How to Drive a London Bus: Measuring Performance in a Mobile and Remote Workplace

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ABSTRACT

This paper examines how London bus drivers have responded to performance monitoring via a telematics device called *Drivewell*. This device calculates a score based on various recordable driving-related events like abrupt braking or irregular turning actions. Our qualitative methodology incorporated semi-structured interviews and ethnographic fieldwork in order to explore drivers' attitudes towards the system and its effect on driving behaviour and working conditions. Our findings illustrate how bus operators simultaneously accommodate and resist the demands *Drivewell* places upon them. Our work also demonstrates how this digital intervention acts in conjunction with other driver-related technologies, creating a unique digital ecosystem on the modern London bus. Our research contributes to HCI understandings of digital surveillance and performance monitoring in the modern workplace.

Author Keywords

Public Transport; Ethnography; Telematics; Event Monitoring; Workplace Surveillance

ACM Classification Keywords

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

INTRODUCTION

Sensor technology is increasingly deployed as a part of intelligent vehicle infrastructures that give drivers the capacity to monitor traffic and navigation information, check vehicle status, improve driving quality and navigate adverse driving conditions [27]. Recent developments in Intelligent Transportation Systems (ITS) have also allowed interconnected vehicles to exchange information in order to operate a more efficient and passenger-friendly service [27], while minimizing cost and making the entire system more environmentally sound.

These developments have led to some drivers acquiring new responsibilities and being subject to new forms of performance monitoring. For instance, it is now relatively straightforward to install in-vehicle data recorders (IVDR) that monitor driving quality indicators like speed, braking and cornering. Individual drivers can benefit directly from this by registering to either a Pay As You Drive (PAYD) insurance system that charges for distance travelled, or one that rewards good driving by offering lower premiums to those who achieve target driving scores [23]. On an organizational scale, professional drivers may also be signed up to 'fleet telematics' systems [18] that are used to monitor driving across an entire fleet. When integrated into driver appraisals these can become highly effective performance management infrastructures that reward good driving and penalize bad.

In 2010, Transport for London (TfL) integrated just such a system onto all of the city's buses. Before going into service and starting the engine, drivers are now required to place a key fob that identifies them as the operator onto a reader (Figure 1a). If they do not do this, an alarm will sound. This device—known as *Drivewell*—captures driver behaviour and provides feedback in two forms. The first offers immediate notification of undesirable driving or 'events', communicated through a traffic-light module directly above the vehicle's windscreen (Figure 1b). The second provides a more detailed breakdown of performance that drivers can access via a computer terminal located in the capital's bus depots. Information provided includes date of journey, vehicle, duration, 'achievement' (given as a percentage) and overall number of 'events' (or incidences of poor driving). The driver can also assess their performance over time through a series of graphs or view on a map where 'events' occurred (see Figure 1c). All of this data is also relayed to supervisors, who use it to monitor and assess performance. Some of the companies who manage bus routes offer prizes (e.g. a TV) for the best scores over a set period. If poor scores are consistently attained, the driver can be sanctioned formally or forced to undertake additional training.

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Figure 1. From left to right: a) Placing the *Drivewell* key fob onto the reader; b) The *Drivewell* indicator in the driver's cabin (circled red); c) The *Drivewell* computer terminal; and d) close-up of computer terminal screen showing Drivewell scores.

The aim of this study was to explore the extent that *Drivewell* has been accepted by bus drivers and to understand its impact on their behaviour. In achieving this, we conducted ethnographic fieldwork, conducted over a period of 14 months, which consisted of continuous contact with research participants and formal interviews with 15 drivers. Through this, we sought to achieve a sophisticated understanding of the perceived costs and benefits of this kind of remote surveillance and the varying ways drivers incorporated *Drivewell* into their work practice. In this, we discuss both how some have accommodated to, whilst others have actively resisted, the technology; how it has transformed driving appraisals; and how it works interdependently with other surveillance technologies.

Our contribution to the field is three-fold. First, we advance HCI's knowledge on the ways that telematics influences driver behaviour, safety and wellbeing as well as large-scale transport informatics (a key issue for the Internet of Things). Second, the work also speaks to a highly controversial theoretical debate about the privileging of data-performance in the management of a workforce [5]. Finally, we assess the utility of *Drivewell* and consider new forms of resistance against modern forms of digital surveillance.

BACKGROUND

Telematics and Pay As You Drive (PAYD)

There have been numerous studies about the deployment of telematics technology in private vehicles, with considerable attention being paid to the relative costs and benefits of PAYD. Introduced in the late 1990s as an innovative method of determining insurance premiums, PAYD uses a GPS receiver and a small on-board computer to record data on location, speed, mileage and time of driving. A reduction in cost of this technology has facilitated the emergence of new business models that specifically target vulnerable drivers, like the young and inexperienced (who typically have to pay large insurance premiums) [12].

