Personal Digital Urbanism:

The Promise and the Mess of New Mobility Technologies

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Abstract

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The presence of digital technologies is expanding in professional planning practice and in everyday urban life. Recent research has asked what digitality *does* in cities, and answers by examining how these technologies produce novel practices, spaces, and social arrangements. In this dissertation, I extend this work by answering that one thing digitality does is that it *promises*. I focus specifically on the promises that digital technologies can allow the city to be known with certainty, and can solve its problems. I argue that this promise is dangerous in two ways. First, its abstract visions can never be completely realized in the particular socio-material messiness of the city, leaving those who had imagined digital objects satisfying their desires for certainty and solvability both disappointed that these were not achieved and underprepared to manage in their absence. Second, this promise is misleading in offering a vision of improving the city by transcending its messiness—infrastructures, environments, physical artifacts, personal desires, indeterminate actions, and political conflict—rather than recognizing such materiality and agency as both ineradicable and as essential to any social transformation. The dissertation is guided by an analytical approach that brings together the ideas of the promise and the mess, a theoretical bifocal capable of seeing the digital as both an imagined, desired ideal and a concrete, situated practice that I offer as a way to avoid tendencies to either overdetermine or under-politicize new technological practices.

The empirical basis of the dissertation is a qualitative study of new mobility technologies, a case of the digitization of the city. New mobility refers to smartphone apps for real-time travel information, mobility services accessed primarily through an app interface, and supporting data infrastructures. The research has three components. First, a study of the visions for how digital technologies can address urban transportation challenges uses material from professional reports, interviews, and industry conferences to show that the promise of new mobility speaks to desires among planners to achieve certainty and solvability and to avoid the more difficult work of building infrastructure or changing behavior. Second, an examination of the development of data specifications and their use in monitoring and regulating Seattle's bikeshare vendors examines the ways digitality translates the messiness of the street into data on the screen, and traces the conflicts that appear as digital visions are realized. Third, interviews and focus groups with 40 Seattle-based travelers, including young professionals and residents of senior living facilities, generated accounts of travelers' situated experiences of the oscillation between the promises of app-based mobility services and the messiness of getting around. In these studies, I find that digitality can obscure as well as it reveals, and so should be used with care. I conclude by suggesting that we might more productively engage digitality by repoliticizing its promise, and by learning to live well with the mess of the city. The project urges planning to consider the promise of digitality as itself a kind of plan, and at the same time to make an active effort to plan beyond the digital.

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In Memoriam

ROBERT MUGERAUER

Years ago, when the notion that I could go to grad school to study cities and technology was a spark in search of some kindling, I emailed Prof. Bob Mugerauer. Tentative, uncertain of myself, I wondered whether I might find a home in doctoral studies at the University of Washington. His response was attentive and encouraging, and, in subsequent exchanges negotiating graduate admissions, he made an institutional process personable. "I just go by 'bob,'" he wrote me in an early postscript, "many students call me 'dr bob.'"

Dr. Bob helped arrange a visit to campus. He shared a paper he'd written on tech companies in Texas, and picked up the tab for Thai noodles across the street. Right away, he impressed me as genuinely curious about my interests and confident in my ability to pursue them. For reasons I will never fully understand, Dr. Bob in those early days saw a scholar in me, and so allowed me to see one in myself.

I came to UW with Dr. Bob on my advisory committee. In the years that followed, Bob was the mentor I needed as I found my intellectual footing. He was the person I turned to when, in the day-to-day grind of grad school, I needed to remember the questions that drove me. We read Latour together, and he taught me what good research looks like outside the positivist paradigm. He was always introducing me to another text or thinker that reminded him of me, and quickly insisted that I was the only judge of its utility in my own thought. He gave me a model of the kind scholarship I aspired to: curious, rigorous, and unconstrained by the well-worn path. Most of all, Dr. Bob was warm, kind, and, I had no doubt, genuinely cared for his students.

Dr. Bob died on May 8, 2022, while I was writing this dissertation. I am sad I never got to hear his reaction to it, but I can only hope that his spirit is evident in it. I miss Bob. I am grateful for his mentorship, for the fuel and oxygen he gave to that little flame. I am a better thinker, a better teacher, a better scholar because of him.

