Demanding Labor: Workplace Conditions in On-Demand Transit

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Workplaces of all kinds continue to be transformed by computing. One example of these transformations is in public transportation, where transit agencies are experimenting with on-demand transit to address long-standing challenges in delivering first- and last-mile service. On-demand transit shares some features with ridesharing services like Uber and Lyft: riders request service when and where they are. Although rideshare systems have provided a set of interaction idioms and familiar interfaces upon which to model on-demand systems, work settings and labor conditions are very different. These differences matter and the way "disruptive" systems impact the work environment of public transit operators remains under examined. We report on interviews with transit operators from a 6-month pilot program. Our findings illustrate how the shift in in-vehicle technologies and service expectations affected work processes, well-being, and safety and we offer insight into the consequences of digital labor in the context of on-demand transit.

CCS Concepts: • **Human-centered computing → Interaction design**; **Empirical studies in interaction design**; **Ubiquitous and mobile computing**; **Empirical studies in ubiquitous and mobile computing**;

Additional Key Words and Phrases: On-demand Transit, Worker Well-being, Future of Work, Qualitative Methods

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1 Introduction

Across the public transit systems of the U.S., the persistent challenge of delivering first- and last-mile service to areas not well served by fixed-route services continues to limit urban mobility. This is particularly true for riders most dependent on transit in outlying suburbs and low-income communities as they typically face a dearth of transit options [10, 73]. To address this challenge, U.S. transit agencies are currently undergoing a transformation through the application of new technologies

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aimed at improving first/last-mile connectivity through approaches like micro-mobility—including bikes, e-bikes, and e-scooters—as well as through on-demand transit services that direct smaller multi-passenger vans to connect riders to transit hubs [1, 3, 71]. In contrast to fixed-route service where busses and trains traverse a set route on a set schedule, on-demand transit delivers service where and when riders need it, allowing for flexibility in scheduling as well as geographic coverage. Such solutions promise to make transit a more viable option for more riders, improving access for riders who are not well served by existing fixed-route service, reducing the number of single-occupant vehicles on the road, and ultimately helping move to more sustainable transportation systems [63].

While on-demand transit systems have long been included in visions of urban mobility (e.g., [37]), as rideshare services like Uber and Lyft became widespread, there was a renewed push to develop on-demand services within public transit agencies. In the push to develop and test on-demand transit systems—from the underlying dynamic routing software, to in-vehicle interfaces for vehicle operators, to public interfaces for transit riders—rideshare systems offered a basis for organizing the work and providing the service. The familiar interaction idioms of requesting, managing, and delivering rides where adopted uncritically for on-demand transit; however, there are important differences between on-demand transit and rideshare systems. At a very basic level, rideshare systems rely on private vehicles and typically provide individual, door-to-door transportation. In contrast, on-demand transit use specialized vehicles whose drivers have received specialized training, and trips are not individual door-to-door, they are often organized around a limited number of virtual stops and require multi-passenger routing to preserve some of the efficiencies of fixed-route service.

Within these differences arise important tensions in the way interfaces for using on-demand transit present functionality to rider and vehicle operator alike. Because early pilot systems for on-demand transit have so heavily built on the information design and interaction idioms of established rideshare interfaces, they have introduced mismatches between user expectation and system capability; they have also introduced changes into the work environment of transit operators who now have to bridge between the rules and accountabilities they have in providing transportation to the public, and the shifted expectations of individualized transportation introduced by the on-demand interaction. These differences matter, as the superficial analog between rideshare services and on-demand service has led to interfaces and underlying computational management that misplace assumptions about how vehicle operators interact with the service, manage their work, and engage with their ridership.

The study we present here provides insight into the consequences of these differences and the changing work environment of transit operators following a 6-month pilot deployment of on-demand transit in a city in the Southeast U.S. To date, evaluations of on-demand transit have largely been focused on passengers' experience or on system-wide effects induced by introducing this new category of service [33]. These studies have demonstrated the tension between perceived improvement to transit service [73], and the resilience of entrenched modes of transportation despite improved cost and efficiency [68], but have not closely examined how on-demand systems affect the work of being a transit operator. Instead of focusing on the rider experience, we were specifically focused on the impact the new software and interfaces had on the vehicle operators. We wanted to understand how the interfaces of the on-demand system (re-)structured work and mediated between operator and management, as well as operator and transit rider. To do this, we conducted ethnographic observation and semi-structured interviews with the transit operators involved in a 6-month pilot deployment of on-demand transit in our city. Our analysis of these interviews provides insight into the vehicle operators' daily experiences with the *technology environment*, *customer interactions*, *operator safety*, and *dispatch interactions*. Across these areas, there was a common thread that highlighted how the on-demand transit system created and structured differential visibilities between frontline workers and management, altering the realities and expectations of being transit service providers. Our work contributes to a growing body of literature in **human–computer interaction (HCI)** concerned with the future of work, and in particular, on the changes technology is bringing to the blue-collar workforce (e.g., [13, 22, 64, 67]).

2 Related Work

The transformation of the workplace has long been a foundational element of HCI research. That pursuit was initially anchored in the locations and domains of different forms of knowledge work [24, 50, 72], but as computing capabilities have spread through all aspects of contemporary life, we now find computing making new inroads into manual and blue-collar work environments [17, 46, 64]. As these work environments change, we need to better understand how to build interfaces and systems that integrate into patterns and practices of work that are fundamentally different from the office workplaces of computing's and HCI's origin. Among these differences, there are alternate material constraints with respect to mobility and durability of devices in blue-collar work environments, as well as considerations around worker and public safety. These factors arise both through the way new systems organize work and workers, and through the socio-technical interactions between work and social environments. Understanding how to design for these environments first requires us to understand how work is organized and undertaken so that the assumptions we might carry forward from existing systems can be identified and examined. The evolution of public transit is one such setting where work is being transformed through new technologies. The analogous interfaces brought over from rideshare platforms introduce complications because the work conditions and environments of public transit bus operators are very different from the individual proprietor model that is the foundation of the rideshare platforms.

2.1 The Move to On-Demand Transit

While on-demand transit has received renewed attention, it has existed in different forms since mid-last century. The Aramis service in France is one such system developed in the late 1960s that attempted to provide personal rapid transit to link a growing suburban ridership to existing urban transit hubs [37]. The recent vigor in the development of on-demand services leverages recent advances in mobile computing and machine learning to provide a more flexible and responsive transit service to improve availability and access to existing transit networks [26]. Within the U.S., developing new modes of public transit is crucial because urban mobility remains a major barrier to enabling economic and social security. Access to jobs [14, 70], education [15], healthcare [16], and food all greatly depend on individuals and families being able to access transportation [54]; and in the U.S. context, that typically means owning a car [9, 42]. For low-income individuals, car ownership remains a challenge, and limited service from existing public transportation networks is often unable to make up the difference. The result is that functional urban mobility is effectively inaccessible. For a time, ridesharing services from companies like Uber and Lyft were advocated as solutions to these accessibility issues; however, such services remain expensive when compared to transit, and they contribute to an increase in road-network congestion and undermine efforts to make the overall transportation network more sustainable [20].

Expanding public transit is one way to address issues of cost and traffic pressure: public transit is both more cost efficient and makes better use of existing, and finite, road infrastructure. However, public transit authorities have struggled to provide robust first/last-mile access within their transit networks [28]. On-demand transit systems address this by providing shuttles for the first/last-mile of connectivity to existing fixed-route bus and rail transit hubs. On-demand transit differs from micro-mobility, where scooters or other forms of individual transportation close the first/last-mile gap, in that the vehicles are multi-passenger and the routes are multi-stop, thus regaining some of the efficiency of fixed-route service. To make this work, on-demand systems build on sophisticated routing and scheduling models to more efficiently integrate riders with high-volume transit hubs to reduce overall transit time and make the best use of existing infrastructure [5, 18, 55].

The development of this category of public transit represents a significant shift in how transit authorities organize and provide accessible transportation. In particular, these kind of responsive transit systems allow for temporal and geographic flexibility—concentrating additional capacity when and where it is needed—without the infrastructural overhead needed for fixed-route buses or rail. Furthermore, because on-demand services use smaller vehicles, they are able to provide access to parts of a city that might otherwise be inaccessible to large city busses. Pilot studies for this category of transit have rolled out in Canberra, Australia, and in Ann Arbor and Ypsilanti, Michigan. More recently, initial commercial deployments have begun with transit authorities in the U.S. and Europe.[1]

While this new category of transit service is transforming how cities address issues of transit access, they are also transforming how work is done within the transit authority. Particularly for vehicle operators, the move from fixed-route service to an on-demand model introduces new technologies that need to be managed, new processes when passengers board and alight, and different expectations from the riding public as an on-demand service begins to look like the individual ridesharing services of Uber and Lyft while still operating under the labor and regulatory environments of established transit agencies.

2.2 Digital Labor Platforms Meet Traditional Workplaces

HCI and related fields have long identified the challenge that new workplace computing capabilities introduce mismatches on whose shoulder new types of labor falls where the benefit of that labor is accrued [34, 35]. However, those early settings were largely focused on forms of administrative work and how that work related to organizational and professional practices—largely human, social settings. The introduction of algorithmic platforms shifts the dynamic from a data entry and management setting where computing infrastructure connects different human labor roles, to a task and process management setting where the algorithmic system dictates the work conditions to the human. In these new regimes of algorithmic work management, the system brokers all aspects of the work experience, setting the tasks, the timing, and the completion criteria. Further, the system is the work as there are no other channels of access to management or co-workers. When those channels do arise, they sit outside the managed environment in parallel systems for worker organization and mobilization, as in instances seen through efforts to support MTurkers [30, 60], and in targeted interventions to provide automated support for gig-platform delivery drivers [11].

Rideshare platforms are an example of this class of algorithmic work management, where a complex computational system orders requests and directs human labor to satisfy those requests. As such, one place to start to understand how computing is transforming work is through services like Uber and Lyft where a growing dependence on algorithmic management raises particular concerns around the effect on the human experience of doing the work. One key risk is that algorithm-mediated work introduces a new way of inducing labor exploitation through information and power asymmetries [36, 56, 74]. While these concerns have arisen out of rideshare platforms (and other so-called share-economy settings) where algorithmic platforms are effectively organizing a labor market, for on-demand public transit, the technology is not organizing a labor market itself, but is instead organizing tasks within an established and hierarchical setting, with long-held norms, professional accountabilities, contracts, and importantly, labor unions. This mismatch raises

[1]See https://ridewithvia.com/case-study

the question of what happens when tools explicitly designed to operate outside of established regulatory settings are folded back into those settings where conditions and accountabilities need to be maintained?

As computing continues its move out of knowledge-environments, we need to develop a similar understanding into the dynamics make traditional workplaces. Here "traditional" is a shorthand for blue-color, skilled, and other physical work environments that have, until recently, largely not been the imagined users at the center of computing-driven workplace changes (see e.g., [57, 58, 64]). The tension here is that the kinds of efficiencies and optimizations that computing offers the knowledge worker do not resonate with, nor are they meaningful for, the skilled laborer [41, 59]. The introduction of computing transforms manual work into data work, undermining worker autonomy, professional identity, and sense of meaning [4, 64].