Studies in this field have illustrated how these initiatives can have a positive affect on driving behaviour. Bolderdijk et al [4] studied a group of young drivers who had signed up to a PAYD system that allowed them to save money on their insurance premium if they adhered to predefined speed limits. Speed was monitored over the period of a year with PAYD drivers showing significantly reduced speed when compared with non-PAYD drivers. Benefits extend beyond personal gain: economic and environmental impact studies have illustrated that PAYD schemes can be more effective for lowering fuel consumption than tax on gasoline [28].

Despite these benefits, a number of costs have been identified in the literature. Duri et al [14] for instance, identified the potential for data misuse, including the risk of it being sold to third parties without explicit consent. They also highlighted the danger of those with malicious intent accessing driver location. Subsequent studies by Iqbal et al [19; 20] have also outlined the privacy and security risks of leaked or hacked GPS data, in terms of the identification of home addresses and the unsolicited monitoring of driver behaviour and style.

There is also an argument that the telematic devices can over-complicate the task of driving. Lansdown et al [21], for instance, describe the problems associated with a range of new 'additional-to-driving' activities, including both operations that are unrelated to driving (e.g. the use of mobile phones) and tasks that are driving-related, but make the activity more convoluted (e.g. navigation and route guidance systems). As such, there is reason to hypothesise that telematics systems—either because of in-car feedback or through a driver consciously changing their behaviour because of the awareness of being monitored—might adversely complicate driving and, thus, adversely affect it and increase the risk of accident.

Driver surveillance and appraisal

We see telematics in general and remote monitoring of driver performance in particular as sitting within the wider remit of surveillance. Sociological contributions in this field are often dystopian in theme (e.g. [16]), and concerned with the concepts of 'power', 'politics' and 'employee meaning-making'. This stands in contrast to psychological contributions where there is a greater concern for the efficacy of surveillance and those factors (including economic ones) that make it beneficial in the workplace [1]. The earliest published theories of management, dating back to 1916, understood control and monitoring as central to the supervisor's task [15]. Employee monitoring therefore is

well established and related to long-standard practices such as clocking in and out, measuring output and payment by task completion. The development of information systems gave early large-scale organizations the ability to police their subordinates and gain an advantage over their commercial rivals [2]. It has also been shown surveillance can diminish employee wellbeing and the nature and intensity of it says much about how a company views its workers [1].

Surveillance and remote appraisal practices have steadily grown within vehicle fleet management, where issues such as speed, safety and timeliness are key to the successful running of a business. Historically, driver-appraisals were more subjective and made by a person. However, a number of key indicators can now be objectively measured via the various telematics platforms, which can identify and reward those who drive within established parameters. Simsek et al [33] identify a number of such objective indicators, including speed, the idle duration of vehicles, fuel costs—all indirect measurements of good driver performance. Additionally, where it is important to map the position of vehicles in the fleet in relation to each other, GPS based metrics such as headway (distance between vehicles) can also be used as a key performance indicator (e.g. [27]).

Bus drivers

Professional bus drivers face difficult and taxing daily tasks. They must negotiate a range of challenges in their physical environment, both outside and inside their vehicle, including traffic congestion, passenger demands and the maintenance of good operational control of the bus. Research spanning over fifty years has demonstrated that this is one of the most stressful jobs, leading to a range of negative physical, behavioural and psychological outcomes [35]. In the 1950s, a series of studies by Morris and colleagues (e.g. [24]) showed that bus drivers were twice as likely to die from coronary heart disease (CHD) than conductors working alongside them. In 1991 Rosengren et al [32] found CHD rates in bus drivers were three times the rate of 30 other sampled populations, once socio-economic factors had been taken into consideration. In a range of studies that assessed perceived stressors associated with such poor health outcomes, 69% of drivers cited traffic as the main problem [13] although fatigue associated with unusual or demanding shift patterns is also a known problem leading to poor driver health [8]. If we add to this the known psychological impact associated with difficult interactions with passengers [35]; the musculoskeletal disorders linked with poor cabin posture [35] and the gastrointestinal problems associated with meal hour irregularity and generally poor eating habits [35] then it is not surprising to find that bus drivers show unusually high levels of absenteeism [37] and high job turnover [25].

Recent years have seen further demands placed upon London's bus drivers, including the elimination of cash payments [29] and the introduction of 'headway' system where drivers monitor the distance of the bus in front and behind via an LCD display [30]. In part, our work analyses a further technological demand placed upon this occupational group that further reduces their autonomy.

METHOD

The data presented here was collected over a period of 14 months as part of on-going research studying digital technologies and the work practices of London bus drivers. Our results are derived from qualitative data, collected primarily through ethnography and semi-structured, in-depth interviews with 15 bus drivers, 10 of whom were interviewed twice. On average, our interviews lasted 50 minutes and all were audio-recorded and transcribed verbatim.

