Digitally Driven: How Location Based Services Impact on the Work Practices of London Bus Drivers

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ABSTRACT
This paper examines how an occupational group has adapted to the demands of working with a Location Based Service (LBS). Instead of following a rigid timetable, London's bus drivers are now required to maintain an equal distance between the bus in front and the one behind. Our qualitative study employs ethnographic fieldwork and in-depth semi-structured interviews to elicit drivers' perspectives of the new system and show how it has modified their driving and general work conditions. We explore how passengers influence the movement of the bus and how the technology frames bus drivers' relationships to their managers and commuters. This work contributes to our understanding of the impact of LBS in the workplace and shows how technological imperatives can be established that cause unanticipated consequences and gradually undermine human relationships.

Author Keywords
Public Transport; Location Based Services; LBS; Location Based Devices; LBD; Auto ethnography; Ethnography.

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

INTRODUCTION
Digital technologies have become an integral part of modern travel. Increasingly, transport companies are seeking to support passengers by providing location based services (LBS) that can alert them to when the next train or bus is arriving and maintain schedules between vehicles to deliver a more regular service. In this paper we focus on the ways the implementation of an LBS - the iBus and its associated headway timing system - has changed the work

practices of London bus drivers. These technologies help drivers co-ordinate with one another, make services more efficient and ensure an even distance is kept between buses on the same route. While most of these technologies have been introduced to enhance the reliability, frequency and passenger experience, they also impose significant changes to traditional bus driving work practices. Ge et al. [16] suggest that LBS and driver monitoring have the capacity to improve staff behaviour - reducing fraud and improving efficient driving in taxis, for example - but we must also be aware that 'panopticon' workplace monitoring practices can adversely affect staff morale [39]. The idea of a panopticon has been inherently linked to LBS monitoring systems. The premise is one of complete surveillance without knowledge of when and where one is being explicitly watched. In the modern workplace, new forms of "electronic panopticon" [2, p.2] are implemented in the hope that, with constant yet covert surveillance, employees will become more compliant.

The work context in this study is bus transport - an area where HCI research has been eclectic. Prior work has studied systems to support traffic regulation at junctions [4], technologies to assist conductors [1], studies of media sharing among commuters [23], in-bus information systems for the visually impaired [35], and systems to encourage fuel-efficient driving habits [25]. In the specific context of London buses, prior work has studied the introduction of new automated fare collection systems [21] and the lived experiences of passengers [19]. However, no work has examined the impact LBS can have on these important transportation systems, nor the implications for drivers and their long-established work practices.

In our study we adopted an ethnographic approach, using qualitative fieldwork. Our contribution to the field is threefold. First, we advance HCI's understanding of the ways LBS can change driving behaviour, relationships in the workplace and experiences of public transportation. Second and more generally, we add to our understanding of the role of such systems in surveillance and control, illustrating the ways LBS can change workplace power dynamics. Finally, we suggest ways to improve the implementation of LBS in this workplace.

RELATED WORK

Outside of the workplace, the use of LBS to share information with family and friends has become popular, particularly amongst young people [32]. Research has illustrated the benefits of using LBS to support communication among family members and friends [e.g. 2, 3, 7, 34]. There have also been studies reporting the privacy concerns around location data sharing [6, 8]. Unsurprisingly, people are more willing to share location data with friends and family than with colleagues [7].

LBS studies conducted within the workplace are relatively scarce. Those studies that exist tend to be office-based and focus on the protection of lone workers [26] or on raising awareness between co-workers—such as the use of 'active badges' for worker monitoring in a research institution [17], and public broadcasts of the relative location of colleagues [27] (e.g. at work, at-home). Such interventions were well received, but crucially they were opt-in systems designed to support worker collaboration. Mandatory use of LBS monitoring in the workplace is often resisted as it can result in changes to time-management, workload and morale [21]. In a study exploring the implementation of GPS-monitoring for parole officers to supplement parolee supervision in the US, Shklovski et al. found that the technology radically transformed their relationships [28]. Previously held organisational values of reintegration and progression deteriorated, giving way to a new standard of surveillance and recidivism. Parole officers maintained that although the technology offered new ways to keep track of parolees, more human interaction was preferred.

When more stringent systems are introduced for top-down performance monitoring [22, 29, 36] workers often report concerns about privacy and invasiveness [38, 39]. Even when privacy principles can be established and upheld, resistance to LBS monitoring is strong [39]. This can be mediated however by perceived risk to the worker and by trust in the employer [24]. Lone workers or vulnerable individuals can accept that their job carries significant risk and that some type of monitoring is desirable. A study of 387 employees in the US, UK and India, found that employees overwhelmingly resisted workplace monitoring [36]. However, those who perceived themselves as vulnerable, who had higher levels of self-efficacy and greater levels of trust in their employer 'were more amenable to monitoring' [p.229].