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No one has had a greater influence on this project than Mark Purcell, who some time ago recognized that I had something I wanted to say, then took on the patient task of asking me to say it, and to say it better. If any reader detects Mark's intellectual contribution within this work, I would take it as praise. But I suspect that what Mark would recognize as the real testament to his mentorship is if anyone reads the work as authentically my own. This work is stronger because of what he taught me. It was more satisfying to write because he trusted me. Mark has been everything I wanted in an advisor, and everything my work needed. For that I am exceedingly grateful.

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Thank you to the many students I have taught over these years. I am inspired by their idealism and their get-down-to-business perseverance. Their thinking has pushed my own.

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In more ways than one, this work is indebted to my parents. In raising me, they did not just prioritize education, they demonstrated each day its value in a life well lived. I am still learning how much of my thinking is a product of their influence. Their confidence in me is the ground from which everything else has grown. I am grateful beyond measure for them.

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This work coincided with a very difficult time in my life. Thank you to my therapist, Margaret, for teaching me to get unstuck. Thank you to Pete and Kethi for trusting a stranger in a time of need. Thank you to Seattle's baristas, the Cascade range, Franz Schubert, and a terrier mix named Chickpea for the beauty they have brought to my days. Above all, thank you to my family: to Ann for listening; to Mark, Jess, Nora, Isaac, and Logan for their extraordinary hospitality; to Meghan for inspiring me; and to Mom and Dad for their unwavering support in all forms. I can only hope that someone some day will feel from me the bone-deep love that I have felt from my family while doing this work.

This work coincided with some of the most joyful and wonderous days of my life. Elena, my light, this is for you.

December, 2022
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CHAPTER 1

Introduction

Digitality promises

It's a Monday morning in April, 2019, and I am ready to leave my apartment and head to campus. Walking out the door, I begin to turn right while taking my phone out of my pocket and opening an app, OneBusAway. After I select my bus stop on 23rd Avenue East, saved to my favorites, it tells me that my bus, the 48, will arrive there in 6 minutes. The walk is usually 8 minutes. Should I run for it? The app says the next 48 after that will be in 21 minutes, and, if I miss the first one, that'll be long wait. I stop on the sidewalk, phone in hand. In the opposite direction from 23rd Avenue is Broadway, where the 49 also goes to campus. I check that stop on OneBusAway and learn the next 49s are arriving in 2 and 12 minutes. The walk is 9 minutes or so. It's a safer bet. Either way, I'm in no danger of being late for anything, but I'd rather not stand around at the bus stop. I turn around and walk to Broadway. When I get to the stop, there are just two other people waiting, eyes on their phones. At this time of day, there would usually be a crowd. Did I just miss a bus? I know the app's arrival times aren't always accurate. Across the street I can see two Jump bikes. It's been raining all weekend, but now it's a sunny morning. It might be nice to splurge on a ride. Before crossing the street, I open the Jump app on my phone to see if the bikes are available. It opens a map centered on my current location. One bike across the street is shown as available, with a 61% battery level. The other doesn't show up at all, but one is enough. I walk across the street to the available bike and use my phone to scan a QR code. The bike unlocks, and a clock begins counting on the app, showing that my rental has begun. It's an easy ride down the hill to campus, although that turning car did cut a little close. I find a rack next to Gould Hall where I can park the bike, pulling out its cable, then looping it around the rack an inserting it back in the bike to lock it. The bike beeps, and a notification on my phone tells me that my trip has ended. It says I rode a distance of 2.6 miles in 11 minutes, and that my credit card was charged $3.75.

