live healthier [28, 36] or more sustainable lives [29, 73]. The rising use of smartphones and wearables has supported the emergence of a movement surrounding 'The Quantified Self' [45]. People are becoming increasingly accustomed to self-monitoring and self-tracking aspects of their lives and making sense of the resulting data [43]. It was perhaps inevitable that these ideas would extend into the workplace, and now we see consideration of what data-driven and quantified workplaces could and should look like [48, 49, 52]. The notion of a data-driven workplace poses opportunities and challenges for HCI research. It can support the utilization of data to make workers more productive (e.g. suggesting more effective route plans to workers in warehouses [77]); it can build awareness of the practices of colleagues [9, 63]; it can support decision-making on issues related to workplace comfort and the health of staff [18]; and ultimately the collection and presentation of data related to worker activity can be used for performance management [77]. At the same time questions have been raised around how the quantification of workplaces removes worker agency [61], provides new forms of controlling workers [40, 62] and accounts for work in ways that are decontextualized and artificially objective [62].

In this paper, we study an occupational group—telecommunications field engineers—that has experienced the introduction of a suite of new smartphone applications and related data-driven performance management. The work of a field engineer typically involves driving between locations, completing 'jobs' related to testing, installing and repairing telecommunications equipment, and reporting back on this work. It is work usually performed alone, involving large amounts of travel, and the completion of a designated number of jobs each day. Mobile technologies and equipment have long been central to field engineers' work. However, mobile applications are not just enabling new, more efficient workflows but also drastically changing the nature of the work itself. Mobile, location-based scheduling means that engineers now start and end their work days from their home; location monitoring, job reports and app analytics all support remote performance management; interactions with colleagues are rare, serendipitous or mediated via telecommunications; and the replacement of bulky equipment with app-based alternatives means they are now highly reliant on their smartphone for all forms of communication and tasks.

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We conducted a qualitative study to examine how the introduction of these technologies has been experienced by telecoms field engineers. Through interviews, workshops, and probe activities with 23 engineers, we examined their working patterns and the roles new smartphone applications play in the management and completion of their work. Our contribution to the field of HCI is three-fold. First, we offer a qualitative account of an occupational group experiencing significant changes to their workplace through the introduction of new data-driven performance management technologies. Second, we explain how location-based and remote monitoring technologies foster concerns around control and agency, induce fears around worker performance, and lead to creative workarounds and adoption of the technology. Third, we draw out critical implications for the introduction of these technologies by discussing the ways they affect worker autonomy, engender worker resistance, and create new forms of unaccounted work.

RELATED WORK

Workplace Monitoring and Performance Management

The transformative impact of new technologies on the workplace has long been established in the computer supported cooperative work research. Fieldwork in the print industry [12, 15] demonstrated how the introduction of workflow and networking systems can disrupt the 'workflow from within'. New systems necessitate additional 'articulation work' [66] so that altered work practices continue to produce desired outcomes, and often leads to re-structuring and re-ordering of workflows and re-configuring structures in ways that ultimately generate new organizational designs. Practices and technologies of workplace monitoring and performance management have also attracted intense academic interest. The sociological literature on monitoring (e.g. [27]) often frames it as a form of surveillance and control, highlighting the politics of such ventures and the disempowerment of workers. Occupational and management psychology literature instead highlights the ways in which monitoring of performance can enhance and benefit the workplace. Early studies of workplace management established that surveillance and monitoring are central to the role of managers and supervisors [26], and practices (such as monitoring the time workers clock in and out, the quantity of their output, and setting goals for them to achieve) have been long-established measures of labor. Information technologies have also long been implicated in the measurement and monitoring of worker productivity: automating the logging time spent doing certain tasks [16], monitoring their locations [50] and collating and visualizing worker outputs for performance review [23].

Opt-in monitoring technologies have shown positive responses from workers—especially in environments involving close collaboration [68] and lone working [59]. For instance, [9] note that workplace presence awareness systems (e.g. MyUnity) that accommodate individual preferences and 'thresholds' around privacy facilitate communication among a dispersed workforce and foster a sense of community. Such technologies can also facilitate collaborative problem-solving and troubleshooting among mobile workers and infuse a sense of social connectedness in lone workforces [58]. Indeed, when troubleshooting and presence awareness systems leverage 'opportune moments' for interruption (e.g. based on workers' physiological [31], cognitive and affective states [47, 56]) and also utilize design features that support critical communication (e.g. implicit knowledge sharing [32]), collaboration and problem-solving is further improved and group work is enhanced.

Nevertheless, the top-down introduction of such systems often leads to concerns around privacy and invasiveness [78, 79]. In some cases, workplace monitoring technologies have been demonstrated to have a negative influence on the wellbeing of workers [5] with increases in both physical and psychological strain [71]. Workplace monitoring can also impact morale [41], perception of workloads [5], and relations between staff and managers [64]. They can also raise concerns over the decontextualized and depersonalized nature of data gathered for the purposes of monitoring [40, 62, 70], and its value or fairness as a measure of performance and success of an individual [23]. Furthermore, as interactions between workers and management get mediated by data, pre-existing tensions or misunderstandings can be intensified [61]. Perhaps unsurprisingly, there are well-documented examples of how workers resist, circumnavigate, and workaround monitoring technologies that are felt to be burdensome or invasive [22, 62].