Trust and employer disclosure are two of the key components of the predictive models of LBS acceptance [20, 32]. In the workplace, intentions to use LBS have been identified as a function of three factors: (i) the perceived usefulness of the technology; (ii) trust in the LBS provider and (iii) willingness to disclose information to the employer. In considering this current study, we would predict that the relationship between employer and employee be important. What is distinctive in this work however is the way in which the usefulness of LBS within

the London transport system can be contested by a number of different parties—not simply employer and employee, but the passengers themselves. As we will see, the proposed passenger benefits of LBS are not to be taken for granted.

LONDON'S BUS NETWORK

London has one of the world's largest bus networks; facilitating over 1.8 billion passenger journeys a year on 7,500 buses servicing over 700 different routes [31]. This form of public transport is an integral part of London life and it is estimated that 90 percent of Londoners live less than 400 meters from one of the Capital's 19,500 bus stops.

London Buses, a subsidy of *Transport for London* (TfL) are in charge of contracting out different routes to the 17 companies operating bus routes in London. London Buses also control the age and specifications of vehicles and allocate routes through a tendering system where operators bid to run them for a 5 year period. Operators have to work within guidelines set by TfL and are in charge of driver recruitment and vehicle procurement. TfL are the local government body responsible for setting bus routes and service levels. They also monitor service quality, manage bus stations and stops, set fares, assist drivers in the case of diversions and traffic accidents and provide passenger information. This body also incorporates a bus command and control hub called *CentreComm*.

Timetables, bus bunching and the headway system

Before 2009 London's buses ran to a timetable. Copies were displayed at bus stops and on TfL's website, listing the times a bus was scheduled to arrive at named locations. Although timetables are designed to schedule buses evenly, anyone familiar with the old adage, *"You wait ages for a bus and then two come along at once"*, will recognize that buses regularly bunch together, creating an unreliable service and long waiting times. Bunching occurs because even if a bus is slightly late it will pick up extra passengers who would have taken the next bus. These additional commuters delay the bus even further and cause the bus behind to run ahead of schedule as it has fewer people to pick up. Eventually, this bus will catch the one in front.

In 2009 the 'headway' system was adopted as a corrective measure to avoid bus bunching. Instead of publishing a specific time, the headway approach uses LBS to measure the distance between buses. Instead of a published timetable, notices now state the estimated time between services (e.g. 'services run every 5-7 minutes'). The iBus terminal, fitted on all London buses, contains a GPS-based system that provides drivers with an LCD display informing them how far the bus in front and behind are (Figure 1). The driver is expected to keep an equal distance between the two within a two-minute time frame. All buses are monitored externally by controllers at CentreComm who watch 2 to 3 routes at a time, to an accuracy of 10 metres [9]. The controllers can request the driver to moderate their driving via on-screen prompts or verbally through a radio.

Figure 1. The iBus terminal

Name	Age	Service	Name	Age	Service
Peter	40-45	26-30 years[1]	Frank	40-45	10-15 years
Tony	60-65	10-15 years	Mark	50-55	24 years
Jim	46-50	10-15 years	Keith	40-45	10-15 years
Mike	60-65	10-15 years	Lee	30-35	0-5 years
Ron	65-70	6-10 years	Lesley	40-45	0-5 years

Table 1: Research participants

METHOD

Inadvertently, data collection began five years ago when the lead author was given special dispensation to join a bus-drivers' football team. This involved training sessions, competitive games and frequent social gatherings where he gained an interest and appreciation for how technology impacted the working lives of this occupational group. This was a popular topic of conversation among drivers who frequently mused about how their jobs had changed over the years. This background and awareness provided the motivations and cornerstone of this research.

When the formal research commenced, our cordiality with this group greatly eased access. Ethnographic fieldwork consisted of riding on different buses with our participants, both when they were driving and when they were not. While riding a bus with participants, they were asked to provide a commentary on the driver's performance and speculate on the specific motivations for each passenger encounter or subtle driving technique. While riding a bus with a participant driving, the researcher kept a detailed log of the journey, and sat on the seat nearest the driver. Officially, passengers are supposed to stand behind a yellow-painted line and are forbidden to talk or distract the driver. Despite this, our participants would regularly beckon the researcher to stand by the cab. Drivers were enthusiastic about relaying the intricacies of their work and these observations fed into semi-structured interviews with 10 bus drivers and one ex-bus driver who now has a position working closely with controllers. All participants, with the exception of Lesley, were male and this reflects the gender makeup of the profession. Details of drivers, their age and length of service is provided in Table 1. All names have been changed and ages and length of services given in bands to protect participant confidentiality

A total of 8 routes were observed two or three times each. Half of these journeys were with a participant driving and half with a participant riding along with the researcher. The journey time for a typical route was an hour. The lead researcher is also a native Londoner and was able to draw on his experiences of being a bus passenger in the city.