Meanwhile, some planners at the Seattle Department of Transportation's downtown office are discussing the future of bikeshare program. In the past, the three current vendors have provided periodic reports to SDOT that include data on the ending location of every trip in a simple CSV format. SDOT has asked the vendors to begin transferring data in real time using a new standard called the Mobility Data Specification, but adoption has been rocky. This data would describe the full route of every trip, and would give SDOT a better picture of vendors' compliance with various permit requirements. Of course, SDOT doesn't yet have the servers, staff, and processes to analyze all of that efficiently. Right now, an analyst is doing a quarterly report using the vendor data and GIS to map the distribution of trip ends. The bikeshare program has funding to build designated parking areas, keeping shared bikes from blocking pedestrians on sidewalks, and city officials hope that the trip data they've been getting can help them decide where to build them. The office is getting a lot of complaints about mis-parked bikes, and staff want to be able to show residents that they are in control of the situation. The team imagines what else might be done with more detailed trip data. Uber and Lyft don't share data with anywhere near that kind of resolution, but one planner imagines how, if they did, transportation officials might better regulate ride-hailing services. With real-time, two-way communication between the city and the vendors, they could implement congestion charges, incentives for carpooling, and requirements for availability in underserved areas. The city is choking on its traffic. Surely these data tools can help.

Two decades ago, Ash Amin and Nigel Thrift wrote that “the modern city exists as a haze of software instructions. Nearly every urban practice is becoming mediated by code” (Amin & Thrift, 2002, p. 125). Geographers at the time were observing the ubiquity of computing in the urban environment and noting the resulting “automatic production of space” (N. Thrift & French, 2002), the “sorting” of people by software (S. D. N. Graham, 2005), the “spatial formation of collective life” around code (Kitchin & Dodge, 2005), and “a world where we not only think of cities but cities think of us” (Crang & Graham, 2007, p. 789). And that was before the widespread adoption of smartphones, whose proliferation further expanded the spatial reach of software and launched a more recent wave of scholarship dealing with the digital and the city. In this literature, much of it focused on apps and platforms, software again features as a productive, disruptive, or otherwise transformative feature of contemporary urbanism (Ash et al., 2018; Barns, 2020; Bissell, 2020; Leszczynski, 2019a; Richardson, 2020b). In just one example of the echoes of Amin and Thrift’s thought, Sarah Barns writes that “with billions of sensors and devices now distributed throughout urban environments, the routine is now being computed daily” (Barns, 2021, p. 3204). Many of these accounts feature vignettes not unlike the two above to show that the digital is everywhere in the city.

Of course, in those vignettes is much more than algorithms and data. There are also people and infrastructure; there is the city. In my commute, there are streets, sunny skies, a steel cable, hills, eyesight, and other commuters. At the (fictionalized) SDOT offices, there are permits, vendor relationships, complaints, and parking areas. And there are human beings who think and feel—I *worry* about standing at a bus stop but not about being late, the transportation officials *hope* and *imagine*—as they engage with digital data. This quick glance can show us, as indeed much of the digital geographies literature does, that code is not laid atop an urban tabula rasa, but weaves its way around and through everyday practice and infrastructure. Whether implicitly or explicitly, tech companies, city officials, software users, researchers, and theorists are asking and imagining how new forms of digitality relate to this messiness of people and things.

The digital is everywhere in the city, and it appears to be doing something, but what? And how should we think about it? In this dissertation, I answer that one thing digitality does is that it makes *promises*. Smartphone apps promise me that the next bus will arrive in 12 minutes, and that I can access a bike that will take me where I want to go. Application interfaces promise SDOT visibility into every bike trip, and new tools for controlling traffic. Within these data and algorithms are imagined futures, large or small, in which the city can be known more completely and its problems can be solved. Recognizing that digitality promises invites us to look beyond the technical specifications of a tool or observations of its use to see how the tool works in dialogue with some human desire. It redirects our critical attention away from the evaluation of its success in achieving its purpose and towards an evaluation of that purpose itself. In this way, seeing how digitality promises requires seeing a *personal* dimension of technology, since a promise is not a statement that stands alone, but a relation between a vision and a person who engages with it, whether credulously or not. My goal in this dissertation, then, is to understand the digital by understanding the people around it. The use of “personal” in the title of this work does not mean customized for individual preferences, but instead points to the project’s concern with the body, experience, and desires of a human person. And, as we know, this person is always situated among other people and non-human things, including especially digital artifacts.