In the specific context of mobile work there has been a recent rise in systems that support remote monitoring. Some examples are framed explicitly as responding to concerns over the vulnerability of lone workers [59]. Others focus on monitoring the driving of vehicles, measuring the economy or quality of driving [62], or if workers maintain a set schedule [61]. However, business and management literature highlights that employers and managers often have concerns over how remote workers might "slack off" [17] or engage in counter-productive behavior [34] as they are not under the watchful eye of employers. As such, there is a growing suite of mobile applications that exist to remedy (but also perpetuate) this lack of trust, enabling mobile and remote workers to clock-in and out of work [74], to sign-in and out of locations and jobs [39], and to alert if they take too long on breaks or go beyond set geographical boundaries [24].

Finally, the possibility that the technology-facilitated monitoring of remote workers could be "perceived and resented as surveillance" [25 p39] has long been recognized as a concern. Akhtar and Moore [2] argue that workplace technology of this kind neutralizes labor relations, rendering the power and politics of labor (c.f. [27]) invisible. Such observations form part of a broader critical engagement with the 'quantified workplace' [49]: a topic which formed the basis for a workshop discussion at CSCW 2016 [48]. In HCI we have seen studies of how the quantification of work can

both promote reflection upon work practice but also feelings that the real work of an occupation is not being recognized [62]. Yet, as noted by Moore [53], despite the long-contested use of digital technology to monitor worker performance and productivity, quantification and algorithmic or data-driven work appear to be on the rise. Perhaps most prominently, these trends appear to clearly materialize in the case of on-demand workforces [40, 51, 72] emerging within the rapidly evolving landscape of 'gig' or platform economy [37].

Mobile and Lone Working, and Occupational Health

There has been considerable research on the impact that lone, remote working has on employees. The occupational health literature highlights how mobile workers, especially those spending large amounts of time driving, experience increased risk of musculoskeletal symptoms and lower levels of mental health due to long working days, high work demands, and lowered interaction with colleagues [19, 20]. Mulki et al. [55] identified that feelings of isolation in such workers could occur due to multivariate issues including a lack of personal contact with colleagues, losing a sense of camaraderie, and feelings of being 'left out'. Relatedly, Orr [57] noted the role that serendipitous meetings and breaks played for developing communities of practice and care between otherwise distributed team members.

The above highlight how mobile and lone workers often experience a lack of social connectivity, control, and self-efficacy in their work, experiences which subsequently relate to stress and anxiety [35, 69]. Theoretical models in the field of organizational psychology postulate that high job demands and a low sense of control [35], and imbalanced social exchanges and reciprocity in the workplace coupled with insufficient social support [69], constitute stressors and are linked to employee distress. These propositions are in line with Dirks and Ferrin's [21] observation that working with a manager with whom trust and reciprocity has not been established has detrimental effects on worker wellbeing, and results in feelings powerlessness.

Given the above, we might assume that telecoms field engineers are at risk of at least some of these work stressors because of limited contact with colleagues and remote relations with management. Considering the work on performance monitoring technologies, it might be expected that occupational health risks for this population may be further exaggerated through the addition of more stressors. However, equally, new technologies might instead support greater control and recognition of work.

THE WORK OF A FIELD ENGINEER

Our research was conducted with a telecommunications company based in the UK. One of the subsidiary's main responsibilities is to manage the local access network that connects customers (businesses and private homes) to their local telephone exchange—starting at the 'main distribution frame' in an 'exchange' and ending at the 'network termination point' at the customer's premises. The field engineers install and maintain the physical wiring and network that connects properties to the national network. Typical 'jobs' for a field engineer might include: visiting a customer's home to install a new telecoms line, connecting a broken telecoms line to a nearby terminal, or visiting local exchanges to install new cabling to connect a new line to the national network. In total, there are approximately 14,000 field engineers working for the company across the UK, who complete just under 30,000 'jobs' each working day. As such, engineers are very visible customer-facing staff for the company. However, an engineer can easily have relatively little contact with customers throughout their day; much of their work at exchanges is done in isolation and often it is not necessary to physically access a customer's property in order to connect or reconnect it to the telephone network.

Because of the nature of their work, the field engineer spends a large amount of time on the move between jobs. Engineers are provided with a dedicated company van and, since the introduction of location tracking, most engineers take the van home with them at the end of each day. This means that their work day starts and ends from the moment they 'clock-in' and 'clock-out' of their shift in their van. As such, the engineers can have little physical contact with fellow field engineers, and even less with their managers, on a day-to-day basis. Their primary contact with their team and manager is via monthly conference calls. A consequence of this is that mobile technology is central for the engineers to communicate and coordinate with colleagues.

The Field Engineer's Smartphone

Location-based and communications technologies have substantially changed the field engineer's work. However, it is the introduction of smartphones that has perhaps changed the role most drastically. Prior to smartphones, engineers would carry a range of bulky equipment with them in their vans to enable them to receive jobs and log their completion, check phone lines and wiring, and identify faults. As well as taking up space in vans, this equipment was seen to be poorly integrated with one-another and other systems. Therefore, in 2013 the company we conducted our studies with introduced a range of applications that ran on iPhones. While the range of apps is too numerous to discuss here, some of the key ones discussed by participants in our study include:

Your Jobs: Sends engineers their jobs for the day, which they can access early in the morning. They also use this to report on job progress, bring up notes related to previous work done at the same location, and to log the job as 'complete'. It also gives expected time slots for the completion of jobs.