The lead author's close social connections with most participants granted us 'insider status' and motivated them to be incredibly helpful during fieldwork. This afforded the opportunity to contact drivers after the interview phase to ask them to clarify points and pose follow-up questions. After fieldwork we also received a number of text messages from interviewees relaying details that they thought were important but neglected to mention during fieldwork. These informal relationships also helped us to triangulate our data by double-checking assertions made by other drivers.

The lead author's personal history with this occupational group made our research bear the hallmarks of auto ethnography, a method that to date has only been employed selectively in HCI [11]. It is characterized as an 'autobiographical genre of writing and research that connects the personal to the cultural' [12, p.739]. A benefit of this approach is giving an insider's view of the research subject. Due to this familiarity, it is unhelpful to characterize data analysis as a segregated process in our research. Analysis began in the field when we decided what issues appeared to be relevant and what questions were important to ask drivers. After fieldwork, all interviews were anonymised and transcribed. Following Glaser and Strauss [17] this data along with our fieldwork diary was coded at the sentence to paragraph level to develop themes [17]. This data was then reassembled using selective quoting to illustrate these themes.

FINDINGS

Three themes were identified from our analysis of the data: *driving modification*, *surveillance and control*, and *passenger and driver interaction*.

Driving modification

This section highlights the how LBS has caused bus drivers to modify their driving behaviour through the requirement to respond to the iBus prompts, by continually altering and managing their pace, and by enforcing new professional standards on their work practices.

Responding to the headway system

Three of our participants were very positive about the iBus and headway system. Tony, who started driving buses in

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[1] Peter began working as a conductor at 15.

the early 80s, likes to treat the demands of keeping an equal headway as a type of game, enjoying the challenge that the system demands:

> *"I prefer it like it is because you've only got to glance up at a bus stop and you can see straightaway how early or late* [you are]*. If you've got to slow down, you stay at a bus stop a little bit longer so you know the traffic lights will be red by the time you get there. Whereas if you're running late, you'll hopefully get the green light."* (Tony)

Tony's positive attitude towards the headway system stood him apart from most drivers who were contemptuous of it. Mike reflected nostalgically about the bus timetable that he used to work to and articulated a sense of disorientation and uncertainty in his work since the introduction of the new system: *"you don't know where you are now. When you had the old timetable system you knew where you're supposed to be and that."* Jim was more candid and forthright in his opinion: *"Basically,* [it] *is the biggest load of shit going, because it don't work. It don't work, it's the worst thing they've ever brought out."*

Overall, drivers felt the LBS created an additional burden to their work and made it more stressful. Frank felt that the new system took away his agency and resented that he couldn't use his situational knowledge to drive the bus optimally. This implies that the new system deskills the driver and marginalizes them from the various driving decisions they used to be able to make:

> *"They can tell us to slow down. That can be infuriating because you're doing your job, you're going at the rate of what the traffic conditions and the passenger conditions are allowing you."* (Frank)

Frank believed that the essence of bus driving had been lost. To maintain a headway drivers often had to slow down in what they felt were inappropriate places. During fieldwork, we observed some of these frustrations first hand when Jim had to pull over to the side of the road for 5 minutes. During this time, he called the researcher over and said these type of interruptions were one of the worst things about his job. Others complained that this heavily-mediated driving style caused them grief from passengers:

"The other day when I was told to lose a bit of time on the bus in front, there was this woman on the bus, who, because I was driving slowly, was getting really upset about it: *"Why are you driving so slowly?"* I said, *"I've got to lose a bit of time. I'm too close to the bus in front."* She was getting really, really worked up about it." (Ron)

Passenger anger was all too evident during fieldwork, often aimed at what they saw as unnecessary delays to their journey. Frustration was especially fierce on mornings as people travelled to work or had transport connections to make. The need to drive to the demands of headway created additional work, as drivers needed to expel emotional labour in interactions with passengers frustrated with the irregular movement of the bus.