The relationality that comes into view when we see digitality's work of promising is a way around the analytical separation of people and technologies that underlies the many technology studies, including some of those cited above, that tend to see new digital tools more narrowly as either empowering certain behaviors or controlling the people who use it. Such views risk focusing on technologies in themselves, what they are and what they do, while missing the surrounding networks of people and things in which they are embedded. In surveying recent scholarship on the digitally mediated city, Gillian Rose (2017) has taken issue with an inclination in this work to view digital technologies as a productive force with new capacities for automatically shaping the city that is somehow separate from human agency. This is a trap I am cautious to avoid. Rather than view humans and software as distinct entities vying for control of the city, Rose offers theorizations of humans as "always already (digitally) sociotechnical" (p. 789), and this idea becomes an important pillar for my work. Recognizing the co-constitution of the digital and the human means we need not subscribe to a zero-sum proposition in which an increase in the digital in the city must be attended by a corresponding decrease in the personal, the political, or the infrastructural.

What we often find, however, is that digitality promises just that. My research identifies two core promises of digitality: certainty and solvability. It further shows how imagining technologies delivering certainty and solvability invites us to overlook the heterogeneous desires and indeterminate behaviors of people as well as the concrete environments and artifacts with which they act. These two dimensions—agency and materiality—constitute what I call the *mess*. The mess is our lived reality. It is particular, concrete, indeterminate, and irreducible, and it gets in the way of knowing the world with certainty and of intervening with confidence that the results will achieve their intention. Promises that transcend such messiness are useful; indeed they are necessary for making sense of the world and what we want it to be. At the same time, such promises are dangerous. I argue in this dissertation that digitality's promises of certainty and solvability leave us unprepared for dealing with the city's messiness of agency and materiality that they hope to escape, but never fully can. Further, I want to challenge the idea that we should *want* to escape the mess, since doing so devalues the openness of an urban public made up of autonomous agents acting in ambiguous and untraceable relations. Such a public is far more conducive to the full realization of the self than the alternative, a public of deterministic clarity. The point is not to claim that these promises are either inaccurate or unproductive, and in fact much of my work will illustrate the utility the promise as a site for articulating, revealing, and wrestling with collective values. Rather, the point is that the promise of digitality is not sufficient for the work of making a better city, and by tempting us into believing that it is, as I will show it too often does, it misleads us.

I build this argument with my research on emerging digital technologies for urban mobility, specifically the use of smartphones apps and their associated data in transportation planning and everyday travel. These tools and practices fall under the umbrella of "new mobility," a catch-all term within transportation planning that describes various ways in which urban mobility is or can be shaped by emerging computer hardware and software technologies. New mobility comprises both future-oriented visions and actual concrete practices, and it crosses social and temporal scales from an individual traveler planning a trip to a transportation agency planning a system. It allows me to empirically observe the relations between promise and mess in practices spanning from the digital artifact to an affected person. I will further introduce this research and the theoretical framework that guides it shortly, but first, the following section differentiates my project from several existing views of digital urbanism.

Lenses for digital urbanism

The digital, referring to information and communications technologies based on digital computers and to the various social practices surrounding them, has become a topic of interest within various fields of geography and planning. This section briefly introduces some of the main threads of this literature: smart city critiques, theories of the digital mediation of space, and accounts of app-mediated urban experience. I am especially interested in flagging two hazards that I want to avoid. The first is seeing either technologies or capitalist structures as deterministic, operating with a force exceeding the agency of situated actors to do something differently. The second is apolitical descriptivism, which sees agency, but lacks a critical view of the value-laden structures through which actors work. Before offering the framing of the promise and mess as a way to avoid these traps, let me outline some of the ways the literature has examined the role of digitality in the city.