Ethnography attempts to understand the 'social meanings and ordinary activities' of a group, as they occur in 'naturally occurring setting' [6, p.10]. This is achieved by researchers observing and participating in as many of the activities of a cultural group as possible. Although for practical reasons we were unable to participate in the activity of driving, we spent as much time as possible observing this activity. Our fieldwork consisted of 'focused' bus riding around London for a total of five weeks (two at the beginning of fieldwork and three at the end). Here the researcher either shadowed a participant while they were driving or rode with one as a fellow passenger. During these rides, the driver would be asked to provide a commentary of the journey as it relates to *Drivewell* scores. One driver also wore a wearable camera that automatically takes pictures at 10-second intervals during two workdays. The images were later played back to the driver who was asked to reflect on *Drivewell* considerations for each part of his route. A detailed fieldwork diary was kept to record all of these interactions.

As the researchers already knew five participants, we were able to elicit perspectives in more sociable settings, either at bus garages during their breaks or in cafes and pubs after work. Employing the recruitment strategy of 'snowball-sampling' [3], we asked these informants to identify other potential participants. A plethora of classic ethnographies have demonstrated how 'key informants' like these work to smooth access (e.g. [36]). However this familiarity also meant that we had to pay acute attention to reflexivity, affording a genuine consideration of the partialities and bias we might bring into our work.

After fieldwork, we assembled all the raw data (interview transcripts and fieldwork diary) on a Microsoft word document to get an overview. We brought order to this by organizing sections under categories and then we drew out overarching themes. We then sorted the data further by breaking these themes into codes. This allowed us to group information together and assess related material.

FINDINGS

Four substantial themes were identified from this analysis: accommodating and accepting *Drivewell*; questioning the value of *Drivewell*; resisting and subverting *Drivewell* and managing multiple forms of performance monitoring. Each of these is discussed in the following sections.

Accommodating and accepting *Drivewell*

Interviews provided an initial opportunity to explore how our participants have incorporated *Drivewell* into their work routines. As will be noted throughout our findings, *Drivewell* is hugely divisive—while some drivers see it as a positive way of improving passenger service and gathering constructive feedback, others regard it as inherently flawed and counterproductive. However, it was clear that *Drivewell* had impacted on behaviour for some. Throughout bus journeys the lead author took with our participant drivers, it was observed how they would frequently glance at the *Drivewell* module located above their windscreen. Jimmy, who was one of the most enthusiastic drivers in regards to the system, was observed to check the indicator more than most:

> ***Interviewer:*** *Do you keep an eye on that a lot?*
>
> ***Jimmy:*** *Yes, yes, yes. Not to go red.*
>
> ***Interviewer:*** *And do you find it quite responsive, like if you brake?*
>
> ***Jimmy:*** *Yes, you have to go smoothly and nicely, so, otherwise they go red, it's not good.*

Jimmy's use of *Drivewell* is illustrative of its capacity to encourage a form of self-surveillance. Unlike most of the drivers we spoke to, Jimmy appears to have accepted *Drivewell* fully. When asked if he felt it had made him a safer driver, he noted: *Hundred percent. Hundred percent. If there's no monitors on the buses, some drivers, they don't care. They just drive whatever they like. Because of that [Drivewell], they are controlled.* Alan shared a similar sentiment: *"Well, it helps. It probably makes you try that little bit harder to get a better score, you know?"* As Alan alludes to here, one of the perceived values of *Drivewell* was the encouragement it would give drivers to achieve "better" or "good" scores. However, what was considered to be a good score or not differed widely across our participants. This was not helped by seemingly frequent changes from TfL and local bus garages in defining "target" scores and how these related to the traffic light feedback system situated on the buses. Jimmy, for example, tried to achieve green all the time and a 100% target. Nobby was another driver that appreciated the system and the feedback it gave—however, he typically aimed for a much lower score: *"The thing is 80% is the guideline. As long as you stick to around that then you can go under the radar, as they say."* Alan explained how while he did check on his scores frequently, he was careful not to attain too high a score all the time:

> ***Alan:*** *I think I drive about the right speed and the right comfort, and I try and get the balance. If you try and get too much of a high score I think you're going to slow down a bit too much. I like to get a happy medium – get around reasonably quick but not too quick so it's too uncomfortable. Have the score sort of above average.*

It was notable how, while all of the drivers did check on their scores, it was only a small number who took it very seriously. For instance, Erik targeted *"between 86 and 94 percent"* but stated: "*I don't worry about it. […] As long as I keep my score exactly the same every week, I like to be in the amber."* In a similar vein, Ray explained how he did check-in on his scores but he didn't feel this impacted on his driving behaviour: "*I drive the same way as I do day in day out. Like I say, I check my scores every now and again, and they seem fine to me."*

Bob was an example of a very cautious and careful bus driver, who prided himself in providing what he considered *"good service"* to passengers. He explained how: "*Service to me is comfortable drive and safe drive, and if passengers are happy, then you're happy and everybody is happy."* Bob had become weary in recent years of the ways various bus companies had developed systems to "catch drivers out". He regularly checked his *Drivewell* score but admitted this was more out of curiosity rather than a genuine interest in receiving feedback on his driving.