2.3 Worker Well-Being

Beyond managing on the job technology, a key consideration for a worker whose job interfaces with the general public is that of personal well-being. Working with the public introduces a set of risks, but also a professional identity around service. Part of the balance between these rests in operator autonomy. Even though there are important differences between on-demand transit operators and rideshare drivers, the way these two kinds of systems organize work share enough similarities to indicate where problems might arise due to the new exposures posed by algorithmic management [27, 45, 76]: both enable greater flexibility by directly requesting the location and timing of ride pick-up and drop-off, and vehicle operators in both systems respond *in situ* to incoming ride requests rather than follow a fixed route and schedule. This creates a set of potentially common factors that contributed well-being for both rideshare and on-demand transit operators resulting from the dynamic and unpredictable work environment.

Here, well-being describes "the combination of feeling good and functioning effectively" in the workplace [29]. The notion of well-being touches many attributes that make a workplace attractive and a job desirable. Across the different elements that contribute to well-being, the most consistently identified factors are worker autonomy and fair and ethical management [23, 39, 52, 66]; essentially, a workplace that respects worker expertise and trusts them to do their job in the best way they see fit, along with a management team whose values match creates an environment where workers can thrive. And yet, the conclusion from prior analysis of algorithmic work management systems suggests that the "the impact on workers' autonomy [from these systems] is consistently negative" [52]; and in particular, the automation of work assignment has been shown to have negative impacts on worker autonomy and experiences of well-being [39]. These contribute to a mismatch between the way these automated systems design work and the way workers wish to carry it out.

Interpreting these issues within the context of on-demand transit, the initial similarities between rideshare platforms and on-demand transit systems begin to fray. Where drivers for rideshare have some control over what rides they accept or decline, the hours they work, the duration of their shifts, and where in the city go, on-demand transit operators do not have those same choices. At the root of these difference is that urban transit authorities are under a different set of regulatory obligations than private rideshare, and as such must serve everyone within a service area. Operators cannot refuse a ride request or choose to exclude neighborhoods. These mandates obviate the unintended bias that can appear in other rideshare platforms where workers avoid neighborhoods or customers based on perceptions of gender and race [25], but they also mean operators need to navigate difficult interactions with the riding public [19, 69]. The most significant outcome is that operators have very little say in how their work is directed.

The consequence of these differences is that rideshare platforms provide a useful, but limited point of departure for understanding the worker experience of on-demand transit systems. And developing robust insight into how work and work conditions are changing as these systems are developed and deployed across the U.S. is crucial to building human-centered interfaces that empower, rather than disenfranchise workers across all sectors, not just knowledge workers. The study we present here advances research on worker experiences as blue-collar jobs continues to be transformed through the application of automation and computer-mediated interactions within the work environment. This includes understanding experiences of well-being within the work environment and how work practices and expectations are changing as a result of new capabilities for, as well as new demands on, the labor force.

3 Context and Method

Beginning in March 2022, the local transit authority and our university partnered to run an on-demand transit pilot. The research team included investigators from the fields of urban planning, civil engineering, systems engineering, and HCI all working with the city's public transit agency to plan, develop, and deploy the pilot. The pilot ran in pre-defined service zones that were anchored by a subway or bus transit hub with the expectation that the service would provide first/last-mile access to those transit hubs for the surrounding areas that had poor or no existing fixed-route service.

The pilot initially started in three zones, anonymously referred to here as East, West, and South. The initial zone boundaries were expanded in May 2022 to improve service access, and a fourth zone, North, was added in a more suburban area. Zones East and West were primarily residential areas. The South zone was a commercial area where several large warehouse distribution centers were located. In each case, the zones were selected based on limited access to current fixed-route buses. The service was meant to expand access to the residents and workers by linking riders to existing bus and rail services at the in-zone transit hubs. Trips on the service were limited to within each zone; there were no cross-zone trips provided, and zone boundaries were strictly adhered to. The service was available weekdays from 6 AM to 7 PM and cost $2.50, which included transfer to/from bus and rail service. This price point was consistent with current transit fare and did not reflect the actual cost or anticipated fee structure the transit agency might adopt if the program were to be implemented beyond the initial pilot.

Volunteer vehicle operators came from the transit agency's paratransit service. The paratransit service runs specialized vehicles to service individuals with physical disabilities who cannot otherwise access transit, and as we discuss below, became a basis of comparison for the operators as it was run as a reservation-based, door-to-door service. The reason the agency solicited volunteers from paratransit was because the vans being used for the pilot were the same as those used for paratransit—multi-passenger vans that were ADA accessible—and so the operators were already trained and licensed on those vehicles.

High-level attributes of the operators in the pilot: 12 of 17 operators were female, 5 were male; professional experience ranged from driving for the transit authority for 1 year, to almost 10 years. Operators had set shifts throughout the pilot, with a morning shift that ran from 6 AM to 1 PM and an evening shift that ran from 1 PM to 7 PM. Nine of 17 participants only drove the morning shift, five only drove evening shift, and the rest of the operators drove a mix of morning and evening shifts throughout the duration of the pilot.

3.1 Method

To understand operator experience driving for the on-demand service, how they managed rider interactions, and how the service compared to the normal service they provided before (and after) the pilot, we conducted ride-along observations and semi-structured interviews with the vehicle operators who were part of the pilot. We spent a total of 4 hours of observation in the West service zone to gain insight into the practical physical and embodied experience of using the on-demand service. Observations occurred early in the pilot and we selected the West service zone because it saw rider adoption earlier than the other zones. The observations were conducted to help the research team understand the basic flow of work—the *see* the service in action—and to orient our semi-structured interview script. The subsequent semi-structured interviews were held after the conclusion of the pilot program once the operators returned to their prior assignments in paratransit. The interviews were scheduled at the end of the operators' scheduled shift and conducted in one of two vehicle depots. Vehicle operators did not have to agree to the semi-structured and we made clear during the process that they could elect to not speak to us or end the interview at any time. The time spent in the interviews was compensated at the operators' normal hourly rate by the transit agency.

In total, we conducted eight semi-structured interviews with a total of 17 vehicle operators. The semi-structured interviews were conducted by two researchers, were audio recorded, and then transcribed for analysis. The semi-structured interviews were designed to allow for individual as small-group interviews to manage power dynamics between researchers and the vehicle operators and as a way to manage the logistic of several operators ending their shifts at the same time. Three of the interviews were with individual operators, two with two operators together, two with three operators, and one interview grouped four operators together. We recognized that small-group interviews can introduce challenges for allowing every individual to share their experience—commonly due to one person dominating the conversation or steering the conversation in a particular direction. To counter these pitfalls, we worked to give each operator time to respond to our questions, following up directly if an operator did not answer, and we followed our interview script closely to ensure each operator had the opportunity to respond to all of our questions. Reflecting on our approach, the small-group sessions were far more effective than the individual sessions at eliciting detailed and comprehensive accounts of their time working on the pilot. We believe this is in part due to the shift in the power dynamic during the pair-wise and small group sessions and from operators being able to remind each other and recall experiences from a pilot that ran for 6 months.

The interviews ranged from 20 to 80 minutes in length depending on the time it took to elicit responses from each operator (see Table A1 in Appendix A for additional details). Following our interview guide, we asked the operators about their driving experiences in the pilot, their typical workflow, how they managed the software, how they interacted with riders and dispatchers. We wanted to know how working on the pilot evolved from the initial launch through to its conclusion and for insight into where they thought the overall service could be improved or be made better—either for ridership, or for themselves as employees.

We analyzed the transcripts of the interviews inductively, allowing us to develop themes around work practices that captured the experiences operators had when using the technology and carrying out their daily work responsibilities [12, 62]. Our focus during the coding process was on instances where operators discussed specific experiences with the technology, when they elaborated on how the technology and novel transit service impacted their interactions with their riders; and on how the pilot program changed their work environment, including labor conditions and relationship to existing processes and workplace expectations.

4 Findings

Through our analysis of the interview data, we developed four thematic areas of attention for the transit operators, including: *technology environment*, *customer interactions*, *operator safety*, and *dispatch interactions.* Each of these areas developed from the experiences the operators discussed during the interviews and the key breakdowns and concerns they had to manage during the six-month pilot.

4.1 Technology Environments

The first thematic area concerns the *technology environment* the operators inhabited. Each of the operators had been working for the transit authority for at least 1 year, and consequently, had to adapt from a familiar set of in-vehicle technologies and processes as the pilot program launched. The biggest change for the operators was the consolidation of interfaces they needed to manage from several, to a single Driver app installed on a tablet computer mounted to the right of the steering wheel. The existing process for paratransit revolved around an older mobile device that ran what was called the Mobility app, along with paper records that were set out with the operator at the beginning of each shift. Operators would need to enter addresses from the paper records manually into the old application, which then managed routing and directions to pick-up and drop-off addresses. The paper records were also used to track riders and maintain records. In contrast, for the on-demand pilot, these interfaces were replaced with a single Driver app that provided all the features needed to operate the on-demand service: acknowledging ride requests, providing turn-by-turn navigation, checking passengers in as they boarded the vehicle, and checking them out once they arrived at their destination.

Through the interviews, the operators agreed that the pilot Driver app was easier to use than the existing Mobility app. O1 mentioned that "the whole app was simple and easy compared to the Mobility app because we have less to do. We don't need to manually switch in and out of the app... [Routing] is through Google maps and it's all blended in." O3 shared the same opinion, adding that "[on Mobility app], you gotta take the address for pickup and put it in, it's better to not have to do that [on the Driver app]." Compared to operators' experience driving for paratransit, which required repetitive and disruptive manual data entry for service record keeping and navigation, the Driver app reduced this administrative burden by integrating into a single interface that did not disrupt the operator's workflow. Further, because it was built on new tablet hardware and software (an Android tablet), integration across the Driver app, turn-by-turn directions in maps, and direct network-enabled connection with the service back-end, there was less work for the drivers to manage in the technology itself.

However, there were some technical breakdowns and process challenges that arose through running the pilot program. The most prominent challenge was how the Driver app managed notifications when new trip requests arrived for specific operators. Rides were assigned algorithmically by the system—a ride request would be initiated by a rider and the system would route that request to the nearest vehicle. The operator would then need to accept the request. If that did not happen within an allotted time, the request would be routed to the next-closest vehicle or trigger intervention from dispatch. This procedure created two kinds of breakdowns. The first was connected to the technical dependency that the in-vehicle tablet was working and responsive, which was not always the case: O3 complained that "I don't even know... Some mornings you hear [the trip request alert], some mornings you won't." In addition, O2 recalled that "[sometimes I came back from a break], I had to close out and open the app back up again for a few times – it seemed the app just froze the tablet." O11 got logged out of the app randomly and unintentionally, and "[the Driver app] did not even make a beep." If the operator missed too many notifications of incoming trip requests, this would eventually trigger intervention from dispatch. This intervention highlighted an increase in operator surveillance enabled by the on-demand system. Where monitoring was previously done via radio and intermittent vehicle location updates, the on-demand system enabled fine-grained and near-real-time monitoring of operator activity, contributing to an erosion of autonomy. The second breakdown was social, as some operators were identified as gaming the system by declining requests so they could remain parked in the idle location. While this created some tension between operators, the bigger impact was on the poor rider experience because the declined rides made it appear like the service was not working or was slow to acknowledge and set up a trip. This was particularly acute for trips that were a transfer from a train line to the on-demand service: riders could see the service vehicles in the parking area of the train station and became confused when their requests did not result in the vehicles moving to the pick-up area. O6 explained, "we'll be at the train station [parked in the idle area], by the time we start to pull out, they [riders] already walking to the bus, and I'm like, you didn't even give me a chance to come around to get you."