In academia and in professional practice, much of the attention to the intersection between information technologies and urbanism has fallen under the umbrella of "smart cities." It is difficult to say exactly what a smart city is, and the flexibility and vagueness of the label is no small part of the appeal (Hollands, 2008). In general, the term refers both to regional economic development centered on high-tech industries and innovation and to the uses of distributed sensors, networks, big data, and algorithms within government, usually in partnership with private corporations (Goodspeed, 2015). These two tracks are related, but more relevant to my work is the latter. By the mid-2000s, multinational IT conglomerates were selling governments visions of "smart city" technologies focused on new opportunities for efficient service delivery, environmental sustainability, and citizen participation (Kitchin, 2014). Within geography and planning, a wave of criticism followed, faulting the smart city for its large-scale solutionism ignorant of actual urban dynamics (Greenfield, 2013), its “empty rhetoric” focused on promoting an external vision of global economic competitiveness rather than addressing internal social issues (Wiig, 2016), its corporate takeover of local democracy (Vanolo, 2014), its neoliberal ideology (Grossi & Pianezzi, 2017), and its technologically facilitated control of individuals and publics (Krivỳ, 2016; Sadowski & Pasquale, 2015), among others (Brauneis & Goodman, 2017; Gabrys, 2014; Hatuka & Zur, 2020; Luque-Ayala & Marvin, 2015; Zambonelli et al., 2018).

These critiques, by now well established, are useful insofar as they challenge narratives of straightforward technological solutions to social problems, but they have their limits. One is the abstracting heights from which they view their smart city targets. Shelton, Zook, and Wiig (2015) identify

> a tendency within these critical accounts to see the smart city as a kind of universal, rational and depoliticised project that largely plays out according to the terms of profit-maximising, multinational technology companies. Ironically, this account has a good deal in common with the celebratory marketing literature produced by the likes of IBM, Cisco and Siemens, among others, which in effect reifies the vision of the smart city they wish to promote. (p. 14)

As an alternative, they propose studying the “actually existing smart city,” to reveal how technological “interventions are always the outcomes of, and awkwardly integrated into, existing social and spatial constellations of urban governance and the built environment” (Shelton et al., 2015, p. 14). This move comes straight from the science and technology studies (STS) playbook, which complicates simple narratives of technological progress with the study of messy particulars of sociotechnical practice. The “actually existing smart city” framing also points to a broader concern with literature that critiques the smart city, which is that it does not just overlook the particulars of actual practice, but its macro analytic positions smart city discourses and technologies as deterministic, arriving from a separate plane of investor agendas, state control, and engineering solutions to touch down on an urban populace that will be dispossessed, surveilled, or abstracted. Data privacy and surveillance, already a central concern in critiques of big tech generally, feature prominently in smart city critiques (Swanlund & Schuurman, 2019; Thatcher et al., 2016). Broadly speaking, this literature leans heavily on the structural theories of political economy, leading to what Leszczynski (2019a, p. 191) identifies as "techno-masculinist tendencies to advance universalizing apocalyptic critiques." Critiquing smart cities within the political-economic arena too easily sets up a confrontation between structural forces of domination and resistance that is both empirically suspect and politically discouraging. Even when authors avoid dystopian narratives by pointing out that urban computation is in reality flawed and incomplete, with "granularity and gaps" that allow political action through "the new shadows and opacities that they produce" (Crang & Graham, 2007, p. 814), they perpetuate a view of people and technologies as separate (G. Rose, 2017), where tech either enhances or interferes with a preexisting human will.

A wide-ranging literature addressing the city and digital technologies has also emerged outside the smart cities frame. Without being limited to the institutional settings of the corporation or government, this work is interested in mediating relationships between software and urban spaces. Some of it, mentioned briefly above, insists that space is increasingly produced with and through code (S. D. N. Graham, 2005; Kitchin & Dodge, 2011; N. Thrift & French, 2002), a line of theorization that comes out of geography's rejection of the idea of space as a neutral, pre-given container for human activity. It further extends the field's engagements in the 1990s with information technology's visions of a separate "cyberspace" or virtual worlds, which imagined the internet as a new kind of city (W. J. Mitchell, 1996) bringing about the "death of distance" (Cairncross, 1997) by reminding us that communication does not supersede geography (S. Graham, 1998; Kinsley, 2014). This work says that digitality is not *replacing* urban space, but it is mediating or transforming it. Rob Kitchin and Martin Dodge's influential work on "code/space" is representative of this thought (Dodge et al., 2009; Dodge & Kitchin, 2004; Kitchin & Dodge, 2005, 2011). They claim that code is now so essential to the production of many modern spaces—as in software for ticketing and security at the airport, or for scanning barcodes at the supermarket—that without it, the space no longer exists in the same way. Unlike the smart cities critiques, however, this literature lacks a strong critical voice, concerning itself instead with a descriptive inventory of emerging spatial digital entanglements.