Speeding up and slowing down
As a safety issue, drivers were not supposed to be told to drive faster in order to make up time. However, some drivers confessed to doing this. Jim explained how sometimes: *"You've just got to floor it in between stops"*. A number of the drivers described feeling pressurized to drive faster even though safety and driving law made them reluctant to do so. This created greater pressure for drivers: *"There's a lot of pressure for you to accelerate to bring that needle back, if you know what I mean."* (Peter). Some drivers resented this and refused to be coaxed into driving fast. There was still a range of driving strategies they could employ without actually driving faster:

> *"If you start slowing down and looking left and right at a junction, you keep going on, you are driving effectively on road conditions. If the lights have changed red when you are approaching them, if you back off, ideally they will go around and you can get through that second set of lights. No point racing up to them."* (Frank)

During fieldwork drivers' interactions with the researcher would vary greatly depending on whether he had to make up time or not. On some journeys, it was not possible to speak to the driver until the end of the route. On being asked how they make up lost time, a couple of drivers even admitted to driving past passengers: *"Drive straight past them* […] *Especially if somebody said to me the day before, "Oi, you fucking arsehole, I've been waiting half an hour"* (Frank). Others admitted to only being motivated to move fast if they were near the end of a shift or their lunch break:

> *"You don't want to be late. If you're late, sometimes, you just have to swallow it. "Right, there's nothing I can do about it," and you're late. Other than that, you will put your foot down and will be quite upset when there are people at bus stops putting their hand up or ringing the bloody bell."* (Jim)

Slowing down a bus or 'losing time' is a different activity altogether. Unlike making up time, this is something that controllers can, and often do, ask drivers to do via the iBus terminal. This can cause distress as a lot of drivers feel they are at the mercy of traffic conditions and other drivers:

> *"There is nothing worse than when you're trying to lose time. You can guarantee that the lights will all be green and every driver will be absolutely so charming. They'll flash to let you out and you're thinking, "No, please go. I'm trying to lose two minutes."* (Ron)

On two occasions, drivers called the researcher to the front of the bus to vent his anger towards the faceless controllers who were asking them to slow down. The most straightforward method of slowing down a bus is to park it at a bus stop. While this tactic is the one recommended by TfL, bus drivers do not enjoy employing it as they get

complaints from customers. They also have difficulty in communicating why they are stopped and the demands of the headway system as opposed to a more traditional timetable. Instead, most drivers employ a variety of strategies to discretely slow down the journey:

"If you do it discretely you don't have to ask, and it is only poodle along, break, put your handbrake on, turn round, open the doors, lower the bus. There are ways. Everything takes seconds, but everything works into that minute. It doesn't take long to lose that minute." (Keith).

When needing to lose time, we witnessed that drivers regularly gave more attention to passengers and spent a greater amount of time on routine activities like opening and closing the bus doors and pulling away more gently. Other participants described how they had to change their attitude and behaviour towards other drivers on the road:

"As a bus driver, you do feel you have to be an assertive driver because nobody will let you out. When you're running early, you do the opposite and traffic tries to let you out". (Frank)

Frank explained how he adapts his driving personality depends on the demands of the headway system. The drivers have to continually move between rather selfish and altruistic approaches to driving.

Enforcement of professional standards
Driving behaviour was also adjusted as the tracking systems on their buses had prevented the drivers transgressing some workplace rules. As Ron articulates, controllers have the ability to ascertain the location of all buses in real-time. This annoyed him greatly because in the past he parked at bus stops to do some shopping or carry out other errands:

"The disadvantage is there is absolutely no chance you can slope off anywhere because they know exactly where you are. They know the times that you arrive at every bus-stop. Every single thing is recorded." (Ron)

Jim vented his dislike of being closely monitored at work and explains how it has prevented him from taking unsanctioned breaks:

"The iBus is a pain in the arse, they know exactly where you are. I used to go off route in the old days round my mate's house […] *for an hour and a half, and then pick my time up on the way back up the next time. No one knew anything. Now they know exactly where you are."*

Another driver relayed a story of a colleague actually taking his bus out of service in order to transport a horse from one field to another:

"I do know of someone actually transporting a horse. It was a driver, he actually took his horse to move it to another field […] *all on the hush-hush."* (Keith)

Others spoke about how they used to compete with each other to see how many times they could drive around a round-a-bout with passengers on board. One driver spoke proudly of managing to do it twelve times with a vehicle full of passengers. Although some travellers complained, he asserted he was a new driver and wasn't sure what exit to take. Two drivers also admitted that prior to iBus they were able to cover-up minor accidents they had. Even a minor traffic accident now means drivers have to fill in paperwork, something many begrudged.

Surveillance and control
Here we explore driver's perceptions of LBS as a source of surveillance, how controllers use the information provided by LBS to control drivers and also the ability of drivers to resist the controlling qualities of this technology.