Ask for an Assist: Engineers use this to request an 'assist' from another engineer who is nearby and might have necessary skills and equipment. The number of assists an engineer requests via the app is logged.

See Your Team: A map-based application that allows the engineers to see where their colleagues are and see how they are progressing with jobs.

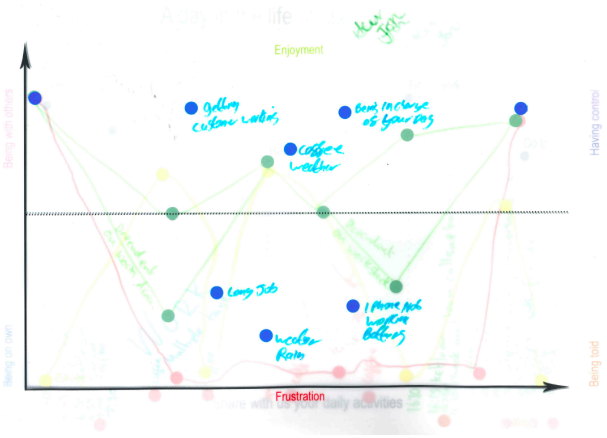

Figure 1. Example of timeline created as part of the first activities in workshop one, with layers mapping different feelings in relation to daily activities and routines.

Connected: A company specific hybrid of Facebook or Twitter which allows engineers to share 'updates' and information that can be viewed by other staff. It was introduced as a means of helping staff feel connected to one-another and part of a larger team.

Your Performance: This presents engineers with charts and visualizations of their performance to date in relation to specific performance indicators on a weekly, monthly, and annual basis. Indicators include the number of assists received, the number of jobs completed compared to a quota, customer feedback, how many jobs they have completed that then had to be re-opened, among others. During our study, engineers could also view the data of other team members and look at their own performance in relation to colleagues.

QuickTest: Allows engineers to conduct a 'line' or 'circuit' test to see if a telecoms line is working. They can use this application to conduct a test without being physically collocated with a telephone line.

Each of these applications are intended to make the field engineers' job simpler or more productive. Some also aim to grant them greater control over their work—such as enabling them to schedule jobs for the day or making judgments based on their professional performance. However, these apps are also interwoven with the employer's existing performance monitoring processes and promote new indicators of worker productivity and quality. Furthermore, prior research [38] on similar occupations highlights how mobile technologies can in fact hinder performance, especially in relation to existing routines and practices.

METHOD

The aims of our study were three-fold. First, we aimed to gain a broad understanding of the field engineer's work, what a typical work day is comprised of, and the various challenges they face in working on their own. Second, we wished to understand how digital technologies, specifically the recently introduced smartphone applications, affect their daily work and relationships with colleagues. Finally, we aimed to identify with them aspects of their work they desired to be changed, and to explore how new technologies might address these. To examine these topics, we designed a qualitative study that employed several methods of data collection, with each stage informing the direction of the following stage. These are described below.

Figure 2. Examples of (a) participants creating their magic machines in workshop one and probe responses to (b) 'my workplace' and (c) 'something I am never without'.

Interviews

Initially, semi-structured interviews were conducted with 14 field engineers. Interviews began by inviting participants to share their workplace biography. They were prompted to talk about how long they have been working as an engineer, how they entered the occupation, and how the role had changed over time. When appropriate, the researcher prompted them to elaborate on the role that technologies play in helping them complete, manage and coordinate their work. Also, given the nature of the occupation as requiring extensive periods of lone working, we invited them to talk about feelings of isolation, and the role that technologies played in mitigating against these, if at all. Interviews lasted between 42 and 124 minutes (60 minutes on average).

Co-design Workshops and Cultural Probes

Following the interviews, a series of workshops and probe activities were conducted with participants to further explore themes identified in the interviews.

Workshop 1: Timelines and Magic Machines

At this first workshop, we explored more deeply the different schedules and routines field engineers work to, and the ways in which technologies support scheduling and connections with colleagues. Participants worked in pairs to create timelines of their typical work day (from wakening to sleep). We prompted participants to include both daily recurring events and one-off occurrences. Following this, participants were asked to further reflect on the events they had identified by mapping onto them feelings of 'being on my own versus being with others', 'being told versus having control' and 'frustration versus enjoyment' (Figure 1). Once completed and discussed with the wider group, participants were placed

into new groups of two or three and invited to create 'magic machines' [3, 10]. This activity invited participants to identify an event from their timelines and to create a 'magic' technology that responded to and potentially alleviated identified problems. Participants were given a range of materials (cardboard, stickers, shapes, wire and stick on buttons etc.) and asked to assemble their machine (Figure 2a). The main purpose of this activity was to elicit further talk between participants about the nature of their work and how its conditions could be changed in the future. Once they had constructed their machine, the researchers questioned them on what it was, asking them to physically demonstrate the machine to the rest of the group.

Cultural Probes

At the end of the first workshop, cultural probes [30] were given to participants. The probe pack comprised of a customized disposable camera with 14 prompts and corresponding 'photo journal' (for participants to provide short written descriptions of their photos). In the spirit of past probe studies, the prompts were intentionally ambiguous. The prompts also responded to the insights from the initial interviews. For example, one prompt invited participants to photograph "something that is time-consuming", while another asked for "something that you'd share with others". Participants were asked to complete the probe responses (e.g. Figure 2b and 2c) in advance of the second workshop.