Another frustration emerged from the workflow to acknowledge pick-up and drop-off. O5 described their frustration in redundant flows to confirm pick-up/drop-off: "there are a little too many tedious steps to confirm a pickup- you have to first confirm arrival, then confirm the rider, and then finally confirm pickup." For the purpose of the pilot, the operators also had to document pick-up and drop-off on paper—this was for continuity in the existing paper-based tracking and archival process in the transit authority. Less apparent from the direct description of the repetitive process is the visual interface and interaction paths needed to accomplish these repetitive tasks (Figure 1). The entire interface used current Android tablet visual layout idioms; however, those idioms assume a screen distance easily glanceable and within easy reach. The mounted location of the tablets in the vehicles was barely within immediate arm's reach, and much lower than eye level—operators would need to fully extend their arms toward the device and to look down from looking up at the road to interact with it. Further, the scale of visual elements on the screen was smaller than appropriate given the distance the screen was situated from the operators' eyes. This caused operators to spend significant time seeking and reaching for the interactable button located at the bottom of the screen (Figure 1). The combination of the smaller perceived size and the placement of the screen created safety concerns within a safety-critical environment [8, 32].

Feedback was also gathered about the Driver app's designation of pick-up and drop-off request. Operators felt their time was not being optimized and devised their own routes for picking up riders they knew. O4 and O5 both wished that the Driver app could notify them of new trips on their way to a destination. O5 added that "it happens very often after I drop someone off, I get a new trip that brings me back to right where I was [on my way to finish the drop-off]... Just give me a chance to deviate [from the order of locations that the app tells me to go in]." This experience was puzzling to the research team because the value of the on-demand service is that it was meant to manage in-coming ride requests so that the vehicle would have multiple riders by the time it arrived at its destination (typically a train or bus transit hub). Due to safety regulations, the transit authority only allowed new trip notifications to come in when the vehicle was determined to be "stopped"—in order to prevent driver distraction. The mismatch here between existing safety regulations and the more dynamic needs of an on-demand service introduced a challenging inefficiency to the service where operators were left traversing their service zones, often with only a single rider aboard.

By the end of the pilot, the operators were familiar with the software, but also felt that a lot of the process had been left to them to simply stumble through and figure out on their own. They wanted far more comprehensive training about the system in general, including training that would help them aid riders unfamiliar with the app. O4 and O5 specifically noted that not a lot of training was provided up front: "we had to figure it out as we went... if you do bring [the pilot] back, you're gonna need more than just 2 hours of training." This underscores a kind of hidden assumption in the way the pilot was rolled out by the research team and transit agency: the interfaces were viewed as familiar enough but were not designed specifically for this transit agency with a clear path of migration from the existing technology ecosystem to the one used in the pilot. Part of this is a natural limitation of a time-limited research pilot, but it also reveals the role the work environment plays in how new systems are adopted and adapted—a role that is familiar in knowledge work settings [49, 50, 51] but under appreciated in blue-collar work environments [64].

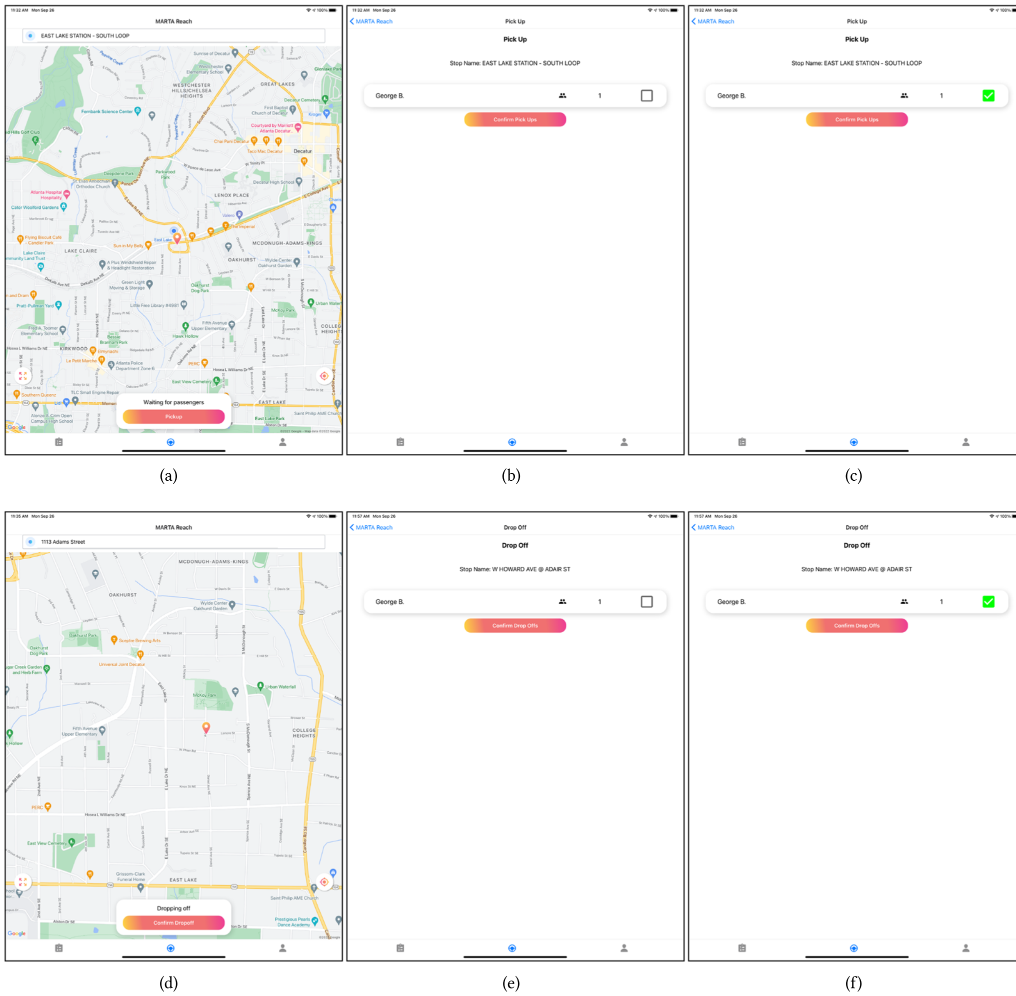

Fig. 1. Screenshots of the Driver app illustrating workflows for picking up and dropping off a passenger. (a–c) capture waiting, picking up, and confirming interfaces that need operators attention. (d–f) illustrate the drop-off flow with confirmation once at the destination. Full-size screenshots can be found in Appendix B.

4.2 Customer Interactions

In addition to managing the technology for the pilot service, operators were also ambassadors to help explain and promote the pilot service. O5 recalled passing out fliers to people in the beginning and O1 mentioned that in the beginning of the pilot, they "got off the bus and talked with people walking by to make them aware [of the program]... and all downloaded the [rider] app on the phone and got familiar with it... and answered questions for people who walked up." However, despite often being the face of the pilot program to the riding public, operators were limited in their ability to provide technical support. O13 talked about observing riders' confusion about using Rider app to request a trip: "people are showing me the [rider] app trying to figure out how to get a ride... (but) their app was completely different from ours. So, we can't tell them how to use the app either."

This created a twin set of informal responsibilities for the operators, explaining the service and providing live technical support for an application experience that was unfamiliar. Explaining the service was important, in part, because it was a novel service in the city and local transit riders needed to know how it differed from the existing fixed-route buses. It was far more difficult to provide live technical support because the way the operators experienced the service through the Driver app was far different from how Riders experience the service through the customer-facing application.

When carrying out specific rides, the operators wanted more information to help them identify riders and communicate with them during the process of pick-up and drop-off. O4 pointed out: "Sometimes we pull up... but the rider was across the street or a little further in front..."; as well as an instance where traffic was blocked due to a train stopped on its track for a long time, causing "[the rider to] cancel the ride and re-book it, but there was no way to tell her what was going on..." Similarly, O12 shared that "[the virtual stops] just show up in the middle of the road – would have been nice to know where people going... like if it's a bus stop/laundromat... so we can drop them off." These situations resulted from an interaction between how the on-demand service was implemented and the real-world constraints of maneuvering a large vehicle in traffic. The way the service identified stop locations was through a series of virtual stops that populated the roads in the service areas. These served as pick-up and drop-off locations and were not quite door-to-door but were dense enough to minimize how far riders would need to walk to find a pick-up location. Within the Rider app, however, the virtual stops did not always indicate which side of the street they were on, and in many cases, could create unsafe traffic conditions by having the transit vehicle stop along busy or fast-moving road segments. These ambiguities and the need to ensure safe vehicle operation meant the operators wanted more information about where they were going and a better ability to adjust based on their knowledge of road and traffic conditions in the service area.

4.3 Operator Safety

One of the major changes to the overall work environment for the operators was the transition from driving for a service that only carried screened passengers, to one that would accept any rider with valid fare. The paratransit service that provided operators for the pilot did not serve the general public in the same way, and, as the operators pointed out, the differential risk associated with serving the general public was reflected in the hour wages of paratransit operators compared to fix-route operators: simply, fixed-route operators were paid more.

Riders who use the paratransit service need to apply and demonstrate specific accessibility needs. Further, when using the service, they must reserve their ride 24 hours prior, and they must show photo ID before boarding a vehicle. In comparison, the on-demand service was meant for anyone, riders simply needed to download the Rider app and register an account with their e-mail addresses before they could start requesting trips. There was no further verification of their identity. As O12 explained: "[for paratransit] we know their name, we know their address, we have contact information.... for [the pilot], they [can] put random names [in the app] and it could anybody." This comports with conditions that have been shown to make rideshare drivers feel uneasy – drivers publicly share their car numbers, photos, and names with riders while riders "only needed to have a smartphone, an e-mail address, and a phone number in order to register as a passenger" [43]. There is very little protection for the drivers and very little recourse for identifying bad passengers. O11 demanded that, "at least we need rider's real names and profile pictures." Further, operators remarked on how the service, by design, took them deeper into neighborhoods than fixed-route buses: "We're basically almost pulling up directly to people's house. So like we're being put in very compromising positions, because we're [a] big [vehicle]..." (O11).

The timing and geography of the pilot also played into perceptions of safety among the operators. Prior research has found that rideshare drivers strategically choose to work in certain locations at certain times to avoid unsafe conditions [2, 38]. The pilot service was much more constrained. Operators were assigned one of two shifts, morning or afternoon, within the areas of operation. The areas chosen for the pilot program were, by design, poorly served by existing transit. This attribute coincided with these neighborhoods being largely low-income and distressed areas where individual safety might be a concern. O11 recalled that "Once I was asked to go sit at the [train] station. I was like no, I'm not comfortable with that… And then later on that week, somebody got shot at the train station somebody got stabbed at the other train station… I'm like you can't be real."

The way the pilot service was designed, the transit authority identified idle locations where vehicles would go to wait when no riders were currently being dispatched by the system. These locations were spread throughout the service zones. There was always an idle location at the zone-anchoring transit hub, while others were located in parking lots or other out-of-the-way areas to reduce the impact of traffic on the service. These locations contributed to perceptions of vulnerability, but also meant that operators had specific challenges supporting each other due to limited communication and shared situational awareness [75]. O11 and O12, who both drove during morning shifts, shared how the situation was worsened by being separated from other operators especially during hours of darkness: "they separated us [into different idle locations] after expanding the zones since there were only 5 of us… so I was sitting behind [a grocery store] by myself, 5 AM in the morning, pitch black… if something happened, we could handle it together… versus you separating us and I'm by myself."