The feeling of being monitored
The introduction of LBS has initiated a new form of surveillance on London's buses. Half of the drivers made Orwellian references when articulating concerns about how LBS impacted upon their privacy: *"When it first came, it was like this Big Brother thing. Personally people didn't like it."* (Frank). Most drivers, especially those who had worked on the buses for some time, spoke about having to psychologically adjust to these new forms of monitoring. However, greater experience and exposure to LBS lessened their concerns and most eventually adopted a philosophical stance: *"At the end of the day, if you have done nothing wrong you have got nothing to worry about. You know? That is what it boils down to."* (Keith).

Others however saw a clear benefit in LBS when used in conjunction with CCTV. CentreComm allowed the police and other emergency services to locate buses near incidents and get access to the CCTV cameras both inside of the bus and surrounding areas. Drivers argued that their provision had helped combat terrorism and crime:

"Like, when that drummer Lee Rigby[2] was killed . We had a group go up to the CentreComm, […] *where they can monitor everything, a lot of the guys that dispatched the first set of ambulances, police cars, were able to watch it in real-time from the CCTV cameras around."* (Lesley)

In a similar vein, Ron recounted an occasion where the monitoring system was central to solving a murder. One driver, Keith, proudly declared during an interview that CCTV allowed them to be *"the eyes and ears of London"*. Here we can hear echoes of Workman who found workers were less likely to object to monitoring if they felt themselves especially vulnerable [36]. The difference here is the drivers perceive the city and not themselves to be in need of extra caution and invigilation.

Continual controller intervention
Controllers are required to intervene when they feel a driver is not maintaining headway. This caused a level of

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[2] Lee Rigby was an off duty British Army soldier who was attacked and killed on the streets of London on 22 May 2013.

animosity directed toward them from drivers: *"They're against you. The controllers are against the drivers."* (Jim). In the first instance, controllers would prompt the drivers to modify their driving through a text message delivered to the iBus terminal. This created an unwelcome distraction from driving and introduced a further level of emotional labour:

"You have got the controllers texting in to the iBus. The driver is supposed to be concentrating on his driving, not looking at a screen in the corner to read these text messages." (Lesley)

There were also numerous instances of the technology not working properly. Keith describes being told to slow down before he had even begun his journey:

"They text me at the stand, "Keep an eye on your headway. Hold back for two minutes." I did, I hadn't left. I waited two minutes, and then came another text, "Driver, please mind your headway." I radioed and said, "I haven't even left yet."

During one journey, while waiting to drive a route the bus was delayed as another bus had parked in the wrong place at the garage. The controllers didn't have this information and Keith became visually agitated as he tried to explain the situation over the radio to them after the journey had started. Among drivers, it was understood that the system contained glitches and would occasionally give controllers false information regarding the location of buses. This created further stress and extra work for drivers who had to communicate with controllers over the radio. This new workload was further added to as controllers would send a radio message to drivers if they had not responded to a text prompt. This caused an additional unwanted distraction as it worked to slow drivers down even further:

"Controllers expect you to answer them straightaway. Now, if you were doing it to the letter of the law, you would have to pull over, put the handbrake on and put it in neutral to answer them." (Frank)

As Frank explains, responding to a radio message is not just a simple task of talking. In the UK it is against the law to use handheld telephones and radios while driving, and it is against company policy to talk on the radio while driving in public. Therefore even the simplest of responses involves pulling over and potentially losing time:

"CentreComm get terribly upset if you don't pull over and stop the bus. Ideally, they'd like you to switch everything off. They say, "We can't hear you," which is a load of bollocks." (Ron)

Lesley found the coercion by controllers so stressful that she left the job after six weeks:

"Training was alright, and then when you are actually out there driving, you have got the controllers moaning at you, your iBus is beeping, and you have got the controller

moaning at you through that. You have got passengers on top, and you just think, no."

Finally, if a driver continues to not respond to the headway system, they are called into the office for a formal discipline hearing. Although nearly all of the drivers we spoke to did their best to maintain headway, two resisted, primarily as slowing down delayed their breaks or leaving times. Here Jim recounts a time when maintaining headway would have meant stopping the bus and finishing work late. He refused and this led to a disciplinary hearing:

"I've been in [a disciplinary] *once. I said to them I ain't doing it, because they want me to finish later as well, even with my last trip. I said, "You can't make me do overtime, it's against the law, and I will not do overtime unless I want to do overtime". They're not going to tell me.* […] *They can have me in every week for all I care; I don't care. They're not making me do overtime."* (Jim)

Passenger and driver interaction

Our final theme explores how bus travel is quite distinct from other forms of public transportation in the greater degree of interaction between passengers and drivers and also in the frequency of stops. This has implications on the ability of drivers to maintain headway, and headway impacts upon the relationships drivers have with their passengers.