While much of the work on digital geographies shares with the smart cities literature a tendency towards abstract claims, other literature does look more closely at the actual everyday practices of people. In the years following the introduction of the iPhone in 2007, a number of researchers began looking at how smartphones' capabilities for connectivity and for providing location-based services generated new spatial practices. In work spanning disciplines of communication and geography, scholars have studied mobile phones' uses in individuals' management of personal privacy, sociability in public space, and locational awareness, among other themes (De Souza e Silva & Frith, 2010; Hatuka & Toch, 2016; Humphreys & Liao, 2011; Liao & Humphreys, 2015; Sutko & de Souza e Silva, 2011; Wilson, 2012; M. A. Zook & Graham, 2007). Whether producing new kinds of space or new kinds of spatial behavior, the digital in this literature is the intervention whose impact must be understood.

I have already noted my alignment with Rose's (2017) critique of a perspective, pervasive in the digital geographies literature, that she argues is helpful in theorizing the agency of technologies but deficient in its treatment of the agency of humans. Perhaps digitality does shape space, but what do *people* do? Or, more accurately, what do *people* *with technologies* do? Earlier, Stephen Graham made a related point in taking issue with accounts of technology that are

> based on a general, and uncritical, use of the metaphor that cities would simply be "impacted" by new communications technologies in the same way as planets are impacted by asteroids. ... ICT technologies were portrayed as arriving from "out there," as a transformative "force" or "shock" hitting the fabric of urban society. (S. Graham, 2004b, p. 10)

One response can be found in a subset of the digital geographies literature, much of it inspired by feminist theory, has turned to the particular, situated messiness in which digital technologies actually work, revealing more nuanced and potentially more hopeful frames for digitally mediated urbanism (Barns, 2020; Elwood & Leszczynski, 2018; Leszczynski, 2019a). Especially relevant for my case is some of the recent work in "platform urbanism," an emerging subfield studying the role of digital platforms in cities, that has been more deliberate in positioning people not as the targets of structural forces but as actors with agency, even if enacted with digital devices. While much of the platform urbanism literature trades in the same macro-theories of exploitation and dispossession as the smart cities critiques, others insist that "platform urbanism is not only a problem of political economy, nor even of digital strategy, but also of everyday socio-spatial practice," and so must "[begin] with the everyday interactions of smartphone-equipped urban subjects" (Barns, 2018, n.p.). With this kind of framing, we can study a person's affective experiences of using apps for ordering food (Bissell, 2020) or for showing current location (Leszczynski, 2019b), rather than focusing only on apps' capitalist capture or geographic abstractions. It also reveals that digital technologies are not the totalizing forces their critics make them out to be, but are "glitchy" (Leszczynski, 2019a) and "hackable" (M. Zook & Graham, 2018).

This brief literature survey has sketched out two dimensions for plotting scholarship on digitality and urbanism. The first spans abstract and particular. Smart cities critiques, for example, tend to work in broad narratives of structural forces, while studies of smartphone use focus on actual situated experiences. The second dimension, often but not always in parallel, runs from normative to descriptive. The anti-capitalist or anti-state critiques of the smart city literature tend to disappear in studies that zoom in on descriptions of what people and technologies actually do in the city. A key contribution of my research is to offer a way to see the situated agency of people and technologies without losing sight of their structural politics. I do this with the idea of the promise and the mess, the theoretical bifocal that I introduce in the following section. By seeing how urban digital technologies *promise*, we can see how they work both with abstract visions and values and with actual personal experiences. I study the mess to show how technologies in themselves do not impact the city, and I will study the promise to show the danger of imagining that they will.