Workshop 2: Reflections and Corporate Fictions

The second workshop was divided into two activities designed in response to findings from workshop one. Participants were split into small groups. To start, each group was invited to review photos from the cultural probe and discuss the similarities and differences between their responses. After this, each group was provided with a 'recruitment brochure' for a fictional company called *TotalComms*. This brochure responded to several of the issues and ideas raised by the participants in interviews and in workshop one. The brochure contained a number of 'services' and 'benefits' that the fictional TotalComms was offering to employees. Inspired by [76], these ideas were purposely questionable and served to promote debate and discussion. Examples included 'Commie' (a robotic assistant and companion); a full-video monitoring system (that watched their every move, to provide assistance if needed), and 'Coq-au-van' (a luxurious company van with full cooking, washing and resting facilities). In the workshop, participants were asked to go through the brochures and annotate them to flag aspects that they liked or disliked. These were then discussed further with the workshop group.

Participants

In total, we met with 23 different field engineers across all stages of data collection. Of the 14 field engineers that participated in the interviews, only 5 could attend the co-design workshops. Therefore, at this stage we recruited a further 9 participants. For practical reasons, we split the participants into three groups for the workshops. All the participants were recruited through our ongoing collaborations with their employer. Participants ranged from 20 to 53 years of age (average age of 33). All but one identified themselves as male, representative of the organization's demographic of engineers. The participants represented diverse levels of experience with the job and period of employment in this role. Despite the range in age and periods of employment, all participants were confident with the equipment provided by the organization, due to continual training. As a thank-you for their time, all participants were provided with gift vouchers (£20 for interviews, £20 per workshop).

Data Analysis

All interviews and workshops were audio recorded and transcribed. This data was treated as a corpus upon which we conducted thematic analysis. Following [13], data at the sentence to paragraph level was summarized using short textual codes. Codes were compared, contrasted, integrated where necessary, and grouped together into themes. Given the iterative nature of our study, preliminary analyses were conducted following the completion of each stage of data collection (e.g. following the completion of interviews, first set of workshops) in order to inform the next stage of research. At the end of the study, the data corpus was reviewed by two authors, re-coded and thematically tied together. This final analysis is presented below.

FINDINGS

Our analysis led to the construction of 4 themes: *being monitored and monitoring others; independence and (not) being in control; maintaining good performance data;* and *backchannels, socialization and job demands.*

Being Monitored and Monitoring Others

All of the participants were aware that their phones, vans and other work systems they used were monitored, with some commenting on the wealth of data gathered about them:

> *We are told right from day one. Every button we press on our iPhone, everything we do is monitored, we know because of the Industry we are in.* (P15, W2G2)

There was an awareness that this data would be used for the purposes of performance management and the coaching of engineers. Each engineer can continually access the data related to their performance via their work provided iPhone and laptop using the *Your Performance* application:

> *So on here, your dashboard this tells you* […] *everything, your skills, what you're good at, what you're bad at. Your quality in depth, estimated time of arrival, how many faults, repeats you get, how many assists. There's just gallons of it.* (P21, W1G2)

The response to this kind of performance management varied greatly between participants. Three saw it as a means of better managing and improving their own performance. For example, P19 (W2G1) identified the usefulness of being presented with this data, as it *"spurred him on"* and let him think *"I can do this"* when he had challenging jobs. However, the other engineers worried about the gathering of this data. There was a strong sense that data collected might be used

against them as part of regular performance review processes. There was also a fear that this data would be examined closely if a job were to go wrong. This fear was exacerbated further by the engineers' own knowledge and awareness of the sheer amount of data being collected:

> *I think you know people are tracking you and realistically everyone knows that they can't look at everyone's data all of the time. But it is there if there is a problem, someone will dig a bit deeper into it.* (P15, W2G2)

> *They can see when you start the ignition in your van, you start moving, where you parked, where you've been, when you started your job, when you took lunch, how long after your lunch you were still in the exchange.* (P18, W2G1)

> *Then they've got another sheet which monitors the time you get in your van until the time you get to your first job, to the time you come off your first job, your second job, your third job and where you are when you close your jobs* […] *the phone is a monitor.* (P22, W1G2)

It was even noted that the number of times you check on your performance is logged: *"they wanted to know why we never checked on it* [their performance]*"* (P14 W1G2). As such there was a deep awareness that although the engineers were working on their own, much of what they do was tracked, logged and used to assess the quality of their work.

While many engineers identified these technologies as a means for the organization to monitor their activity, a few still saw some benefits. They acknowledged that the data collected was used to identify good practice and reward those that do well: *"There are incentives, if we perform they reward us"* (P20, W1G3); *"I won a day at the races.* […] *Most improved I think it was. I must have been really bad"* (P11, W1G3). A critical point brought up by participants was an awareness that the data that the apps both collected and presented back was purposely encouraging competition between them. This was often explicit in the case of managers setting competitions among team members, but induced competition was also facilitated by simply being able to view the progress of team members via the *Your Performance* app. All but two of the participants noted that they would keenly look at how they compared to colleagues: *"the app is good, you can see clearly what you're doing well and if you're not"* (P13, W1G2). The comparison of one-self to other team members was not limited to the use of *Your Performance*. A small number of participants used the *See Your Team* app to see what type of jobs other team members had been getting: *"I check it every morning, just to have a nose, see what jobs they've got."* (P14, Int). Again, however, the availability of this data between colleagues was contentious. This was reflected by P14, who explained that he would check other people's jobs to *"have a bitch and a moan again, 'he's got cab only jobs, how come I've got these faults?'!"* (P14, Int).