During fieldwork it became apparent that the headway system had strained the passenger-driver relationship. The high levels of driver-passenger interaction in bus transportation made bus driving less predictable, especially in terms of the length of time it took passengers to enter and leave the vehicle. The need to get them on and off the bus quickly in order not to fall behind caused drivers to categorize passengers into distinct groups. Experience endowed them with the perception that certain 'types' of passengers were likely to be slow and make maintaining headway more difficult. In particular, older people and parents with young children were seen to take a disproportionate amount of time getting safely on and off the bus. A popular in-joke among drivers involved referring disparagingly to older passengers as 'wombles', the large fictional rodents in a popular British children's stop-animation TV show. The drivers perceived a similarity between the way wombles were unencumbered in their movement and the way the free public travel offered to all Londoners over 60. During fieldwork, Rodney, a driver in his 30s, spoke frankly about his views of this age group:

"It's not like they have anything to do other than ride the bus […] *They DO slow down the bus, they get on slow and get off slow. You can't move until they are sitting down. This can lose 1 minute a bus stop and soon enough, you are running late."*

Talking to older passengers during ethnography, it became apparent that they not only relied on the bus service as a mode of transportation but also valued interactions with

drivers. It was a common complaint that this affability has been lost. Parents with young children, particularly those accompanied by a pushchair, were a further source of driver frustration. The following offers an extreme view, highlighting how this group is stigmatized and resented due to the time it takes them to board and disembark:

"[They're] *lazy bastards. Give the kids fresh air. They go one stop on the fucking bus when the kids could have five minutes in the fresh air, instead of having a smelly armpit hanging over its head. It proper annoys you."* (Jim)

On numerous occasions the researcher witnessed the driver roll his eyes at the sight of a shopper laden with heavy bags or an unsteady older person because he knew they would slow him down. As well as their perceptions towards different categories of passengers, it also became apparent that the technology also directly impacted upon work practices. When a driver is at a stop and sees someone running to get on the bus, they make a judgment whether to wait for them or drive on. Some drivers admitted that the headway system had made them less considerate. They would assess variables such as how much effort a passenger was exerting to get to the stop, whether the passenger might cause further delays (i.e. being older or a parent with young children) and how much longer they would have to wait for the next bus. Tony admitted that if the bus behind him is getting too close, he will forgo his usual considerate nature.

"It depends on how fast they were running and how far behind they are. If I was running late and I knew that there's a bus just a minute behind."

During a ride-a-long when one of our participants was driving a bus, the driver received numerous prompts to say they were not maintaining headway and the bus behind was catching up. At the next stop a prospective passenger flagged down the bus and asked if it was going to Harrow-on-the-Hill. The driver peered at the passenger's large 2-seater pushchair, smiled and said, *"Yes love, but the long way round. You're better off getting the next bus which will be a more direct route for you darling."* After our participant's shift the researcher commented that he was impressed that he found time to give the passenger travel guidance. He laughed and confessed: *"Ha ha, I was bullshiting. Both buses take the same route, I was just trying to make up time".*

Occasionally, the iBus system would ask the driver to slow down, especially if it is too close to a bus ahead. This aspect of the system also greatly affected the relationship a bus driver has with their passengers. Some of our participants admitted to becoming irritable if customers asked them questions about why they were running slow.

"I have said, "Hold on, I'll tell you at the next bus stop" or something like that. But the trouble with a lot of passengers is they don't realise that we've got a schedule to keep." (Tony)

While the requirement to interact with passengers when they board could be time consuming in some cases, innovations in recent years has reduced the time-burden this places on drivers. Recent years has seen the introduction of the Oyster Card, a prepaid card intended to reduce cash transactions and eliminate the need for drivers to check travel passes. Frank asserted that this development has made his job easier:

"When you have people get on with, 'Travel cards', you have to scrutinise the date more than anything else...Then, different areas have different zones. With the card, you go on the noise…One bleep: yes; two bleeps: no."

Frank articulates the benefits in reallocating the function of dispensing and scrutinizing travel cards from drivers to computers. Most drivers were in agreement with Frank, talking about the difficulty and time-intensive activity of inspecting travel passes, especially as many passengers held the pass too far away for the driver to read accurately or obscured important details with their fingers (this was routinely done by passengers who attempt to travel with invalid passes). Oyster took over this wearisome task and the driver just had to take notice of audio signals.