The promise and the mess

The vignettes that opened this chapter are typical of descriptivist accounts of the digitally mediated city, showing how any given technology exists in a particular environment of other objects and people. By drawing attention to ways that digital technologies *promise* in these scenes—the apps make promises to me about my commute, and the planners see promises for the transportation system in bikeshare data—I am opening a door to a more critical evaluation. Promises are relations between a person's desire and an object expected to satisfy it; they offer a vision of something you want and lay out the means for you to attain it. Promises are inherently relational, not only in the connection between a subject and the promised object, but among the subjects who collectively generate, circulate, and maintain promises that gain power in their shared status. All of this is political. When envisioning the use of a new data specification to be used, planners are articulating their values regarding how people ought to behave in the city through discussions of enumerated lists and interface protocols. When I seek current travel information from an app, I am not simply expressing a preference for avoiding waiting at bus stops; I am using a device to sort through how I see myself engaging with the city. At the same time, scenes like these remind us that whatever vision technology promotes is complicated by the mess of people and things that will inevitably interfere with its realization. Studying the promise then is not just about examining discourse or visions on their own, but about seeing the actual practices where promise plays out. In chapter 2, I lay out my case for seeing digitality in the city through a theoretical bifocal that uses the lenses of the promise and the mess together. The promise shows us the personal and political values that animate visions of technological development, while the mess both reminds us that the promise is never totalizing or complete and gives us the material basis in which to observe it. This section introduces these lenses, and in the following section I describe how they work to connect the personal and the digital.

The promise is an anticipation, which makes an imagined future present here and now, and is affective, working through a subject's embodied and visceral relations, not just rational perception. I develop these ideas with Lauren Berlant's (2011) idea of "cruel optimism" and Sara Ahmed's (2010) work on the "promise of happiness," each of which identifies something counterproductive in presents that are always oriented towards idealized futures. The promise in this work is not a transformation of the world, but an affirmation of what we believe the world ought to be, and thus distracts from actually existing oppressions while leaving unchallenged the prevailing beliefs about what "good-life sweetness," in Berlant's phrase, should look like. Ahmed in particular is attentive to the relations that produce and sustain promises, which gain a dominating inertia in becoming associated with group membership. This and related work do not focus so much on what the promise *is*—the content of its visions—as on what the promise *does* for the people who circulate it. Often, we find the promise permits a disengagement from the present by capturing some existing desire and attaching it to an object anticipated to arrive in the future.

The promise is both a story of a better future and an invitation to bring it into being, if only we make the right choices today. This kind of enticement is the language of salesmanship, and so it is unsurprising that we find the promise so often in the visions of new technologies that accompany their marketing. Technologies have long been understood as promises about what society could be as much as actual functioning artifacts; the subfield of technology studies concerned with discourse in particular has taken up this thread (Jasanoff, 2016), but the observation is familiar from popular technological criticism as well. I draw on work that does not dismiss these promises as either naive optimism or corporate propaganda, but takes seriously their society-building functions as myths (Dourish & Bell, 2011; Jasanoff, 2015; Mosco, 2004). The stories we collectively tell about technologies, in this literature, are important to understand in themselves because they animate those technological development projects, and, more broadly, because they give shared meaning to a society. My research on new mobility is interested in this meaning-making work of promises, and is concerned that new mobility's promises reflect and perpetuate values that are problematic in the ways they disconnect us from ourselves, each other, and the city.

Many STS studies have tried to ground such myths in the messiness of practice, looking at utopias or dystopias and saying "OK, but is that how it *really* is?" Poking holes in techno-optimist bubbles is an old sport, and in that tradition one product of my research too is an illustration of how the vision of new mobility is not and cannot be delivered as promised. Messiness is used to counter dystopian thinking too, reassuring us, for example, that digital surveillance has blind spots, capitalist control is partial, and people continue to exercise agency that exceeds the determinism of technologies or capitalism. In doing so, however, messy descriptivism loses the political charge of the normative stance that is implied by labeling a view optimistic or pessimistic. Given a vision in which exact routes of bike trips are reported to transportation officials in real time, the difference between labeling it a utopia or dystopia—as different actors in fact have—is not a matter of description, but of the political values of the labeler.