Independence and (not) Being in Control

All of the participants discussed extensively the ways the different applications supported a sense of independence and control, although the ways this manifested differed. For example, scheduling and balancing workloads is an important demand of the engineers' job, and was now facilitated by the *Your Jobs* application. The ways in which they planned their days—or their days were planned for them—differed widely however. During the first workshop, it was established that there was significant variation in the day-to-day jobs depending on length of service, contract type and level of training. Engineers who were relatively new in service were given a daily schedule referred to as a "tour". A tour comprised of six jobs to be completed over the course of the day—three for the morning and three for the afternoon. When "on tour" engineers automatically received all their jobs via their iPhone at the start of the working day.

While the allocation of jobs was done automatically via the *Your Jobs* application, engineers were given some freedom around when they could conduct the jobs (but they could not move jobs from the morning or the afternoon). Participants explained that they would often schedule the jobs after considering factors such as their perceived difficulty (based on the notes contained in the job and whether the line test worked), the nature of the job (a retail, office, or residential customer, or work at a telephone exchange), and whether a job was in a rural or urban location (to avoid peak hour traffic). Engineers would also plan their tour around the time it would take to travel to jobs, with a view to avoid making their working day longer due to travelling:

> *We try the closest one first because we don't get paid traffic to the first job. And then you try and get the closest job when you come back.* (P15, W1G1)

> *Try to start and end close to home because then you can do the big loop and then come back.* (P2, W1G1)

This capability to allocate the order of jobs throughout the day was viewed positively by all but four participants, as it created a sense of control and autonomy over the job: *You have control.* […] *You can say, 'I'm going to go there, there and there.' And just complete all them.* (P2, W1G3). Others explained that having all jobs sent at the start of the day to their phone gave comfort in knowing what their day might consist of and what challenges they could face. P17 (W2G2) observed that as soon as he woke up he would check his jobs and plan his day out. After this, he would *"test the line"* for jobs via his iPhone, thus being more aware about how easy or difficult these jobs might be. However, despite a sense of comfort generated from this advance awareness of jobs, the risks of prolonged work hours and of work activities invading home life and personal time were also stressed. As P2 explained:

> *Our start time is 8:00, we got to get to our first job for 8:00, you think I'll get to the first job for 8:00, but I'm up at 6:30 every day. My work starts at 6:45, because I'm laying in bed looking at my jobs, testing them all, testing all the lines first thing in the morning to see* (P2, W2G1)

Empathizing with P2's comments, P11 explained how he now leaves his work phone downstairs, turned off, to avoid doing this. There was also a concern from three participants that the freedom to schedule their days offloaded decision making and responsibility from managers to the engineers—

and if they were to make a poor scheduling decision (e.g. getting stuck in traffic and resulting in being unable to complete a job on time) this would be held against them. As such, the sense of control and autonomy deriving from these systems was viewed with some suspicion:

> *The problem we've got is with the task, you've got to do it anyway* [the job]*, so you've got no control. It might take you two or three hours, but you've still got the job so you have still got to do it.* (P18, W1G1)

For those engineers who were not on a tour schedule, jobs were received one-after-the-other as their day progressed. This schedule was primarily accessible to engineers that had worked for the organization for a longer period. Although it did not offer the same freedom, it assigned less responsibility. However, one important challenge engineers on this schedule faced was not knowing what their next job would comprise of until they requested it. This was also a challenge for those engineers on tour if they had completed all their assigned jobs sooner than expected and had time to complete one more. The buffering symbol that appeared on the *Your Jobs* app when requesting a new job was jokingly referred to as the *"wheel of doom"* (P21, W1G2):

> *It is like Russian Roulette sometimes… One of the guys, last week, Friday it was, and at 3:30 pm he is in (anonymized place A) he spun the wheel and he had a jump recovery in (anonymized place B) and it is literally a 5 minute job at the cab. So he had to drive all the way from (A) to (B) to do a 5 minute job and then drive all the way back.* […] *It is what you have got to do.* (P15, W2G2)

Given the competitive nature of some elements of the job, the randomness of job allocations amplified concerns that some engineers got more favorable jobs than others. While there was no evidence of favoritism, it fueled negative sentiment towards managers and some team members, resulting in yet more *"bitching and moaning"* (P14, Int) especially when a job allocation significantly impacted on performance or extended the length of a work day.

Maintaining Good Performance Data

We have already seen that some engineers worried about planning their days and the impact certain jobs and their sequencing may have on performance. Time management was a continually negotiated challenge, with an awareness that poorly organizing your day and not maintaining time would lead to poor reported performance. As each job is allocated an estimated amount of time for completion, all of the engineers explained they were conscious of maintaining a strict schedule which would give them the best chance to improve their data.