Taken together, the change of ridership, the assignment of locations within more distressed parts of the city, and the need to idle at fixed locations while awaiting new ride requests made for an overall work environment that was more stressful. This was expressed most acutely by the female operators, in part because they initially chose the paratransit service because of the added security it offered as a result of population and procedure for gaining access.

4.4 Dispatch Interactions

Dispatchers are the only source of communication between operators and riders and serve as the starting point for resolving any problem. However, dispatchers' supervision was frequently perceived as aggressive and opaque to some operators. In part, this was due to information asymmetries in the system where operators and dispatch had different insight into the present situation but no low-friction way of sharing that wider context. These asymmetries expressed themselves in particular ways within the on-demand pilot, but share similar consequences as information asymmetries that have been noted in other rideshare platforms [76].

One of the most common breakdowns was if a trip request was canceled. Due to limitations in the pilot software platform, those canceled trips were only reflected to the dispatch operators who managed the service areas: they were not automatically forwarded to the vehicle operator so they could divert or stop to accept a new request. O2, O4, O5, and O7 shared a common frustration of not being notified by dispatchers when a trip is canceled. O4 and O5 recalled that they "got notified of cancellations too late" and they were "making 'blank stops." O7 asked for timely updates about canceled tips: "Just tell us if someone canceled." The delayed information sharing contributed to an adversarial relationship with dispatch, where the operators needed more support while acting on requested trips.

This adversarial relationship ran into folk-theories about how the on-demand service worked. Ride assignments were all made algorithmically by the software platform developed by the research team for the pilot. But due to problems of missed notifications or other technology problems, some operators believed that dispatchers were not assigning rides equitably—they misunderstood that ride assignments were made automatically and that dispatch would get involved only in instances where multiple ride requests went ignored (intentionally or, more frequently, due to the tablets not working reliably). For example, O11 felt like they got assigned too many trips while some other operators were slacking off: "There needs to be a better way to monitor the operators... Some people just log off... and don't know that this person isn't logged in... And then I'm like, wow, I've had like 12 trips, and they are still sitting here." While infrequent, this social breakdown arose from gaps between algorithmic work management, worker surveillance, and an ability to skirt work accountability within the on-demand system. While O11 wanted more oversight to prevent this situation, O12 did not like the surveillance from dispatchers, pointing out that they "check on where you are too often" and demand "clear timing of how long we're expected to take to go somewhere... but sometimes there's traffic." There was a kind of misalignment where the system enabled insight into operator conduct when they were doing their job, but failed to provide oversight in the rare instances where operators avoided their responsibilities.

Dispatch interactions were typically infrequent and the result of some technical breakdown—such as when ride requests went unanswered. The exception was when operators needed to request and schedule breaks, which all flowed through dispatch in a way that was different from the paratransit service and from the fixed-route bus service where natural breaks occurred at end stations. Pilot operators received ride requests continually and had to request breaks manually when needed. As O1 recalled: "we have to get on radio and let Dispatch know – we can't go to the bathroom all at the same time." Breaks were not always granted, especially during busy hours, which included the entirety of the evening shift. O7: "Sometimes a new trip comes right up after you drop off... so it's hard to take bathroom breaks. With [paratransit] I can get a nice break... [in the pilot] towards the end we really need more operators [to manage breaks]..." Bathroom accessibility was also an issue in some areas. O4 recalled "I went to [the grocery store in one zone], but when driving in [another zone], there was only one bathroom [at the train station] for all employees... and we didn't have a card to access it..." That *in situ* operational decisions were taken away from the operators and made by dispatch over a radio amplified some of the agonism between labor (the operators) and management (the dispatchers).

The information asymmetry was threaded throughout the pilot. The software platform was meant to offload several tasks and ride assignments to an algorithmic system that would optimize the service for load and time-to-destination. The role of dispatch was to help coordinate where the system was unable, and to provide information to operators as needed. The other role of dispatch was operator oversight, and as is often the case in hierarchical work environments, oversight became the priority over coordination. Dispatch used the ability to track operators to police and discipline the operators' work environment [21, 65], but they simultaneously ignored the local and situated knowledge of traffic and road conditions that might prompt deviations from expected temporal and geographical boundaries.

5 Discussion

Reflecting on the workplace changes brought on by the on-demand transit pilot, it becomes clear how pervasive the effects are in reconfiguring how operators did their jobs. These changes occurred across the technology environment, customer interactions, perceptions of safety, and relationships with management, all of which had impacts on operator experiences of well-being. And while our findings echo that of earlier work in HCI looking at the changing landscape of operator-focused public transit technology [53], there are differences between technologies that help augment existing work practices and those that fundamentally transform expectations of the work being done. Understanding the extent of these changes is important as it helps HCI researchers understand better how to design technologies for work environments that come from different legacies of where and how computing mediates work. It also underscores the role existing work practices, expectations, and cultures of workplace identity shape how both technology and its role in the workplace are perceived [57, 58, 64].

5.1 Mediated Visibilities

A key element to how the on-demand service was experienced was the differential visibilities riders, operators, and dispatchers had to each other. The consequences of differential visibility within the system meant that the kinds of micro-coordination that mobile computing has long enabled was not present [61]. On the benign side, the system did not effectively communicate back to operators when a trip had been canceled; on the more significant side, there was no way for operators and riders to coordinate around alternative pick-up locations when the options provided by the automated system turned out to involve dangerous situations—typically due to stops in high-volume, high-speed traffic, or due to stops signaled on the wrong side of a multi-lane road without a place for safe pedestrian crossing. Taken together, this asymmetry led to a disempowering effect for both operators and transit riders: the operators were unable to make effective real-time adjustments in a service designed for dynamic, real-time adjustments; and the riders ended up having to adjust and move in order to meet the service even though the service was meant to deliver itself to them.

Looking forward to how the mediated experience undermined both operator and rider experiences, empowering smooth interaction between operators and riders requires more information visibility between different parties and an ability to communicate and coordinate directly, without the bottleneck of relying on the dispatcher to relay messages. Mutual visibility of operators and drivers would give each other enough situational context, enabling the service to meet customer need more appropriately, whether that was the result of specific accessibility needs, or as a result of local conditions in the urban environment.

We would first offer that the rough edges of the research product used to run the pilot were anticipated. A significant goal of the pilot deployment was to understand with more fidelity and specificity where the operator- and rider-facing interfaces needed to be improved and to what degree those improvements were constrained to the interfaces themselves versus changes that would be better addressed in how the service was organized and implemented. Interface-level changes would include streamlining the workflow to empower on-demand operators to take appropriate breaks without interruption of the service. System-level changes could include re-examining the allocation and location of the virtual stops riders used to indicate pick-up and drop-off locations so that dangerous traffic conditions or difficult vehicle maneuvers would not be easily requested. System-level changes would also include better alignment with infrastructure that reflects the human needs of operators and riders, e.g., allocating locations with bathrooms.

Beyond direct experience of using the driver interface, the on-demand platform played an important role in supporting operator safety and well-being. Here again, differential visibility and information asymmetries introduced perceived risk in how operators were exposed to unknown individuals. This is largely the confluence of two factors: (1) as covered in the findings, the expectations of the operators coming from the paratransit service where riders were screened; and (2) because pick-up and drop-off locations could be anywhere in a service zone, operators were often in infrequently traveled and less public locations than fixed-route bus service would normally operate. Together, these conditions contributed to perceptions of risk because of unknown rider identities and being situated in environments by themselves. Here, improvements to the system to capture and share rider identity would be a direct response, and because the service is provided by public transit, we can imagine that some of the concerns of implicit bias and racial profiling would be moot due to differences in how service is delivered [25, 44]. In addition, peer-to-peer interaction avenues between operators would provide support for one another, amplifying the situated expertise on traffic and safety conditions as they traversed their service zones. This would also benefit overall worker well-being, as meaningful social and collegial relationships in the workplace have been found to buffer work-related stress, including safety concerns [31].

5.2 Socio-Technical Work Ecosystem

Work is constantly mediated by a set of social, technical, and organizational practices. Establishing, and re-establishing those practices is part of what makes the workplace work [40, 47]: expectations at all levels, from customers, to frontline employees, to management slowly build out how the workplace functions [6]. Changes in one of these areas inevitably lead to very different sets of outcomes. By example, in our fieldwork with the on-demand transit operators, they discussed how fixed-route service operators had different expectations with respect to the kinds of customers they had to serve, and how those expectations were reflected in different pay and work conditions as compared with the paratransit service that was the long-term home of our operators. Breaking down or blurring those distinctions runs up against worker expectation both in terms of the conditions of work, as well as for the compensation provided for that work.

During the pilot, operators were subject to substantial changes not just to what segment of the transit-riding public they served, but to the technology mediating the service, and management's expectations about how they would deliver that service. What was clear by the end of the pilot was that a successful service deployment would require far more training and integration at all levels within the transit authority, not simply the successful delivery of back-end computing operations that managed the on-demand ride queue. While this may seem obvious, the revelation underscores the frequent misalignment between how management expect technology to improve a business environment and the reality of how technology changes roll through a workplace and are confronted with the inertia of how-things-are-done and the professional identities of the workers who do those things [13, 22, 40].

It is also crucial to recognize the in-between-ness of being a transit operator. On one side, they are the public face of the transit system and work directly with the riding public; on the other, they are the frontline worker in a very hierarchical and regulated organization. The operators had to manage the transition to the on-demand system both outwardly to the riding public and upwardly through the chain of management in the transit agency.

With customers, this meant providing *ad hoc* support for a research product [48]—which is to say a deployed system that was far beyond the stage of prototype, but still missing the fit and finish of a final commercial product. Some of these details were reflected through an interface that, while using familiar idioms, was not thoroughly designed to address the accessibility needs of a large portion of the pilot service's initial customers. Interface elements were small, account creation and on-boarding complex, and task pathways for selecting a pick-up and drop-off location differed enough from familiar services like Lyft and Uber to be confusing to many during their initial experience with the service. Moreover, the operators were not regular users of the customer-facing app interface, and so had little direct experience with the challenges customers were facing.

Within the transit agency, the operators were also engaged in managing perceptions of their work with dispatch, which sat in a managerial role of directing operators to different idle locations in anticipation of ride requests, ensuring operators were responding to incoming requests in a timely manner, and approving breaks and other deviations from the established boundaries of the pilot service zone. The last point created a particularly fraught set of interactions, especially in the face of dynamic traffic conditions. The on-demand system would report vehicle location and note if and when it traveled out of the designated service zone. As prior research exploring the organizational knowledge asymmetries and workplace impacts of GPS monitoring has shown

[65], location tracking was inadequate to reflect the accumulated expertise of the operators as they maneuvered their vehicles within those changing conditions. Congestion, rail crossing, and passenger safety were all reasons the operators reported deviating out of the service zone, but it was in those instances of deviation they would need to interact with dispatch to explain their actions. These interactions were something operators sought to avoid as they were intrusions into their autonomy and were perceived as being a greater professional intrusion into how they were managing themselves and their work.

The observation and empirical outcome we would like to drive home here is that, even changes perceived as being modest alterations to existing processes can drive comprehensive realignment of work and accountabilities within the workplace. This realignment then exerts torque on experiences of well-being [7], either as outside customer experiences and frustration are channeled through frontline workers, or as changing experiences of the conditions of the workplace create altered profiles of personal safety and security [29, 39]. It also brings about the common tensions between workplace transparency and surveillance [22, 67], particularly for categories of workers in hierarchical blue-collar positions where worker autonomy and agency do not mirror the knowledge-worker environments in which many of these systems are conceived and developed. Less apparent in this pilot was the role automation played in the shaping of operator work. Because the pilot deployment did not fully implement dynamic pick-up/drop-off routing (and pilot demand did not rise to the level that would require it), we cannot specifically address the more complex scenarios of being redirected while en route in response to new requests.