Other drivers took the contrary view however, feeling that the Oyster system had created additional work for them. Jim and Mike explained how they received more *"aggro"* since the introduction of the card. Often passengers would get on the bus and have no money left on their cards: *"Then they turn round and say, "I've just put £5 on it". "Well, where's your receipt then?"* (Jim). Mike noted that a lot of passengers who do not have money on their card would typically only have large banknotes on them and no small change to pay for a ticket. During fieldwork, it was noted that drivers would have two or three of these 'problem passengers' per route (although this varied depending on the area of London). Other drivers we spoke to confirmed this perception, arguing that, rather than enhancing the efficiency of the bus service, the Oyster card has mystified the payment process and introduced additional barriers that contribute to delays. These were delays that became increasingly difficult to manage in relation to the headway system with its frequent prompts and interruptions from controllers.

As a final point, our participants complained that the Oyster card altered the nature of their work and eliminated the passenger-interaction some valued. One of our participants, Keith, reminisces about this:

"It takes a lot of the one-on-one away from you. A lot of people don't even acknowledge the driver, because they just get on and go, "Beep" and walk past, as if you weren't in the cab. Whereas you used to have to deal [with them].*"* (Keith)

DISCUSSION
Our findings highlight the various ways the introduction of LBS on London's buses has affected long-established work

practices and relationships. While LBS and the headway system was introduced to improve the efficiency of this public service, they have also been applied as a way of managing drivers and introducing new surveillance mechanisms from controllers and TfL. Through careful, value-sensitive ethnographic work, we have shown how LBS technologies can come to fail both employees and consumers - driving priorities based on digital performance data that have reduced driver autonomy, damaged the driver-passenger relationship and led to the most vulnerable of the passengers becoming stigmatized.

The issue of reduced driver autonomy directly addresses employee wellbeing. A large research literature has demonstrated that employees can only cope with increases in job demand when they are also given greater autonomy to make decisions. The Demand-Control model [33] shows that work related stress is the interaction between two key constructs: job demands and decision latitude. In the current study, decision latitude would reflect both the level of skill and creativity the bus drivers can bring to the job and also the autonomy they have to make decisions. Effectively, then, our bus drivers have entered a vicious circle in which the demands placed upon them by various new monitoring technologies cannot be ameliorated by increased decision-latitude—ironically because those same technologies have removed driver autonomy. They no longer feel free to drive at appropriate speeds or to respond to customer demands in an appropriate manner. Effectively, any kind of playfulness or creativity in their work has now been eliminated.

Deskilling and reskilling: the driver's changing role

The ways in which technology can come to fundamentally change job roles is well rehearsed in the function allocation literature that was particularly prevalent in the 1990s. At this time the rapid introduction of new technologies into workplaces necessitated a consideration of the distribution of work between humans and machines [12]. Early work was essentially Taylorist in its approach - the machine would fit into a carefully articulated workflow process in order to improve productivity. Such an approach eschewed a nuanced understanding of the broader context for workplace activity [37]. Subsequently a number of studies brought a critical perspective to function allocation, arguing that the changes associated with a new technology are inevitably mediated by the communities it serves [5] and that at the outset, a full understanding of the *richer context* of work is essential [37].

Such perspectives are still valuable now as we consider the work role changes described in the current study. Specifically, we see here how a complex set of technologies has fundamentally changed driver function; from removing the interpersonal interaction with the customer at the boarding point (*Oyster*), to removing timetabling decisions and, ultimately, compromising the drivers ability to make safe decisions in relation to speed and to address passenger care and comfort (headway). There is no doubt that the

introduction of monitoring technology has helped curb mischievous driver behaviour and it is likely that it has improved scheduling from the passenger perspective (although that is not something we explicitly addressed in this study). However the technology has also 'bitten back' [30] in the sense that it has created some unfortunate unintended consequences, which include increased workload and reduced autonomy leading to unsafe driving and in some cases, passenger discrimination.

The passenger perspective

In the few documented passenger studies in relation to LBS, the use of mobile devices to deliver and communicate real-time transit information was shown to have positive influences on passenger satisfaction, reducing perceived wait time, sense of security and public transport usage [14]. Certainly, in the web-based survey conducted by Ferris et al., a new set of passenger applications provided by the Seattle OneBusAway system was well received and passengers were able to plan their travel much more effectively and reduce wait-time. Crucially, their study addressed only the communication of bus location to passengers and remained silent on the issue of whether the same information was used to drive bus-driver behaviour [14]. Yet here is the crux of the issue in our own study. The sharing of information either between drivers or between passengers would not seem to be the divisive issue. Instead, the direct surveillance of drivers by controllers has changed the way that drivers respond to passengers.