For many participants managing and controlling their time around a complex set of jobs was a continuous burden that brought on stress. Given the diversity of jobs, the unpredictability of traffic, and the temperamental nature of their work technologies, experiencing delays and problems during a day was often inevitable and it was common for engineers to get home later than expected. Occasionally, to recover from delays, all but three participants said they skip breaks or eat their lunch in their vans to recoup lost time: *Depends if you are in a rush. You might want to get close to your next job like you said and just sit in the van and have a sandwich.* (P11, W1G3). Four mentioned they would avoid drinking too much during the day and declined offers of a drink from customers to reduce the likelihood of needing to find a restroom between jobs. One participant provided a rather extreme example of how they were caught *"off guard"* and used a bucket provided in the van (for digging up dirt and soil around electrical wiring) to *"relieve themselves"* to avoid going on a detour looking for a bathroom. It was also noted that whether they had taken their breaks was also logged—so they would make sure to register the start and end of breaks and lunches, even if they were unable to take them.

A further concern regarding maintaining performance was associated with how data on their competency on certain jobs was being captured. The primary measures for the quality of their work was feedback from customers and how often an engineer would *"call in an assist"* (P12, W2G2) via the *Ask for an Assist* application. This latter function was available as a last resort for engineers who felt they were unable to complete a job, so that the allotted job can be "*returned*" and "*sent back*" and allocated to someone else. Engineers reported on a wide range of reasons why they may be unable to complete a job—from not being experienced enough for a specific type of fault, to not having required equipment, to being stuck in traffic or on a previous job. A returned job would usually be picked up by another nearby engineer.

While all participants had used the formal process to seek help, there was some contestation around its value. For some there was a desire to do well for the rest of the team; failure to complete jobs successfully would require another team member to come out to provide support or repair mistakes. Not only was this viewed negatively by engineers, there was also a fear of becoming a burden to colleagues. Furthermore, *"calling out an assist"* would *"go against you because it goes against your stats"* (P12, Int). Therefore, there was a temptation for engineers to continue working on a difficult job—even at the risk of extending their job time and risking further performance issues—instead of requesting help.

It also became clear that participants circumnavigated the formal processes of calling for an assist via the designated app. Four engineers explained how they would use the *See Your Team* app to see which of their *"matey"* workmates were working in the local area. P04 explained how calling in a favor from someone this way was preferable to contacting the call-centre for help: "*I know that guy, I'll try and see how close he is to getting here and giving me a hand*" (P04, Int). If their workmate is able to help, then officially they have to "complete" their current job then "sign in" to their colleagues' job to provide the assist. While not following the formal protocols for getting an assist, there was some legitimacy from an organizational perspective to this process. Furthermore, as the engineer asking for help did not officially log a request for an assist, this was not captured on

performance data. However, it did require trust from the engineer helping out with the assist, as it could negatively impact any further jobs they needed to complete.

In some cases, twelve participants explained how they would circumnavigate the company procedures completely, and send SMSs or group messages through WhatsApp or Facebook via their personal phones to see who was nearby. In these cases, the exchange of messages themselves would involve seeking informal advice. It also provides a way for nearby colleagues to take slight detours between jobs to help out their team mates. Indeed, P13 noted that it was common practice between certain circles of workmates to informally check-in and see if anyone needed help at the end of the day:

> *One person will end up with an hour at the end of the day where they've got no work so what they'll do is send a text message to everybody else in the team and just say, "I'm free for an hour, if anybody needs a hand, give me a call", they'll come and help you. So yeah, it's quite a common thing that they all help or they're all willing to help, it's really good*. (P13, Int)

Backchannels, Socialization, and Job Demands

As noted above, social networking and instant messaging services, such as Facebook, Twitter and WhatsApp, were used by all participants. These provided a space for building *"a personal connection"* (P2, W2G1) with workmates through the sharing of jokes, experiences, and—as above—by assisting each other with challenging jobs. All but four of the engineers saw private social networks or instant messaging groups as a place where work could be chatted about freely, away from the *"watchful eye"* of the organization's bespoke social platforms. The use of these platforms, accessed on their personal devices, gave a sense of freedom. Instant messaging and private Facebook groups were also used as a space where the team members felt comfortable complaining about their role, with P14 noting that they provide a *"slag-off page as well, sort of thing. Like blokes whining, moaning on there and everything."* (P14, W2G3).

Lunchtime presented the most common occasion for communicating with each other by phone. While two engineers preferred spending their lunches on their own, most would phone up colleagues on their team, or their families and non-work mates, to check-in and chat. Others made an effort to seek fellow engineers and physically meet up with them. A common practice was to drive to one of the exchanges, as that provided a likely location where other engineers would be having lunch after completing jobs:

> *At lunchtimes you've got your exchange,* […] *and every town's got an exchange, so you go there and if there's a van in the car park, you do kind of, oh there's somebody there, so you go and have a chat.* (P1, Int)

P1 went on to explain that he enjoyed going to the exchanges as it was an opportunity to meet engineers from other teams. Fifteen of the participants, however, preferred to spend time with their core group of work pals. While those groups who used instant messaging and Facebook to chat would sometimes co-ordinate meet-ups via these, there was also a reliance on the *See Your Team* app to locate workmates for social reasons:

> *We can see where all the team are, I know I do it and a few other people do it, when we're about to set lunch* […] *we sort of see who's around us and we agree to meet up at a café or a restaurant or a McDonalds and we have our lunch, a quick chat.* (P5, Int)