6 Conclusion

What we have endeavored to illustrate with this study are the pervasive changes to work conditions new technologies bring when introduced to the workplace. While HCI has a long history of understanding these changes within the context of the knowledge-based workplace, the conditions, assumptions, and impacts of new technologies in blue-collar workplaces are now becoming more salient as computing moves into new environments. By understanding transit operator experiences with a novel on-demand system and set of interfaces, we were able to gain insight into how customer-facing blue-collar workers manage their jobs, their customers, and their management. Issues of individual agency, autonomy, and safety drove many of the operator concerns around how the system was deployed and its implications to their long-term work environment should it be adopted beyond the pilot phase. This is particularly important because on the surface, on-demand transit systems might be easily misclassified with rideshare and other gig-platform systems. And while some features might be analogous, the overall work environment, professionalization, and economic structure differ dramatically and play an important role in how operators gain satisfaction from the work and understand and enact their own autonomy.

While our study provides analytic insight into the work-lives of our transit operators during the pilot study, it is situated in the context of a public transit agency in the southeastern U.S., and as such, reflects the particulars of that fieldsite. This context, for example, means that because the operators in our study came from the paratransit service, their only point of comparison in terms of how their work changed, was to their time in the existing reservation-based transit service. As pointed out above, the conditions of paratransit differ dramatically to those operators in the fixed-route service face. There are opportunities to expand that understanding by including perspectives from operators across a broader spectrum of transit services and by studying existing systems that already operate at city-scale and are not partitioned off to relatively limited pilot service zones. Such a cross-city investigation would help situate the impact of on-demand transit systems across different transit agency environments and labor circumstances. What our findings suggest is that there are substantial requirements on system design that are tied to the local organizational milieu.

The question that remains are what are the common workplace conditions that translate across contexts to advance positive working conditions for blue-collar labor?

As HCI continues to engage in understanding the conditions and building the interfaces that will determine the future of work, we need to expand our understanding of work environments that look and operate very differently than the familiar white-collar and knowledge workers office environment. The differences include the physical locations and environmental demands on those systems, but also the organizational, social, and cultural attributes of professional identity and labor conditions. These elements together create complex relationships to work, to technology, and to each other.

References

[1] Rusul L. Abduljabbar, Sohani Liyanage, and Hussein Dia. 2021. The role of micro-mobility in shaping sustainable cities: A systematic literature review. *Transportation Research Part D: Transport and Environment* 92 (2021), 102734. DOI: https://doi.org/10.1016/j.trd.2021.102734

[2] Mashael Yousef Almoqbel, Anchita Komalchand Likhar, and Donghee Yvette Wohn. 2019. Understanding safety concerns and protection behaviors of rideshare drivers. In *Proceedings of the 2019 on Computers and People Research Conference (SIGMIS-CPR '19)*. ACM, New York, NY, 77. DOI: https://doi.org/10.1145/3322385.3322391

[3] Mashael Yousef Almoqbel and Donghee Yvette Wohn. 2019. Individual and collaborative behaviors of rideshare drivers in protecting their safety. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (Nov. 2019), 1–21. DOI: https://doi.org/10.1145/3359319

[4] Catherine Bailey and Adrian Madden. 2017. Time reclaimed: Temporality and the experience of meaningful work. *Work, Employment and Society* 31, 1 (Feb. 2017), 3–18. DOI: https://doi.org/10.1177/0950017015604100

[5] Beste Basciftci and Pascal Van Hentenryck. 2020. Bilevel optimization for on-demand multimodal transit systems. In *Integration of Constraint Programming, Artificial Intelligence, and Operations Research.* Emmanuel Hebrard and Nysret Musliu (Eds.). Springer International Publishing, Cham, Switzerland, 52–68.

[6] Nishani Bourmault and Michel Anteby. 2020. Unpacking the managerial blues: How expectations formed in the past carry Into new jobs. *Organization Science* 31, 6 (Nov. 2020), 1452–1474. DOI: https://doi.org/10.1287/orsc.2020.1361

[7] Geoffrey C. Bowker and Susan Leigh Star. 1999. *Sorting Things Out: Classification and Its Consequences*. MIT Press, Cambridge, MA.

[8] Raluca Budui. 2019. Tesla's touchscreen UI: A case study of car-dashboard user interface. Retrieved from https://www.nngroup.com/articles/tesla-big-touchscreen/

[9] Robert D. Bullard. 2003. Addressing urban transportation equity in the United States. *Fordham Urban Law Journal* 31 (2003), 1183.

[10] Johanna Bürstlein, David López, and Bilal Farooq. 2021. Exploring first-mile on-demand transit solutions for North American suburbia: A case study of Markham, Canada. *Transportation Research Part A: Policy and Practice* 153 (2021), 261–283. DOI: https://doi.org/10.1016/j.tra.2021.08.018

[11] Dan Calacci and Alex Pentland. 2022. Bargaining with the black-box: Designing and deploying worker-centric tools to audit algorithmic management. *Proceedings of the ACM on Human-Computer Interaction* 6, CSCW2, Article 428 (Nov. 2022), 24 pages. DOI: https://doi.org/10.1145/3570601

[12] Kathy Charmaz. 2014. *Constructing Grounded Theory* (2nd. ed.). Sage, London; Thousand Oaks, CA.

[13] EunJeong Cheon, Cristina Zaga, Hee Rin Lee, Maria Luce Lupetti, Lynn Dombrowski, and Malte F. Jung. 2021. Human-machine partnerships in the future of work: Exploring the role of emerging technologies in future workplaces. In *Companion Publication of the 2021 Conference on Computer Supported Cooperative Work and Social Computing*. ACM, 323–326. DOI: https://doi.org/10.1145/3462204.3481726

[14] Raj Chetty, Raj Chetty, Nathaniel Hendren, Nathaniel Hendren, Patrick Kline, Patrick Kline, Emmanuel Saez, and Emmanuel Saez. 2014. *Where Is the Land of Opportunity? The Geography of Intergenerational Mobility in the United States*. Technical Report. National Bureau of Economic Research, Cambridge, MA.

[15] Raj Chetty, Nathaniel Hendren, and Lawrence F. Katz. 2015. *The Effects of Exposure to Better Neighborhoods on Children: New Evidence from the Moving to Opportunity Experiment*. Technical Report. Harvard University Working Paper.

[16] Guangqing Chi, Derrick Shapley, Tse-Chuan Yang, and Donghui Wang. 2019. Lost in the Black Belt South: Health outcomes and transportation infrastructure. *Environmental Monitoring and Assessment* 191, 2 (Jun. 2019), 297. DOI: https://doi.org/10.1007/s10661-019-7416-1

[17] Maria Pia Ciano, Patrick Dallasega, Guido Orzes, and Tommaso Rossi. 2021. One-to-one relationships between industry 4.0 technologies and Lean production techniques: A multiple case study. *International Journal of Production Research* 59, 5 (2021), 1386–1410. DOI: https://doi.org/10.1080/00207543.2020.1821119

[18] Kevin Dalmeijer and Pascal Van Hentenryck. 2020. Transfer-expanded graphs for on-demand multimodal transit systems. In *Integration of Constraint Programming, Artificial Intelligence, and Operations Research*. Emmanuel Hebrard and Nysret Musliu (Eds.), Springer International Publishing, Cham, 167–175.

[19] Carol A. Duffy and Ann E. McGoldrick. 1990. Stress and the bus driver in the UK transport industry. *Work & Stress* 4, 1 (1990), 17–27. DOI: https://doi.org/10.1080/02678379008256961

[20] Gregory D. Erhardt, Sneha Roy, Drew Cooper, Bhargava Sana, Mei Chen, and Joe Castiglione. 2019. Do transportation network companies decrease or increase congestion? *Science Advances* 5, 5 (2019), eaau2670. DOI: https://doi.org/10.1126/sciadv.aau2670

[21] Michel Foucault. 1995. *Discipline and Punish: The Birth of the Prison* (2nd. vintage books ed.). Vintage Books, New York, NY.

[22] Sarah E. Fox, Vera Khovanskaya, Clara Crivellaro, Niloufar Salehi, Lynn Dombrowski, Chinmay Kulkarni, Lilly Irani, and Jodi Forlizzi. 2020. Worker-centered design: Expanding HCI methods for supporting labor. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*. ACM, New York, NY, 1–8. DOI: https://doi.org/10.1145/3334480.3375157

[23] Kaori Fujishiro. 2005. *Fairness at Work: Its Impacts on Employee Well-Being*. Ph.D. Dissertation. The Ohio State University.

[24] Jonathan Grudin. 1994. Groupware and social dynamics: Eight challenges for developers. *Communications of the ACM* 37, 1 (Jan. 1994), 92–105. DOI: https://doi.org/10.1145/175222.175230

[25] Anikó Hannák, Claudia Wagner, David Garcia, Alan Mislove, Markus Strohmaier, and Christo Wilson. 2017. Bias in online freelance marketplaces: Evidence from TaskRabbit and fiverr. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17)*. ACM, New York, NY, 1914–1933. DOI: https://doi.org/10.1145/2998181.2998327

[26] Joël Hazan, Nikolaus Lang, Augustin K. Wegscheider, and Benjamin Fassenot. 2019. On-demand transit can unlock urban mobility. Retrieved from https://www.bcg.com/publications/2019/on-demand-transit-can-unlock-urban-mobility

[27] Jane Hsieh, Miranda Karger, Lucas Zagal, and Haiyi Zhu. 2023. Co-designing alternatives for the future of gig worker well-being: Navigating multi-stakeholder incentives and preferences. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23)*. ACM, New York, NY, 664–687. DOI: https://doi.org/10.1145/3563657.3595982

[28] Yantao Huang, Kara M. Kockelman, Venu Garikapati, Lei Zhu, and Stanley Young. 2021. Use of shared automated vehicles for first-mile last-mile service: Micro-simulation of rail-transit connections in Austin, Texas. *Transportation Research Record* 2675, 2 (2021), 135–149. DOI: https://doi.org/10.1177/0361198120962491

[29] Felicia A. Huppert. 2009. Psychological well-being: Evidence regarding its causes and consequences†. *Applied Psychology: Health and Well-Being* 1, 2 (2009), 137–164. DOI: https://doi.org/10.1111/j.1758-0854.2009.01008.x

[30] Lilly C. Irani and M. Six Silberman. 2013. Turkopticon: Interrupting worker invisibility in Amazon mechanical turk. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. ACM, New York, NY, 611–620. DOI: https://doi.org/10.1145/2470654.2470742

[31] Zhou Jiang and Xiaowen Hu. 2015. Knowledge sharing and life satisfaction: The roles of colleague relationships and gender. *Social Indicators Research* 126 (Feb. 2015), 379–394. DOI: https://doi.org/10.1007/s11205-015-0886-9

[32] Heejin Kim, Sunghyuk Kwon, Jiyoon Heo, Hojin Lee, and Min K. Chung. 2014. The effect of touch-key size on the usability of in-vehicle information systems and driving safety during simulated driving. *Applied Ergonomics* 45, 3 (2014), 379–388. DOI: https://doi.org/10.1016/j.apergo.2013.05.006

[33] Maria Kjærup, Mikael B. Skov, and Niels Agerholm. 2020. Digital-enabled last mile: A study of passenger trips in rural, low-density populated areas. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*. ACM, New York, NY, 1–12. DOI: https://doi.org/10.1145/3313831.3376509

[34] Rob Kling. 1978. Six models for the social accountability of computing. *SIGCAS Computers and Society* 9, 2 (1978), 8–18. DOI: https://doi.org/10.1145/958929.958931

[35] Rob Kling. 1991. Cooperation, coordination and control in computer-supported work. *Communications of the ACM* 34, 12 (1991), 83–88. DOI: https://doi.org/10.1145/125319.125396

[36] Neha Kumar, Nassim Jafarinaimi, and Mehrab Bin Morshed. 2018. Uber in Bangladesh: The tangled web of mobility and justice. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW, Article 98 (Nov. 2018), 21 pages. DOI: https://doi.org/10.1145/3274367

[37] Bruno Latour. 1996. *Aramis, or the Love of Technology*. Harvard University Press, Cambridge, MA.