> ***Bob:*** *I sometimes look to see; "They have invested so much money on it, let me see what they're up to," for that purpose, but it's not to see how well I was driving, because I know that I was driving well. I mean, I don't have customer complaints, so as long as they're thinking that I'm giving a good service.*

While the primary way in which drivers spoke about the feedback they got from *Drivewell* was their overall scores for certain periods of time or routes, it was also noted how the system provided a useful means for modifying driving in specific areas. As will be discussed in more detail in the next section, one of the attributes of the *Drivewell* system is that it registers changes in the quality of road surfaces and bus suspension. While this can lead to problems with the quality of data collected, this was also useful for some drivers in modifying how they drive certain routes. For example, Jack was initially very frustrated with *Drivewell* but has come to terms with it over time: *I hated it when it first came in, but as I now am regularly around 100% on it I don't mind."* Jack explained how he started to see the value of the system through the level of feedback it provides a driver about the locations of events. As highlighted in the introduction, drivers can also use a computer terminal at the garage to get more of a detailed breakdown of how *Drivewell* has measured their driving. He explained:

> ***Jack:*** *It will also tell you any number of incidents, which may be where you did break hard. You can then get out a map, it will produce a map on that, show you exactly where, and in a lot of cases you will go, "Oh, yes, I remember that. That car pulled out in front of me" and you had to hit the brakes.*

Through use of the *Drivewell* terminal, Jack explained how he eventually identified a specific location that always caused a negative event on his report. *"There was one pothole on my route. When I first started driving that route I hit it. From then on I noticed all the drivers on that route were just pulling out*

around there, because actually this pothole was so bad it broke a bus." As a result, Jack explained how he had modified his driving down this stretch of road to avoid the pothole, and consequently saw an improvement in his *Drivewell* scores.

Some of our participants described how a competitive culture has emerged among some drivers; this was especially evident when a driver would log-on to the *Drivewell* terminal in the communal areas of the bus depot.

> ***Nobby:*** *When you put your Drivewell key in, which should be a personal thing, and it comes up, people start gathering, and they start looking at your score and what percentage you get. So yes, it can become a sort of competition*

As well as being seen as valuable as a source for reflecting upon and changing driving behavior, some drivers also felt that *Drivewell* contributed greater security and protection to drivers. Nobby explained how "*in many ways it's good, that if you have an accident it will hopefully in many ways help you, not hinder you. Because it can say that you weren't braking hard. You weren't driving stupid".* This view was echoed by Jimmy: "*It's good because if you have accident, all covered. Because everything's recorded. Speed, how was the turns, everything recorded. So in that case we are covered, all the records are there."*

Questioning the value of *Drivewell*

While many of our drivers did see the value—or some of the value—in monitoring the quality of their driving, most also felt that *Drivewell* went beyond what was reasonable and necessary. A selection of our sample made explicit reference to 'big brother' when asked about their general perceptions of the system: *"See, a lot of people when it first came out didn't like it, because it is like big brother is watching you"* (Nobby). Instead of judging it as a positive system that helps to improve their driving by giving them constructive feedback, *Drivewell* was regarded with some suspicion. Drivers believed the real motivation behind it was to increase the capacity to punish drivers: ***"****I don't think the people, who invented that, really thought about that [constructive feedback]. They thought about, "This is a way to catch drivers"* (Bob). Bob's comments illustrate how *Drivewell* has increased feelings of control and diminished feelings of trust between bus drivers and their employers.

Regardless of whether drivers had positive or negative feelings towards *Drivewell*, they were always framed by an overarching suspicion of the system's accuracy and efficacy. Employees felt that the system was somewhat simplistic as a measurement tool and too easily affected by a multitude of other factors that the driver had no control of. For instance many perceived that there were *"bad buses"*, typically older models with poor suspension (like the 'DPS' Dennis Plaxton model) that, if driven, achieve a negative score:

> ***Jack:*** *They also give you the scores for the buses, so you can see that certain buses are not good. The other day I had a DPS, which are not exactly the easiest. These are older buses. Ordinarily on a DPS forget it. There's absolutely no point in worrying about it.*

Alan articulates a similar sentiment: "*Yes, the suspensions vary from bus to bus."* He goes on to explain that the management team were generally aware of this and sympathetic to how the varying nature of bus suspension affects drivers' scores. For this reason, scores had a duel purpose—to first monitor the driver and second, monitor the mechanics of the bus: *"If a bus is constantly getting low scores with every driver they [the management] try and do something about it"* (Alan).