While in general socialization with colleagues was desired by the engineers, there were two participants who preferred the solitude and quiet time that lunch and breaks provided. Furthermore, for those that did desire social interactions with workmates there was a frustration that their ability to do so was heavily hindered by their tight schedules. Planning lunch and breaks—finding somewhere to buy lunch, finding safe and legal locations to park, or spending time looking for the location of workmates and getting to that location—all ate into scarce break periods. Despite these reported examples, social exchanges while working was difficult, had to be deliberately planned, often relied on serendipity, and was highly dependent on asynchronous messaging. Although participants recognized that some of the company's apps (like *Connected*) were intended to keep them in touch with each other, these were time consuming to engage with in an already busy day. Furthermore, all but two acknowledged that when they did get the chance they would use personal apps to chat with workmates, where they were free from the monitoring protocols of the company.

DISCUSSION

Our findings highlight how mobile technologies can impact on a remote, mobile and primarily lone workforce. The technologies that the field engineers use during their work days clearly have several positive attributes. They support engineers to work more independently, can present them with almost real-time information about their jobs, and enable them to perform their work with greater flexibility. However, these applications also support a range of problematic practices and issues that impact their work, the felt quality of this workplace, and relationships with others. We discuss these issues in the following concluding sections.

Relationships with Colleagues and Customers

The apps came with new forms of unrecognized work in regard to managing relationships with other people as well as the personal sentiments surrounding this relational management. Primarily, they placed new burdens on engineers in managing their relationships with colleagues. As we illustrated, *Ask for an Assist* required them to proactively seek help from colleagues when they were in difficulties. While these systems can speed up support seeking and facilitate problem-solving and troubleshooting [58], especially when their design accounts for workers' readiness to collaborate (e.g. based on criteria of optimal interruptbility [31, 47, 56]), our study showed that these technologies were also utilized as means of logging activity and performance; those that seek help too often are profiled as underperforming (or at least that is how it was felt). Therefore, it is not surprising that engineers attempted to

circumnavigate these formal processes. However, even that sometimes came with a cost as they lost face to a co-worker (in an environment where expert practical skill is privileged [46]). Perhaps worse, our findings show that workers occasionally ended up feeling as though they are a burden to others, wasting their time, and potentially causing them their own performance management problems. While there may have been a time when an engineer could visit a colleague and give them a quick informal assist, being under constant monitoring, and therefore potentially answerable for unplanned detours, seriously inhibits an otherwise naturally occurring prosocial behavior within the workplace.

As such, the formalization of lending a hand through these applications, coupled with its quantification for productivity measurement reasons, leads to worry, anxiety and—in many reported cases—an active 'non-use' of the technology by just carrying on trying to do the job yourself. Bernstein [8] highlighted the 'transparency paradox' of performance management technologies, where workers engage with time-consuming behaviors to hide aspects of their work; a practice we saw emerging when engineers continued doing jobs they were unable to complete, concealing their problems, or instead spent time seeking informal help which, itself, may have taken longer to achieve than the formal routes. Furthermore, the will to both seek and give help to others becomes inhibited by processes of social comparison where competition is fostered through locating one's own performance in relation to team members. While we observed a large amount of co-operation between team members, the system of rewards installed alongside these applications promoted individual over team benefits.

Second, we can extend these concerns to other sorts of relationship management issues, such as interactions with customers. The field engineer occupation is unusual as it covers technical skills with substantial customer-facing work. In the words of the employer of our participants, they are "the face" of the enterprise. While this has always been the case, some of the new wave of field engineer apps purposely place them in closer contact with customers; customers get updates based on the location of the driver's van, engineers are meant to contact customers *en route*, and customers have engineers' contact details if they have any questions (and indeed, in one case, a participant reported having a phone call from a customer asking for advice on what Internet package he should purchase). Such interactions with customers are brought into even more relevancy given the problems engineers sometimes face with technical issues with their devices; suddenly, they find themselves having to explain to customers that their job cannot be completed due to the engineers' own telecoms problems. But perhaps most important is that exchanges with customers are also assessed, quantified, and ultimately implicated in performance management, since customers' assessment of the engineer is one more, constantly monitored, performance indicator.

In the case of colleagues and customers, we see how the technologies that support this mobile workplace introduce situations where employees have to carefully regulate their emotions, or in other words engage in forms of emotional labor [33]. Occupational health literature notes that such labor is particularly impactful on workplace stress when unexpected or out of one's own control [54] particularly when there is a lack of co-worker [67] or social support [1].

Flexibility, Accountability, and Intensification of Work

One of the key benefits of the occupation to several engineers was that they had a strong feeling of independence and autonomy in how they managed and completed their day. Indeed, the strong motivational force of perceived control, flexibility, and autonomy in the workplace has also been documented in emerging forms of work organization, such as in the gig economy [72]. At the same time, it was clear from our findings that there was a considerable amount of unaccounted work that occurred in negotiating this flexibility. While apps like *Your Jobs* introduced some flexibility and control, it also necessitated 'articulation work' [66] to plan routes, make decisions about job ordering, and to fit breaks into days. This highlights that a 'flexible' workplace, enabled by remote monitoring and scheduling systems, on one hand provided feelings of autonomy and control through a greater space for choice and on the other promoted anxiety around retaining that control. Being able to schedule parts of a day brought with it a new form of accountability—that making the wrong choice of route, or organizing your day incorrectly, or putting a long job first, would impact your day and be a black mark on your profile. At the same time, aspects that were out of engineers' control—such as unexpected traffic, unavailability of equipment at a location, or being repeatedly assigned tough jobs—were left unrecognized by these performance data trails. In line with previous work, there is a sense that the qualitative aspects of their labor that go into managing their tight schedule fail to be recognized, or simply go ignored [62], suggesting the decontextualization of work under data-driven performance evaluation systems [41]. Furthermore, the opacity of how jobs are algorithmically allocated through the '*wheel of doom*' fed mistrust both towards managers and to peers. This ties with research highlighting the concerns of on-demand workers around the fairness and accuracy of individuals' algorithmic evaluation [41, 51].