[38] Min Kyung Lee, Daniel Kusbit, Evan Metsky, and Laura Dabbish. 2015. Working with machines: The impact of algorithmic and data-driven management on human workers. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, 1603–1612. DOI: https://doi.org/10.1145/2702123.2702548

[39] Min Kyung Lee, Ishan Nigam, Angie Zhang, Joel Afriyie, Zhizhen Qin, and Sicun Gao. 2021. Participatory algorithmic management: Elicitation methods for worker well-being models. In *Proceedings of the 2021 AAAI/ACM Conference on AI, Ethics, and Society*. ACM, 715–726. DOI: https://doi.org/10.1145/3461702.3462628

[40] Myriam Lewkowicz and Romain Liron. 2019. The missing "turn to practice" in the digital transformation of industry. *Computer Supported Cooperative Work* 28, 3 (Jun. 2019), 655–683. DOI: https://doi.org/10.1007/s10606-019-09347-y

[41] Marjolein Lips-Wiersma, Sarah Wright, and Bryan Dik. 2016. Meaningful work: Differences among blue-, pink-, and white-collar occupations. *Career Development International* 21, 5 (Sep. 2016), 534–551. DOI: https://doi.org/10.1108/CDI-04-2016-0052

[42] Catherine Lutz. 2014. The U.S. car colossus and the production of inequality. *American Ethnologist* 41, 2 (2014), 232–245. DOI: https://doi.org/10.1111/amet.12072

[43] Ning F. Ma and Benjamin V. Hanrahan. 2019. Part-time ride-sharing: Recognizing the context in which drivers ride-share and its impact on platform use. *Proceedings of the ACM on Human-Computer Interaction* 3, GROUP (Dec. 2019), 247:1–247:17. DOI: https://doi.org/10.1145/3361128

[44] Jorge Mejia and Chris Parker. 2021. When transparency fails: Bias and financial incentives in ridesharing platforms. *Management Science* 67, 1 (2021), 166–184. DOI: https://doi.org/10.1287/mnsc.2019.3525

[45] Srihari Hulikal Muralidhar, Claus Bossen, and Jacki O'Neill. 2022. Between a rock and a hard place: Negotiating dependencies and precarity in the on-demand economy. *Computer Supported Cooperative Work* 31, 3 (Sep. 2022), 443–486. DOI: https://doi.org/10.1007/s10606-022-09434-7

[46] Elizabeth C. Nelson, Anneke M. Sools, Miriam M. R. Vollenbroek-Hutten, Tibert Verhagen, and Matthijs L. Noordzij. 2020. Embodiment of wearable technology: Qualitative longitudinal study. *JMIR mHealth and uHealth* 8, 11 (Nov. 2020), e16973. DOI: https://doi.org/10.2196/16973

[47] Davide Nicolini. 2013. *Practice Theory, Work, and Organization: An Introduction*. Oxford University Press, Oxford, United Kingdom.

[48] William Odom, Ron Wakkary, Youn-kyung Lim, Audrey Desjardins, Bart Hengeveld, and Richard Banks. 2016. From research prototype to research product. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, 2549–2561. DOI: https://doi.org/10.1145/2858036.2858447

[49] Wanda J. Orlikowski. 1992. The duality of technology: Rethinking the concept of technology in organizations. *Organization Science* 3, 3 (1992), 398–427. DOI: https://doi.org/10.1287/orsc.3.3.398

[50] Wanda J. Orlikowski. 1993. Learning from notes: Organizational issues in groupware implementation. *The Information Society* 9, 3 (1993), 237–250. DOI: https://doi.org/10.1080/01972243.1993.9960143

[51] Wanda J. Orlikowski and Debra C. Gash. 1994. Technological frames: Making sense of information technology in organizations. *ACM Transactions on Information Systems* 12, 2 (Apr. 1994), 174–207. DOI: https://doi.org/10.1145/196734.196745

[52] Xavier Parent-Rocheleau and Sharon K. Parker. 2022. Algorithms as work designers: How algorithmic management influences the design of jobs. *Human Resource Management Review* 32, 3 (2022), 100838. DOI: https://doi.org/10.1016/j.hrmr.2021.100838

[53] Gary Pritchard, John Vines, Pam Briggs, Lisa Thomas, and Patrick Olivier. 2014. Digitally driven: How location based services impact the work practices of London bus drivers. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, NY, 3617–3626. DOI: https://doi.org/10.1145/2556288.2557156

[54] Matthew P. Rabbitt, Laura J. Hales, Michael P. Burke, and Alisha Coleman-Jensen. 2023. Household food security in the United States in 2022. Economic Research Report 325, 53 pages. DOI: https://doi.org/10.22004/ag.econ.338945

[55] Connor Riley, Pascal Van Hentenryck, and Enpeng Yuan. 2020. Real-time dispatching of large-scale ride-sharing systems: Integrating optimization, machine learning, and model predictive control. arXiv:2003.10942. DOI: https://doi.org/10.48550/arXiv.2003.10942

[56] Alex Rosenblat and Luke Stark. 2016. Algorithmic labor and information asymmetries: A case study of uber's drivers. *International Journal of Communication* 10, 27 (Jul. 2016), 3758–3784. DOI: https://doi.org/10.2139/ssrn.2686227

[57] Alyssa Rumsey and Christopher A. Le Dantec. 2019. Clearing the smoke: The changing identities and work in firefighters. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19)*. ACM, New York, NY, 581–592. DOI: https://doi.org/10.1145/3322276.3322292

[58] Alyssa Rumsey and Christopher A. Le Dantec. 2022. Escaping the holodeck: Designing virtual environments for real organizations. In *Human-Technology Interaction: Shaping the Future of Industrial User Interfaces*. Springer, Cham, Switzerland, 223–249.

[59] Tiina Saari, Minna Leinonen, and Katriina Tapanila. 2022. Sources of meaningful work for blue-collar workers. *Social Sciences* 11, 1 (2022). DOI: https://doi.org/10.3390/socsci11010002

[60] Saiph Savage, Chun Wei Chiang, Susumu Saito, Carlos Toxtli, and Jeffrey Bigham. 2020. Becoming the super turker: Increasing wages via a strategy from high earning workers. In *Proceedings of the Web Conference 2020 (WWW '20)*. ACM, New York, NY, 1241–1252. DOI: https://doi.org/10.1145/3366423.3380200

[61] Emily Schildt, Martin Leinfors, and Louise Barkhuus. 2016. Communication, coordination and awareness around continuous location sharing. In *Proceedings of the 2016 ACM International Conference on Supporting Group Work (GROUP '16)*. ACM, New York, NY, 257–265. DOI: https://doi.org/10.1145/2957276.2957289

[62] Irving Seidman. 2019. *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences* (5th. ed.). Teachers College Press, New York, NY.

[63] Susan A. Shaheen and Timothy E. Lipman. 2007. Reducing greenhouse emissions and fuel consumption: Sustainable approaches for surface transportation. *IATSS Research* 31, 1 (Jan. 2007), 6–20. DOI: https://doi.org/10.1016/S0386-1112(14)60179-5

[64] Alyssa Sheehan and Christopher A. Le Dantec. 2023. Making meaning from the digitalization of blue-collar work. *Proceedings of the ACM on Human-Computer Interaction* 7, CSCW2, Article 345 (Oct. 2023), 21 pages. DOI: https://doi.org/10.1145/3610194

[65] Irina Shklovski, Janet Vertesi, Emily Troshynski, and Paul Dourish. 2009. The commodification of location: Dynamics of power in location-based systems. In *Proceedings of the 11th International Conference on Ubiquitous Computing (UbiComp '09)*. ACM, New York, NY, 11–20. DOI: https://doi.org/10.1145/1620545.1620548

[66] Jennifer L. Sparr and Sabine Sonnentag. 2008. Fairness perceptions of supervisor feedback, LMX, and employee well-being at work. *European Journal of Work and Organizational Psychology* 17, 2 (2008), 198–225. DOI: https://doi.org/10.1080/13594320701743590

[67] Franchesca Spektor, Sarah E. Fox, Ezra Awumey, Christine A. Riordan, Hye Jin Rho, Chinmay Kulkarni, Marlen Martinez-Lopez, Betsy Stringam, Ben Begleiter, and Jodi Forlizzi. 2023. Designing for wellbeing: Worker-generated ideas on adapting algorithmic management in the hospitality industry. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23)*. ACM, New York, NY, 623–637. DOI: https://doi.org/10.1145/3563657.3596018

[68] Vu Thi Thao, Sebastian Imhof, and Widar von Arx. 2023. Demand responsive transport: New insights from peri-urban experiences. *Travel Behaviour and Society* 31 (2023), 141–150. DOI: https://doi.org/10.1016/j.tbs.2022.11.012

[69] John L. M. Tse, Rhona Flin, and Kathryn Mearns. 2006. Bus driver well-being review: 50 years of research. *Transportation Research Part F: Traffic Psychology and Behaviour* 9, 2 (2006), 89–114. DOI: https://doi.org/10.1016/j.trf.2005.10.002

[70] Justin Tyndall. 2017. Waiting for the R train: Public transportation and employment. *Urban Studies* 54, 2 (2017), 520–537. DOI: https://doi.org/10.1177/0042098015594079

[71] Xinyi Wang, Xiang Yan, Xilei Zhao, and Zhuoxuan Cao. 2022. Identifying latent shared mobility preference segments in low-income communities: Ride-hailing, fixed-route bus, and mobility-on-demand transit. *Travel Behaviour and Society* 26 (2022), 134–142. DOI: https://doi.org/10.1016/j.tbs.2021.09.011

[72] Terry Winograd. 1993. Categories, disciplines, and social coordination. *Computer Supported Cooperative Work* 2, 3 (Sep. 1993), 191–197. DOI: https://doi.org/10.1007/BF00749016

[73] R. C. P. Wong, Linchuan Yang, and W. Y. Szeto. 2023. Comparing passengers' satisfaction with fixed-route and demand-responsive transport services: Empirical evidence from public light bus services in hong Kong. *Travel Behaviour and Society* 32 (2023), 100583. DOI: https://doi.org/10.1016/j.tbs.2023.100583

[74] Alex J. Wood, Mark Graham, Vili Lehdonvirta, and Isis Hjorth. 2019. Good gig, bad gig: Autonomy and algorithmic control in the global gig economy. *Work, Employment and Society* 33, 1 (2019), 56–75. DOI: https://doi.org/10.1177/0950017018785616

[75] Zheng Yao, Silas Weden, Lea Emerlyn, Haiyi Zhu, and Robert E. Kraut. 2021. Together but alone: Atomization and peer support among gig workers. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW2 (Oct. 2021), 1–29. DOI: https://doi.org/10.1145/3479535

[76] Angie Zhang, Alexander Boltz, Chun Wei Wang, and Min Kyung Lee. 2022. Algorithmic management reimagined for workers and by workers: Centering worker well-being in gig work. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI '22)*. ACM, New York, NY, Article 14, 20 pages. DOI: https://doi.org/10.1145/3491102.3501866

Appendices

A Interview Details

Table A1. Breakdown of Interview Duration in Minutes and Participating Vehicle Operators

Interview	Duration (Min)	Operator
1	37	O1
2	60	O2
3	57	O3, O4, O5
4	55	O6, O7
5	20	O8
6	40	O9, O10
7	72	O11, O12, O13
8	80	O14, O15, O16, O17

B Driver App Screenshots

The following screenshots are provided for improved legibility from Figure 1.