As well as so-called "bad" buses, drivers also argued that some routes were inherently "bad" and if assigned to them, they would be disadvantaged in their assessment:

> ***Jack:*** *But then some routes are bad, and you will see that the drivers on those routes are constantly in the lower range. I don't think they take too much notice of those, because they know that there's nothing really they can do about it.*

Bob summarizes the reasons many of our participants feel that *Drivewell* is a poor measurement of driving quality: *"most of the time, the result is based on the road surface, and crappy buses."* The drivers also felt that there was a clear flaw and irrationality in this measurement as a poor score or a negative event might actually signal good driving. This would be the case if the driver had to brake suddenly to avoid a pedestrian who stumbles onto the road: ***"****You have reacted fast. To me, more than you have done worse, I think you have done well; that's the whole concept"* (Bob). Under these conditions, the reward structure doesn't provide the incentive to drive well for some drivers as through being given a "bad bus" or a "bad route" or even through safe driving they cannot fairly compete against their co-workers:

> ***Interviewer:*** *So those people would never have a chance of winning the TV?*
>
> ***Jack:*** *Not a hope.*

These findings are consistent with other research that has shown how sensor data can be fragile [11]. It is therefore important to attach narratives to such material and put it into context [31].

A further issue of contention was the ways that *Drivewell* generates reports that 'flag' those employees who are potentially driving poorly so that managers can intervene. At this stage, drivers are interviewed by managers, following which a human form of surveillance—"the mystery passenger"—would be used to either confirm or contradict the findings of *Drivewell*. However, disagreement and anecdotal evidence about the inaccuracy of *Drivewell* as a tool to measure performance meant that many of our participants had crafted ready-made excuses in case they are called into the office for sanction. For example, Bob explained how he used to pay attention to *Drivewell* when driving but no longer did because he knew the system was flawed:

> ***Bob:*** *I know that if I get called in, for having a bad performance on that, I know how to back me up…I'd say, "Sort the bus out first, and sort the roads out, then I'll make*

sure that the performance will be 100%,". They can't catch me on that, definitely not. It doesn't tell me anything; it's just a waste of time and money.

It was for these reasons that Bob felt that TfL should revert to the traditional method of human surveillance:

> ***Bob:*** *I would have more mystery shoppers [passengers], because that would give me a better result* […] *remember, you could give a perfect service, but you could be having a bit of attitude to passengers; that, to me, is a bad service. That key thing* [*Drivewell*] *won't tell them that, but a human, at least if you're a mystery traveller, he could be able to tell you that.*

Bob here alludes to what was previously the primary means of assessing the driving quality. "Mystery passengers" would rate aspects of the driving quality across a range of subjective measures, but also be assessing other aspects of their duties that are critical to providing passengers with a good service, such as politeness. Our work therefore contributes to recent literature that questions the privileging of data-performance in the management of a workforce [5]. However, the use of *Drivewell* to identify those drivers who should be assessed with a mystery passenger was seen as an inherent failing in this approach—an issue that was compounded further as most drivers were able to recognize these "mystery" shoppers.

Resisting and subverting *Drivewell*

Despite all of the drivers accommodating *Drivewell* in some way into their work life, they simultaneously resisted and rejected its coercive potential. This type of resistance took a range of forms. Jack characterised his initial reaction to the system as illustrative of his *"natural anarchy"* and what appeared to a generally disobedient attitude to his relationship with management and performance monitoring: "*I went through a period of seeing how much red I could get"* (Jack). While Jack was initially dismissive of the system—and indeed other forms of management control—he did eventually see the value in the system. Other drivers displayed less overt resistances, instead preferring to modify their behaviour just enough so they wouldn't be liable for employer sanction. For instance, in a discussion with Erik and Justin, Erik started to explain how he would deliberately drive badly in order to reduce his overall score:

> ***Erik:*** *As long as you keep it between 70 and 90, they won't say nothing to you. Nothing at all. I keep mine – mine's literally the same every week. If I get into 100, when I'm running late, say I'm running from the garage to Peckham, all I keep doing is slamming the brakes on.*
>
> ***Justin:*** *Keep your score down.*
>
> ***Erik:*** *Yes.*
>
> ***Justin:*** *In case they expect you to get 100 every time?*
>
> ***Erik:*** *Yes, because if you stay in the 100s, then all of a sudden you drop down to the 80s, they'll want to know why. They'll start thinking, "Well, why's he doing that? Why has that gone like that?" So if you keep it the same all the way through, like mine is always between 86 and 94 per cent, and so I've got amber. Every time I look on it, it's amber all the way down. I won't be in your green.*

Erik regards *Drivewell* performance measurement as more complex than just managing to keep his scores in the green or amber zones on a given route. Instead, he looks at his scores over time and imagines the potential implications of him suddenly moving from very good to poorer (but not necessarily bad) scores. Through reflecting on this, he takes the decision to act by ensuring his scores are always *"good enough"* so as to avoid sanctions for consistently poor driving but also so as not to *"raise expectations"* that may not always be met. Furthermore, this tactic of purposefully driving bad on limited occasions affords Erik the luxury of not modifying his driving at other times.