In a rather different approach to passenger satisfaction, Foth et al. [15] noted that passengers place a high value on the subjective personal experience of riding the bus. Consequently they intend to explore interventions designed to make the whole journey more enjoyable, noting that: 'Instead of focusing on efficiency and speed of each of these steps, we will focus on making the experience more enjoyable and meaningful' [15, p3]. It is particularly interesting to us that this is the only other study we have found to take an ethnographic approach. This work is useful in that the authors are at pains to distinguish between the passenger experience of *waiting* for the bus as opposed to the experience of *boarding* the bus—when, as we've seen, LBS surveillance systems may generate unfortunate unintended consequences, particularly for those passengers with mobility difficulties or more complex needs and who are slower to board the bus.

Implications for design

Our findings raise a number of design implications around how future systems should grant the driver greater autonomy and awareness, supporting them in applying their situated knowledge of routes in a flexible fashion, while at the same time, enhancing the passenger experience.

First, the introduction of iBus system transferred the responsibility of managing the buses' pace from the driver to the controller. One side effect of this is frequent miscommunication between drivers and controllers, often

resulting in drivers pulling over and having to explicitly respond to controller requests. One clear area for design innovation therefore is in *new feedback mechanisms to support awareness between drivers and the remote controllers*. A simple resolution to this problem might be in providing the driver a set of predetermined 'responses' through a button-based interface on their dashboard. This would allow them to "acknowledge" the controllers request, or communicate if there is a reason why that request might be difficult to adhere to (i.e. "traffic" or "passengers"). Driver-controller communication might also be improved by providing additional contextual information related to a specific bus without requiring explicit action from the driver. For example, controllers could have greater awareness of passenger numbers by having access to real-time Oyster card data and how long the vehicle is stationary while dropping-off and loading passengers. Taking this idea further, we could also imagine that the iBus system could be better integrated with other existing location based services that provide information on street traffic (e.g. Google Maps Traffic feature). Providing this additional information on passengers and the influence of traffic might mitigate some of the problems of misunderstandings between drivers and controllers, and provide evidence for drivers who feel controllers requests are unreasonable.

Second, there are also opportunities to extend the iBus system to *improve communication and relationships between the drivers and passengers*. Many drivers described difficulties in explaining the headway system to passengers, especially in circumstances where it was necessary to drive slowly or wait at bus stops. While the passengers likely enjoyed the new service and absence of bus-bunching, it was difficult for them to understand how the service was run in practice. We might consider then how displays within the bus and at bus stops might be used to display spatial representations of the distances between buses on the same route.

Finally, there needs to be an *increase in the involvement of drivers in the design of role-transforming technologies*. A surface level analysis of the current role of the driver is that it has become increasingly complex since the implementation of the iBus terminal and the headway system. However, the drivers' role has always been technically complex and required expertise in navigation, time-keeping, relating with passengers and more. Much of the negativity surrounding iBus related to the ways this new technology is at odds with established practices of drivers to manage their bus independent of controllers. Poor training exacerbated this negativity and by drivers not having a complete comprehension of how the system worked. Many of our sample were unfamiliar with using digital technology and an argument can be made that iBus introduced an implied ageism into this workplace. Much like the original aims of co-operative design in Scandinavia, the drivers might have been provided the opportunity to learn about this new technology prior to its introduction and

feel confident to challenge some of the decisions influencing its design.

LIMITATIONS AND FUTURE RESEARCH
Our study was conducted in the United Kingdom, a place with specific cultural conventions when using public transport. Indeed, there are significant differences between transport provision and passenger behaviour in London and almost any other part of the UK. Therefore, some of the insights from our findings are of course limited to our site and future work would benefit from exploring the role of LBS and monitoring technologies on similar work practices in other sites. Our focus on a small group, in order to receive rich and vivid accounts of the experience of technology in their workplace, limited our sample size. Furthermore, while the closeness to the ethnographer supported the elicitation of candid reports, analytical distance was more difficult to achieve.

CONCLUSION
We have provided an initial exploration of the way LBS has been integrated into the working lives of London bus drivers and altered their relationships with customers and colleagues. We have illustrated the complex, and at times, cynical coping strategies of drivers and the varying ways they changed their behaviour to meet the demands of this new system. Our methodological strategy meant that we sacrificed berth, in terms of number of participants, for depth of understanding of the perspectives of drivers. As a result our study affords a valuable insight into how LBS can change the nature of work and how employees integrate and cope with the expectations it places upon them.

ACKNOWLEDGMENTS

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