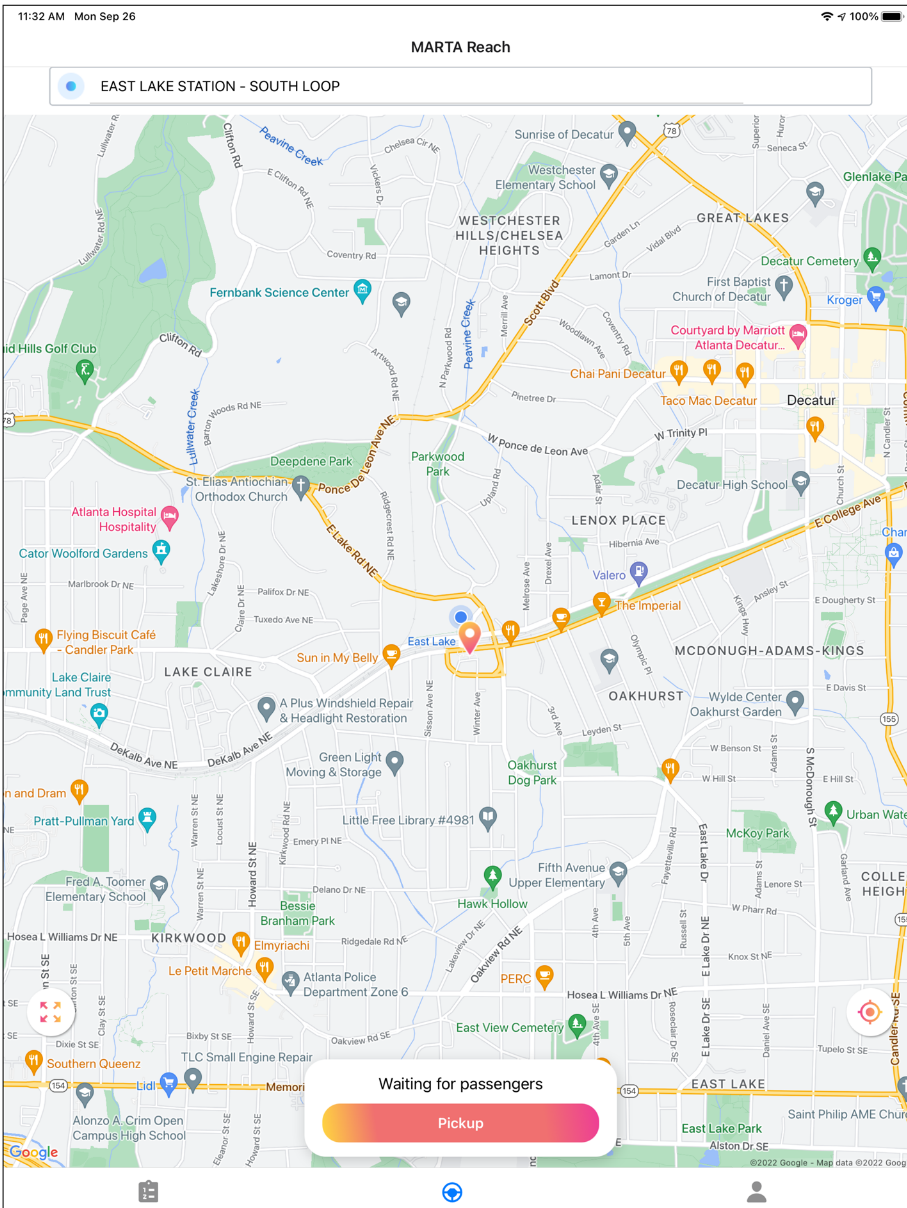

Fig. B1. Location of rider pick-up; pick-up initiated by tapping button in the bottom center.

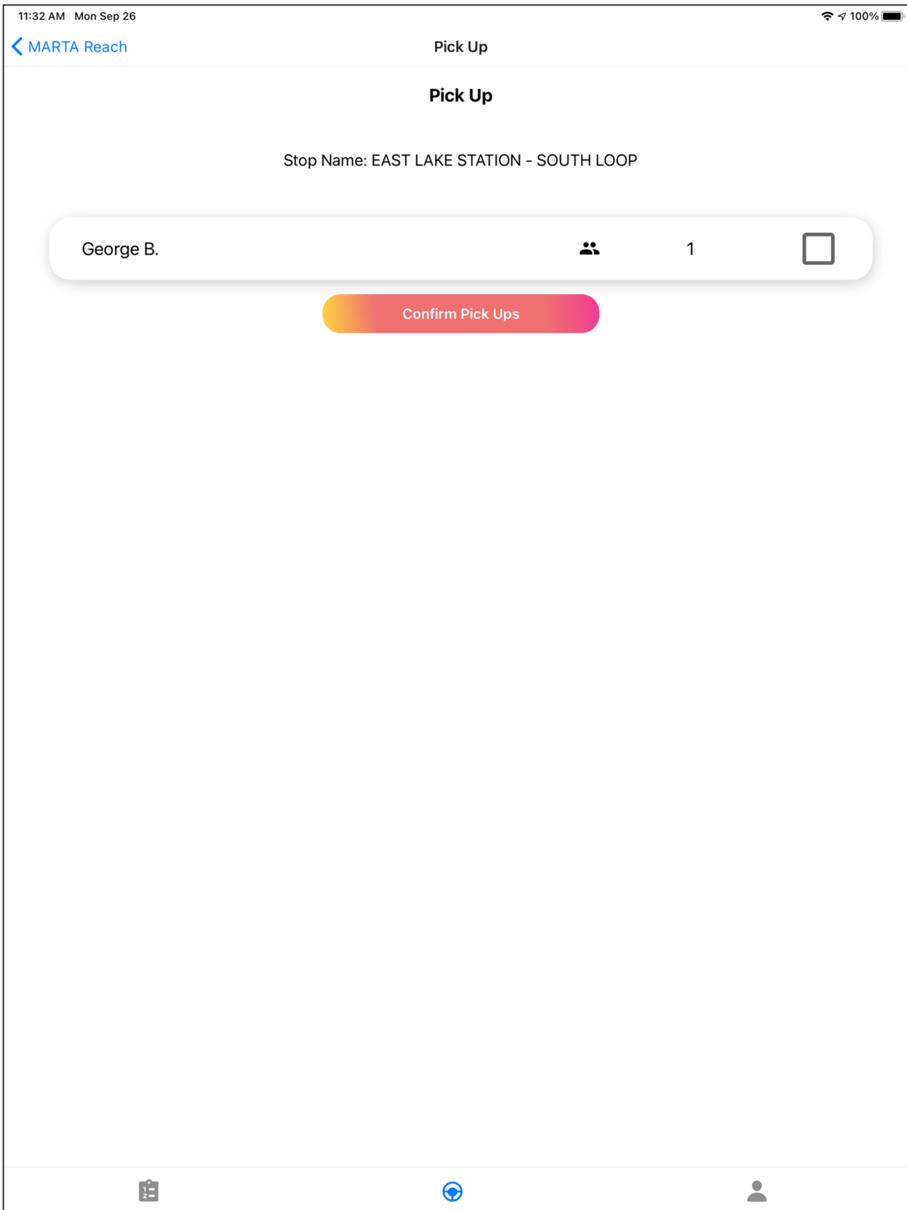

Fig. B2. List of riders to pick-up at stop—here showing a single rider.

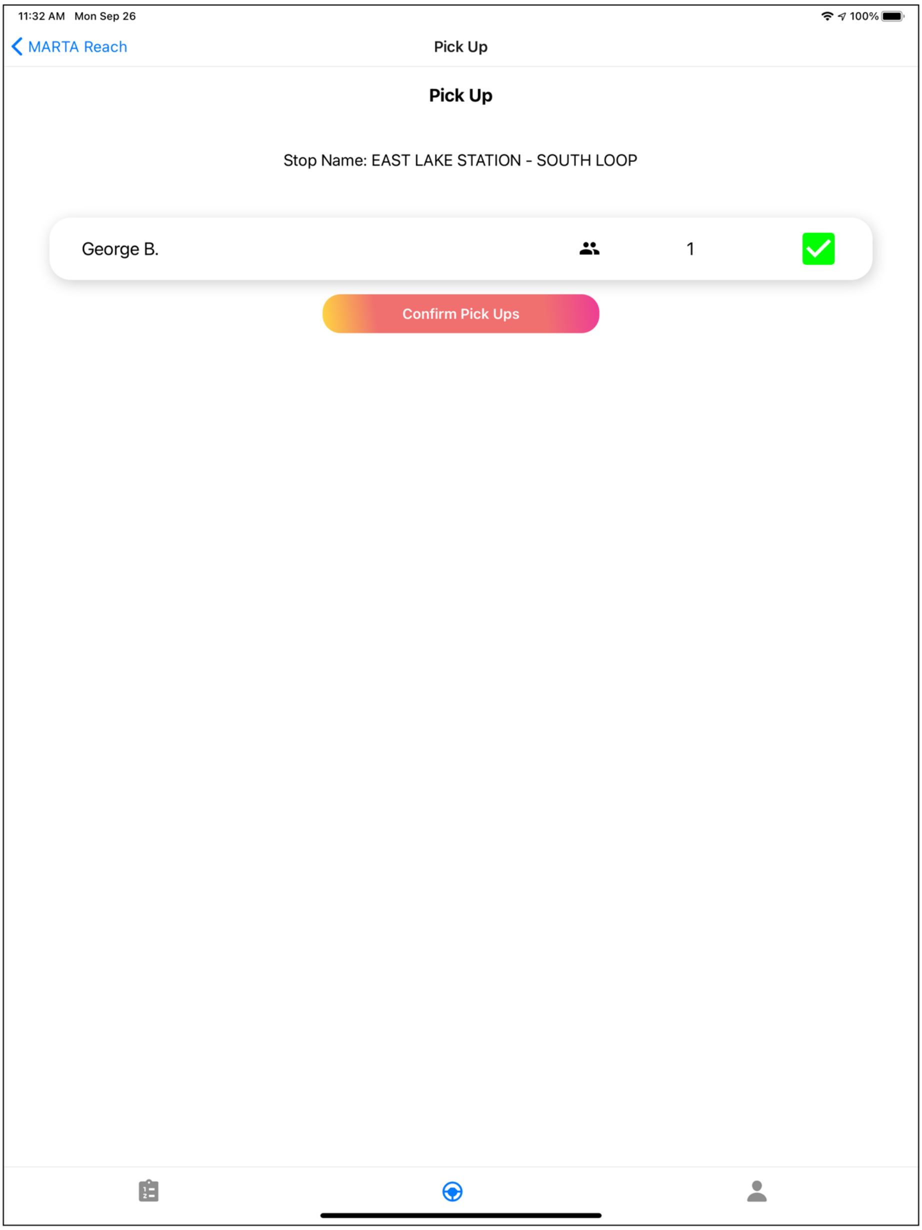

Fig. B3. Confirming rider pick-up by selecting the check-box.