We also observed ways that employees would resist *Drivewell* by attempting to discover ways to circumnavigate its use. As noted in the introduction, drivers are supplied with an individual key that they must plug into the *Drivewell* device every time they drive a bus. Two drivers admitted to neglecting to activate the machine if no passengers were on-board. This would typically happen when they were leaving the garage at the start of their shift. There was a general feeling that this was not a significantly disobedient practice as *Drivewell* is primarily explained to be a system for ensuring passenger comfort and satisfaction: "*It doesn't matter if you do give a rough ride, it's only yourself.* […] *If you're the only one on the bus, what does it matter if you hit a few bumps or something? Like I say, if you take it off, it should make a noise after a while."* (Gordon). By not using the fob at the start of their shifts, the drivers are able to creatively carve themselves a 'gap' in the apparatus of surveillance and resist the continuous extraction of performance information.

As well as removing their *Drivewell* keys at times when no passengers were on-board, a smaller number of drivers discussed how it was possible to circumnavigate it while the bus was in service. On one journey that the researcher accompanied a participant on, it was demonstrated how the key could be removed for a short period of time before the alarm started to become audible. This period of time—somewhere in the region of 10 to 15 seconds depending on the bus—was long enough to disable the system, restart it and stop the system from picking up on a potential event. Gordon explained how this was particularly useful: "*If you see a big pothole and you know you're going to hit it, you could take it off quickly."* However, Gordon was also at pains to explain how he would not do this regularly in practice himself: *"I don't think that's a good idea because you're not concentrating so much on your driving when you're doing things like that"* (Gordon).

Finally, a further instance of subversion was witnessed during fieldwork at a bus depot. As noted above, there were occasions where multiple drivers would gather around their colleagues as they were using the *Drivewell* kiosk to receive a detailed breakdown of their driving report. During one depot visit, drivers gathered around the terminal and listened intently to their colleague explain what was being displayed on the screen. The immediate response from the

researcher was that this driver must have received some extraordinary *Drivewell* scores. However, upon further investigation it was revealed that this driver was showing his colleagues where his holiday home in Spain was: *"That machine is quite useful. One of the drivers, who bought a house in a village in Southern Spain, was able to get that up on the machine and show exactly where the house he bought was"* (Jack). This illustrates how drivers have, even in a small way, the ability to creatively reshape *Drivewell* and use it on their own terms.

Managing multiple forms of performance monitoring

Our final theme relates to the ways that *Drivewell* was considered an additional complication to our participants' already challenging job of bus driving. In some ways the *Drivewell* unit was considered a literal distraction in a driver's cabin. Pat spoke at length about the ways in which he found the system distracting, both within the cabin and as a way of focusing the driver too much on getting good scores:

> ***Pat:*** *In my eyes, the problem is it comes up on a traffic-light system above you. You can be distracted from driving because you're so concerned at getting a good score. […] When it was first introduced, a lot of people were so concerned because, obviously, you're distracted. You're not looking at the road if you're looking up there.*

In many respects, *Drivewell* could be considered as a further addition to what is a complex job requiring great amounts of concentration. The complexity of the role was in many ways illustrated—yet also compounded—by the increasing modes of measuring driver performance. While our fieldwork was focused on the impact of the *Drivewell* system, very often participants talked about it in contrast, or alongside, these other ways their work is being monitored and judged. For instance, CCTV is used to add additional security to passengers but was also known to be a way of checking driver behaviour and action in the case of a complaint or road traffic incident. The iBus terminal—a GPS enabled system that visually displays distances between buses in front and behind on the same route (discussed in [30])—is a way of ensuring regular intervals between buses but is also a tool for real-time assessment of driver punctuality. In one joint interview with Nobby and Jack, there was a strong feeling that all aspects of their work life will soon be monitored: *"it knows your speed* […] *they know everything"* (Jack); *"they know exactly"*; *"you've got cameras, what speed you're doing, if you accelerate too fast* […] *You've got undercover, it's just endless"* (Nobby). The endlessness that Nobby here describes was demonstrated frequently to us as we accompanied drivers on journeys around London. After a limited amount of fieldwork we quickly noticed how many drivers are prone to glance at the iBus LCD and the *Drivewell* indicator almost as much as they check their wing mirrors.

We also observed the qualitative difference between *Drivewell* and other apparatus of surveillance present on London buses and the different ways drivers respond to them. Like iBus headway, *Drivewell* supplies immediate visual feedback. However, if headway performance is poor there are extra prods via text message and then a radio call, and so more importance is placed upon adhering to the demands of this apparatus of surveillance. The "mystery passenger" as a type of surveillance is also experienced differently, as described in the following quote by Jack. It is less immediate and doesn't require a reflexive response, rather it adheres to Foucault's metaphorical use of *panopticon* when explaining modern forms of surveillance – a design that facilitates the discipline of subordinates because it is impossible for them to know when they are being watched [16]..