The suite of apps introduced to the field engineer role clearly intended to simplify elements of day-to-day work. It reduced physical labor related to carrying around significant amounts of bulky equipment, both within their vans or into customers' homes. It also meant that aspects of work that were very burdensome—such as waiting on the phone to be assigned a new job, or searching for notes related to a job—were made simpler. But the simplification of these procedural aspects of the job gives space to intensify the core aspects of this occupation. Engineers would perform considerable amounts of work outside of their contracted hours, planned their days carefully, conducted line tests from their beds before getting

up, and logging breaks and lunch times even when they were still working. Similar to Prasopoulou et al.'s findings [60], some engineers started to have a sense of overly extended working hours, as the workplace itself becomes dramatically extended in space, time and place [75]. As Brodie and Perry [14] note, there is a need for workers to draw 'chalk-lines' around work and home activities to keep some distinction in time. However, this recognition of work expansion into private life under conditions of 'flexible' work seems to become obscure and might be even rationalized within a socio-cultural context of work pre-eminence [11].

Management, Monitoring and Private Spaces

The field engineers clearly felt that their work was closely monitored, not just by their managers who had access to performance data but also by colleagues. While some considered having access to information about their colleagues improved performance and indeed triggered informal support sharing and collaborative troubleshooting [58], this was not always the case. Questions were raised around the motivations of colleagues looking at this data while the technical nature of the role promoted a sharp awareness of the sheer amount of data collected about them (even including how long they spend on certain apps, or how regularly they are reviewing their own performance data). The managerial surveillance alongside this form of 'lateral surveillance' by colleagues [4] clearly invokes and vividly instantiates Foucault's metaphor of 'panopticon'; as a result, participants often regulated their conduct and altered their behaviors (e.g. avoided using formal channels of support), especially when productivity was implicated, under work conditions of omnipresent and ubiquitous surveillance.

In HCI, the study of personal informatics and the quantified self has been of interest for some time (e.g. [42, 65]). As mentioned in the opening of the paper, there has been an interest in how technologies like these can be translated from the personal to the workplace [49]. While these technologies can be framed as opportunities to study and positively influence the conditions of work, they can also be seen as examples of 'dataveillance' where self-tracking is imposed on workers [44]; or in other words, workers become *usees* rather than users of these systems [6], where consent to be monitored is inferred through the terms of their employment. In extreme cases, it has been argued that such systems become a 'streamlined version of the clipboard' that floor managers may have used in time and motion studies of blue-collar workers [52]. While the situation we see with the field engineers is not so extreme, we do see how the collection and presentation of data related to productivity engages staff to think more like a manager, to optimize their performance, and focus on their outputs. In doing so, however, Aktar and Moore [2] note that workers themselves lose sight of the context within which their performance occurs, and the reasons why they make decisions as they do.

Critically, we also saw how many engineers engaged in the 'non-use' [7] of a range of systems that formally supported communications with colleagues. While the company even provided a range of 'social' apps for its employees to use, these were generally avoided since they render the engineers visible to management, suggesting the importance of designing technologies that are attuned to workers' privacy 'thresholds' and preferences [9]. Thus, using closed groups on private platforms to share funny stories or silly pictures, or to simply "moan", might be seen as a small act of resistance in a workplace where you are often alone, but always being watched. This resonates with findings from research with algorithmically-managed on-demand workers [51] who often resorted to online social spaces outside their 'work' platform to build a community and utilize the benefits of social support and knowledge sharing. But perhaps more practically, it suggests the need for ensuring that in remote and mobile workplaces, workers are provided with private spaces where they are no longer under the eye of management. Providing such spaces might start averting time-consuming circumnavigating of formal processes, but also might support productive deviance, experimentation and focus on productive work [8].

CONCLUSION

We studied the work of field engineers and the roles that new performance enhancement and management technologies play in their workplace. Although field engineers see some value in these systems, they have also induced feelings of disconnection from colleagues, and raised concerns about being monitored and remotely performance managed. Moreover, while these technologies simplified aspects of the engineer's work, their use simultaneously led to experiences of work intensification and perceptions of greater responsibility and accountability that rendered any gain of greater job control disputable. Our findings further highlighted the range of acts of resistance engineers have developed and adopted to compensate for lost privacy. We also saw how engineers engage in new forms of work to respond to the demands of these systems in relation to the unexpected interactions they cause with colleagues and customers, and to maintain their schedules for the day. Our study provides insight into the use of monitoring and remote performance management technologies in the workplace, and sheds light into a commonplace yet understudied workplace and worker occupation.

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