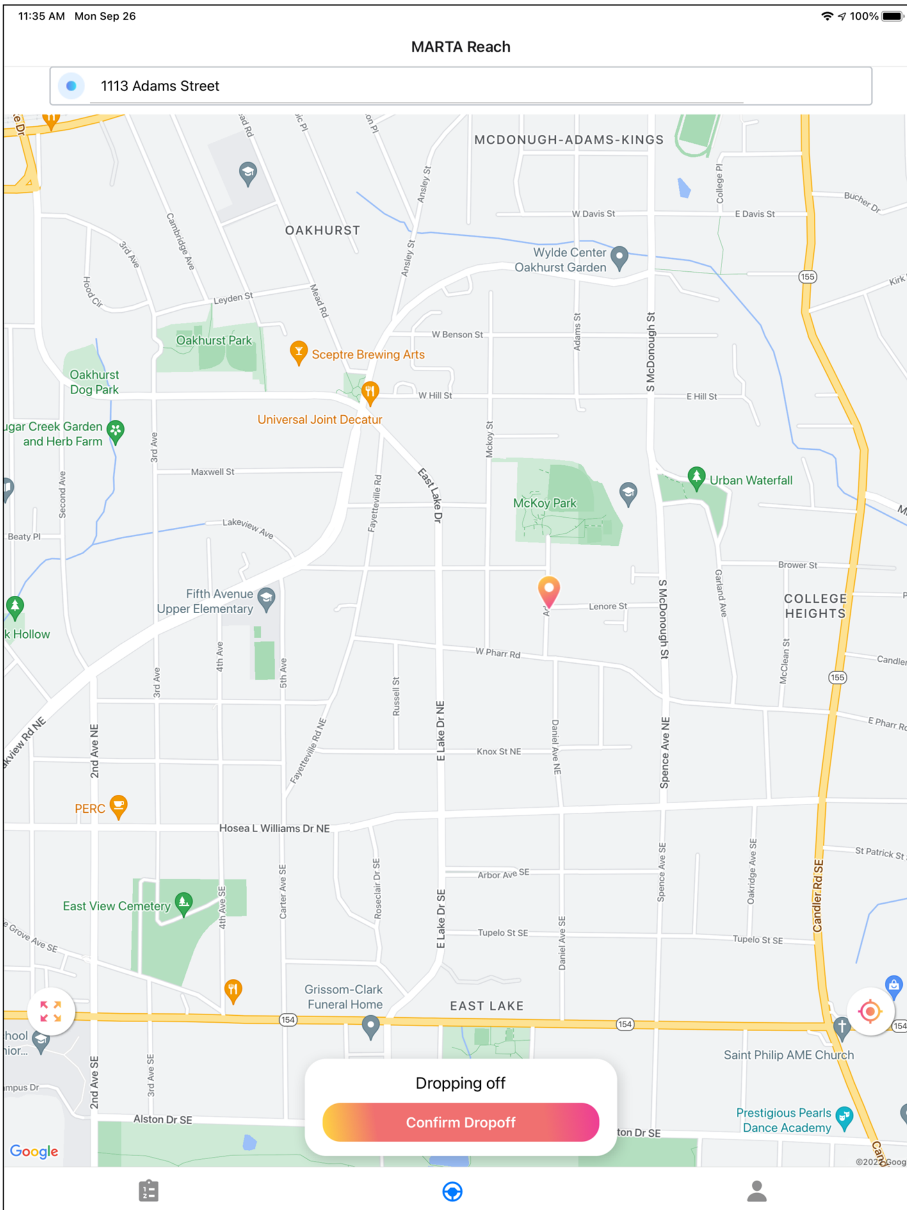

Fig. B4. Location of rider drop-off; drop-off initiated by tapping button in the bottom center.

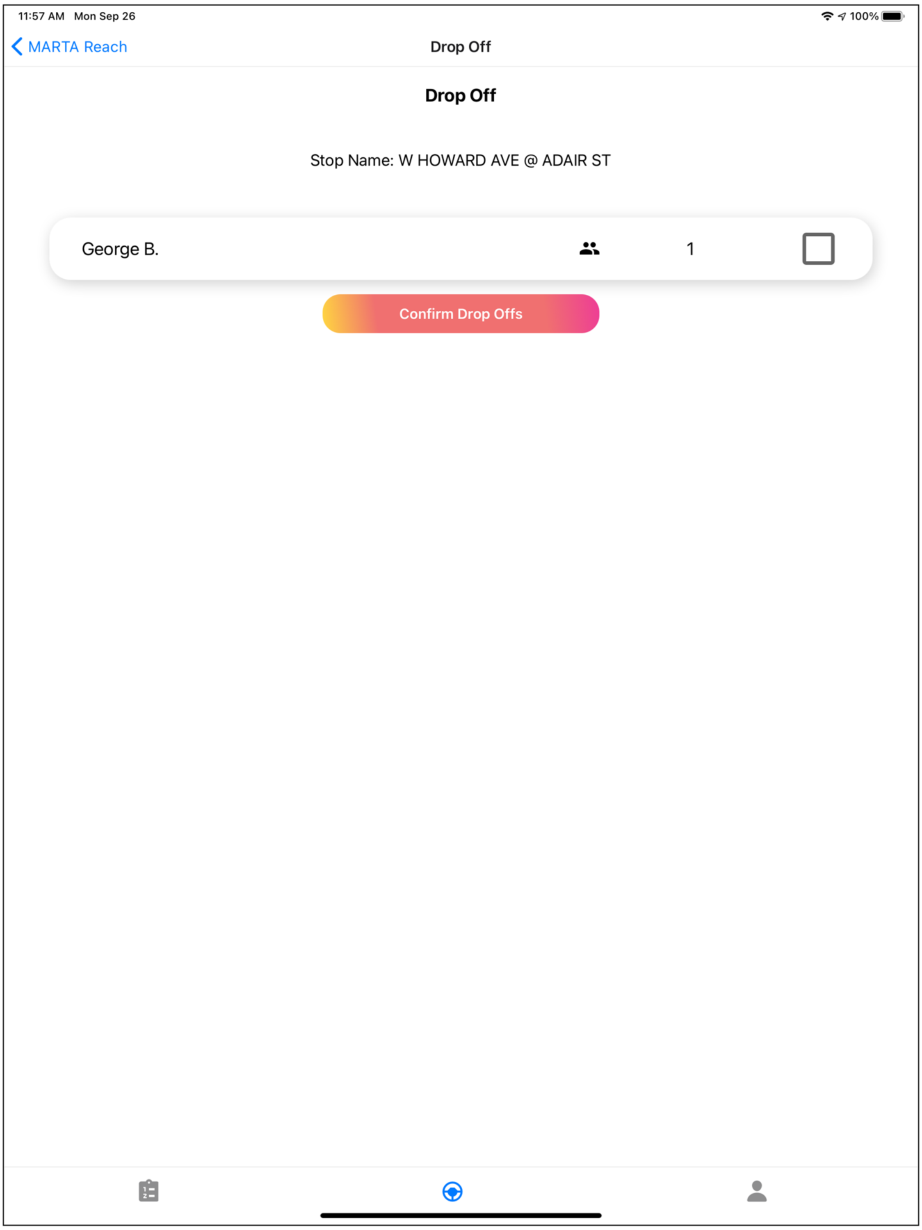

Fig. B5. List of riders to drop-off at stop—here showing a single rider.

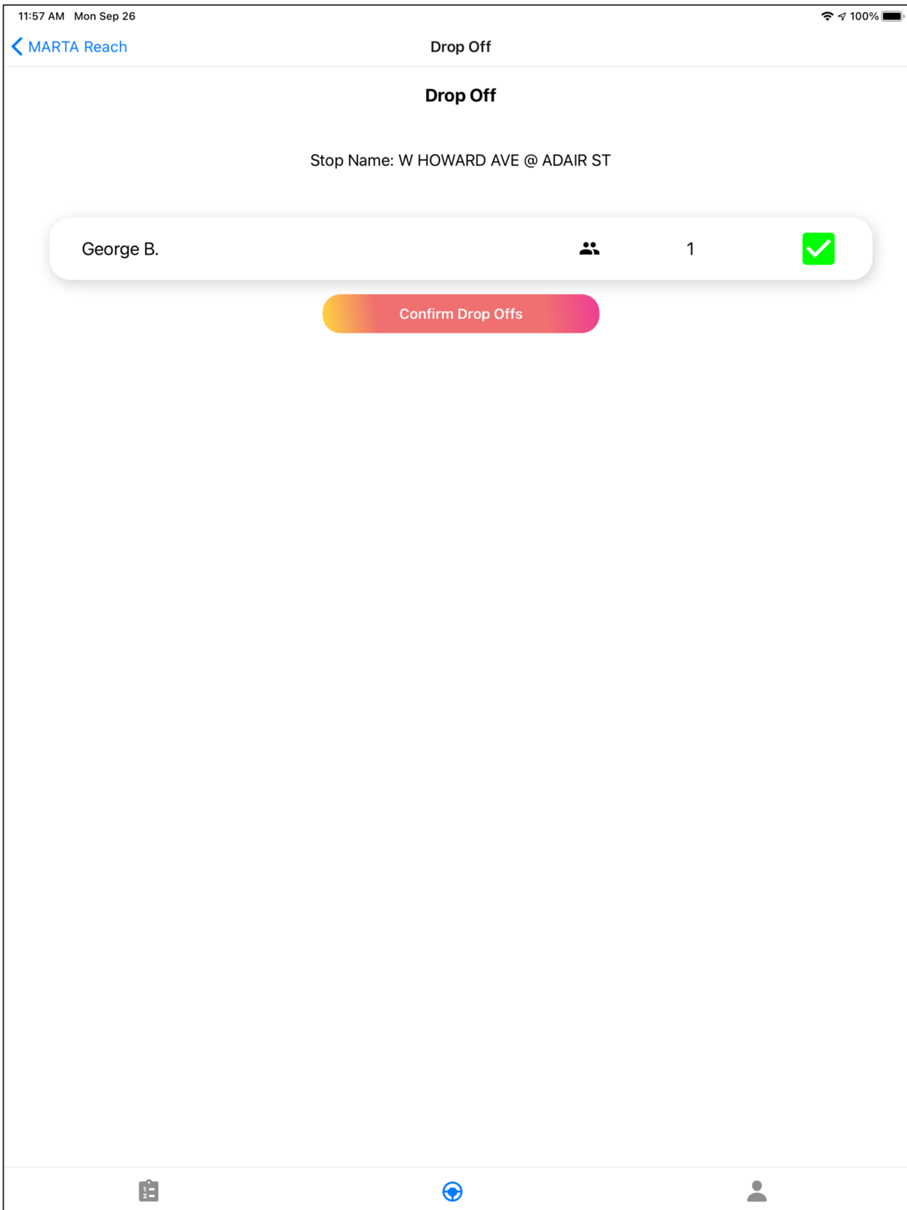

Fig. B6. Confirming rider drop-off by selecting the check-box.

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