> ***Jack:*** *Oh, you get them regularly anyway. You will suddenly get a letter saying, "You were assessed the other day." They don't use our own staff very often, because-*
>
> ***Nobby:*** *We know them.*
>
> ***Jack:*** *You see somebody get on, and you see where they're going to sit, and from then on it's absolutely mirrors, mirrors.*
>
> ***Nobby:*** *Put away your sandwich. (Laughter)*
>
> ***Jack:*** *Yes. Wait until they all sit down.*

It was also apparent that it wasn't just the functional operation of duties in relation to these different forms of monitoring that was challenging, but also that sometimes trade-offs had to be made in prioritising certain measures over others. For example, Nobby explained how he was *"caught out"* one time when his score was adversely affected after he had to leave the bus garage late:

> ***Nobby:*** *Work informed me that I left late, and so obviously my driving was rather erratic. Basically I was driving it like a rally driver from Tottenham to – basically I left about 12 minutes late and given about 50 minutes to do it. So basically when I finished I realised, or when I put my score in, it was down to 60, and therefore I realised it was the way I was driving, because of obviously the braking and the acceleration. So I went from average 80 down to 60.*

On this occasion, Nobby acknowledged he had driven his bus *"like a rally driver"* in order to make up time and not be reprimanded for causing delays to services and not maintaining equal distances between services. However, he realised on reflection that in doing so he had significantly impacted on his *Drivewell* score. He acknowledged on reflection that he may think twice about trying to catch up to schedule like this in the future. In a similar example, Gordon explained how when it came to managing both *Drivewell* (monitoring of acceleration, speed and horizontal movement of the bus) and Headway (keeping a designated gap between the buses in front and behind on the same route) he aimed to keep both in balance with one-another: *"It's getting the happy medium, isn't it? Keep the bus on time, but give a reasonable ride. I try and get that balance about right. If it's too comfortable you might be going too slowly."* (Gordon). After being pressed further on this point, however, Gordon explained how maintaining headway would be prioritised over the quality of his driving:

Gordon: *I don't like the bus in front to get too far away. If it gets a little bit ahead, especially if it's a fast bus driver, we can get further ahead. So you've got a wider headway, plus you can start and get later and later and later because you're picking up passengers who would have missed your bus had you been further down the road. I like to keep closer to the one in front. It makes it easy. You can't get too close because otherwise they will call you up. The controllers will call you up and say, "Hold back two minutes. Hold back three minutes" or whatever. I'd rather just have it so that I can just get away with it without any of them having to say anything to me.*

Gordon reflects on the ways in which he has to negotiate the different forms of surveillance and the ways in which it may impact on his immediate work. He is aware that if he drives too close to the bus ahead of his then he will likely get some *"grief"* from the controller on his Headway system. This may mean being asked to wait for a short period to build the gap up further or receive further *"hassle"* from his controller and potential disciplinary action. The implication here, however, is that by slowing down the likelihood of picking up more passengers increases and thus the bus becomes delayed and becomes too close to one that may be following behind. This would mean having to increase the speed of the bus in order to maintain a distance to the one behind—which, of course, would likely mean more aggressive driving and acceleration, impacting on *Drivewell* scores. Therefore, by carefully managing his Headway all the time, Gordon considers himself better placed to keep his ideal *"middle ground"* between good Headway and *Drivewell* scores.

DISCUSSION AND IMPLICATIONS

Our fieldwork has highlighted the ways telematics systems like *Drivewell* can impact a remote and mobile workforce. The device undoubtedly has some positive impacts, seen most clearly in the way it affords real-time feedback and opportunities for reflection on driving practice. However, there are wider questions about the validity and accuracy of the data collected by *Drivewell*, which was indicative of broader concerns about digital surveillance. We discuss these issues below in three interrelated themes: first we explore the ways *Drivewell* carries assumptions about the nature of good driving and ask whether these assumptions reflect the drivers' own understanding of best practice; second, we consider *Drivewell* as one element in a complex technological ecosystem, asking how well the complexities of driving can best be captured by this integrated telematics platform and exploring the extent to which the systems set up competing demands for the driver; third, we ask whether driver surveillance techniques can be integrated into an effective driver appraisal and reward system that could ultimately improve performance.

What does it mean to drive well?

Drivewell is associated with a number of claims, with published benefits including improved passenger comfort and better fuel efficiency. However *Drivewell* does not directly measure these outcomes, but instead offers a simple proxy measure that can then become a target in its own right. We have seen that drivers can develop quite elaborate strategies to maintain their *Drivewell* score, but we should ask to what extent these strategies ultimately serve the company, the passengers and the drivers.

We have evidence that some drivers have used the system as a learning tool, using the scores to reflect on their driving and consider areas for improvement. These drivers maintain a more nuanced view of their role and responsibilities. They are likely to balance the demands of *Drivewell* with other work demands and in the process are likely to acquire new skills and knowledge that could genuinely lead to better driving. However, the score can become an end in itself—leading either to a race to the top, when drivers compete to get the best score, or a race to mediocrity, when drivers try to establish a readily achievable baseline score and stick to it. Under either circumstance, the score becomes the target and there is a real danger that genuinely good driving—like keeping a safe distance from the vehicle in front, gets lost along the way. This implication is consistent with other research that has highlighted the potential of sensor data to be insubstantial in the accurate measurement of an activity [11] and other work that has demonstrated the importance of attaching narratives to such data [31].

How to drive a London bus

The act of driving a London bus is quite unlike other forms of non-commercial driving, in large part because of a range of technological innovations that have been introduced in the last few years. *Drivewell* operates as part of a technological ecosystem where different devices monitor specific information in relation to driving style (*Drivewell*), location, speed and relationship to other buses (iBus), passenger behaviour (CCTV) and general conduct (mystery passenger). In short, the London Bus is now imbued with an intelligence and ability to communicate with other buses, with passengers and controllers in a way that anticipates the seamless communication of smart objects in the Internet of Things and the eventual roll out of driverless vehicles. There is one very important difference, however. In this system, the human driver is still in complete control of the bus. If the array of on-board devices will ultimately serve to reduce the autonomy of the driver, then two questions should be raised. First, do the different devices work collaborate to support the driver or do they compete for valuable attention and set up competing priorities? Second, do these systems lead to accurate and effective performance management?

In answer to the first question, we found that the different systems can compete in unhelpful ways. Driving well, being sensitive to local conditions and to the needs of passengers is not necessarily compatible with driving in a way that maintains headway between buses [30] or that keeps the bus on schedule. As we have already noted, on-board devices can place additional demands on the driver's attention, adding to the range of 'multiple additional to driving' distractors that are becoming commonplace [21]. As such, if monitoring systems are to exist, they should be implemented in ways that

do not immediately impact on bus drivers' attention and the way work is assessed.

In answer to the second question, we need to return to the organisational literature on performance monitoring and appraisal in order to ask whether telematics are likely to improve worker behaviour, organisational culture and management practice. We know that any surveillance or monitoring system should be designed to appropriately and accurately assess performance on a particular task. We also know that the best performance monitoring systems respect the psychological and emotional elements of a job—such that performance scores are not considered alone [34; 26; 10; 22; 7]. Given the various aforementioned stressors on those who choose bus driving as an occupation, there is a danger that *Drivewell* fails on both counts. As we have seen, drivers have challenged its accuracy, feel that they don't capture good driving in its fullest sense and fail to account for the quality of the vehicle being driven and the nature of the roads travelled. In terms of the integration of this system into the wider organisation we also encounter a perception that the technology is deployed to benefit the employer at the expense of employees. In short, we don't see much recognition of the known stressors already acting on the bus driver, nor much consideration of how new surveillance might add to those stressors.

Resistance in a mobile and remote workplace

Marx famously described the ways workplace surveillance is used as a tool to maintain managerial control on behalf of capital. The architecture of a factory renders workers highly visible and therefore controllable by their supervisors. Workers' resistances to coercion in these spaces consisted of literally throwing a spanner in the works to halt production lines and traditional forms of work solidarity like unionization. We see this in the modern workplace, where research on call centre workers has shown that intense surveillance generates acts of worker resistance, sabotage and non-compliance with managers [17; 9].

For decades, the driver workplace offered few points of comparison with the factory or call-centre context—they worked alone (or in pairs) in a remote and mobile context where performance monitoring was ad hoc and subjective. So what does the implementation of digital surveillance mean in terms of worker resistance? We have seen the various ways that drivers are able to discount the legitimacy of *Drivewell*—questioning its accuracy or appropriateness. We have also seen a number of resistances that include removing the fob for short periods in order to reduce recorded 'events', purposefully performing poorly in order to reduce expectation and challenging managers' interpretation of scores by blaming vehicles and the road. In part, this would seem to be a reflection of the simplicity of the performance measure and it would be interesting to consider the ways the drivers themselves might be able to present their own 'scores' as part of a more sophisticated package of evidence in support of skills. It is interesting, in this regard, that the drivers themselves have adopted the practice of using *Drivewell* in their own evidence-gathering efforts to illustrate problems with a particular bus or route and fostering this kind of agency might be a more acceptable way to go.

CONCLUSION

In this paper we have studied *Drivewell*, a telematics device installed by London's transport authority on their buses to measure and regulate driving. This is an example of an increasing range of driver-surveillance technologies on London's buses. Although drivers did see some value in these systems, they have also caused anxiety and there is deep suspicion about this technology's efficacy and accuracy. Our findings highlighted a range of resistances drivers have developed to compensate for and work-around the Drivewell system. We also saw how drivers have to negotiate between the demands of *Drivewell* and other monitoring systems, some of which are based on competing and contradictory forms of assessment. While these issues emphasise the deep challenges to accepting such monitoring technologies in remote and mobile workplaces, we suggest there are positive opportunities here to harness the learning potential around sensor data and to support the development of skills and self-advocacy in the workplace.

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