It is not enough to simply point out that utopias and dystopias are not real, since technologies sometimes really are transformative, and sometimes really do deliver more or less as promised. New products are designed and built, new practices emerge, old problems fade away. The messiness of everyday life might begin to resemble the myth, even if it can never be quite as simple as its story. Once some imperfect version of these promises are realized, however, they often become invisible. It is only after technologies "cease to be sublime icons of mythology and enter the prosaic world of banality—when they lose their role as sources of utopian visions—that they become important forces for social and economic change" (Mosco, 2004, p. 6). The mess is both the constant obstacle to the realization of technological transcendence and the very site where transformation can occur. Even if many STS accounts of this "prosaic world of banality" lack a normative stance, this need not be inherent to the form. New mobility presents a useful research subject in this respect, since it encompasses both transcendent visions of soon-to-come city-wide digitally coordinated mobility and the by now ordinary practices of checking your phone for bus times.

The role of studying the mess, then, is not simply to sully the promise. The mess is where we can see what the promise does not. In my study, the mess shows us the agency and materiality that digital promises overlook. I see political value in recognizing agency, especially, in relation to digital tools, and so I am wary of promises that sideline the ability of social actors to evaluate and act on their own desires. The mess is also where the promise circulates and can be observed. Even though "the practice of any technology in the world is never quite a simple, straightforward, or idealized as it is imagined to be" (Dourish & Bell, 2011, p. 4), the fact that technologies do not deliver as imagined is by no means fatal to their promise. Indeed, the myth depends on the mess. For one thing, we will see how the mess comprises the sites in which actors articulate promises and keep them alive after the experience of reality challenges the story (Ames, 2019; Sims, 2017).

Just as important, however, is that the mess of ordinary daily life is the mundanity against which technological imaginaries gain the power of the sublime (Mosco, 2004; Nye, 1994). I want to reserve space in this project to examine the promise without reinforcing its glossing over of context and difference or resorting to the abstractions and universals of so much digital criticism. This means looking at the promise not as a transcendent ideal, but as an artifact that appears in a particular place and affects a person in a certain way. If myths are where we collectively sort out the "contradictions in social life that can never be fully resolved" (Mosco, 2004, p. 28), then to dismiss them as false in order to study ordinary life only as it presents itself in practice is to miss something essential about the meaning and politics of that life. Although this study will see frequent occasions when digitality's promise is offered as a way to avoid politics, in chapter 2 I will argue, with Mosco (2004), that foregrounding the promise can be a way to engage with the conflicts and values that can be more difficult to see in the myopia of messy description. It is in the promise of new mobility, not the mess, that I find a troubling view centering the abstract individual, a figure too easily imagined as another digital object (Irani, 2015), and discarding the collective, relational, ambiguous subjects we know from the city.

The personal and the digital

The distinction between the promise and the mess is in part a question of scale, with the promise appearing grand in scope and the mess found in the small and particular. I take up the methodological implications of the question of where to observe these phenomena in chapter 4, but for now, I want to situate the *personal* and the *digital* as the two critical sites for understanding the promise and the mess of new mobility. More than scale, it is a distinction between, on the one hand, desires and visions that seem to lack any materiality, and on the other, the concrete objects and practices that are available for observation that separates the promise and the mess. Each of these can be found in the personal and the digital, which thus guide the selection of subjects in my study.

I suggested above that the lens of the promise is a way to personalize technology, showing us how technological artifacts necessarily interact with desires—whether for some form of social order or for the achievement of some mundane task—that are located within a specific person. Affect theory has argued that our encounters—with objects, people, environments—*affect* us in ways that are not strictly rational or even present in cognitive awareness. It is experienced in individual bodies, but is also a relation among them (Anderson, 2014; Spinney, 2015; N. J. Thrift, 2008). If we see promises as affective, then it is within the affected human subject that we can locate the desire that animates the promise and the dissonance or dysphoria that might be experienced when it fails to materialize. These need not be major or even notable events. Everyday experience gives ample opportunity for seeing individuals' practice of oscillating between imagining what they want and experiencing the actual world. In chapter 3, I will introduce theories of personal autonomy that help us to understand how the subject is defined by both desires and the situated capacity to act on them (C. Mackenzie & Stoljar, 1999b; Nedelsky, 1989; Oshana, 2006), a parallel to the idealistic promise and the messy reality. Adding technologies to this view of subjectivity, as I will do with theories of posthumanism (Braidotti, 2013; D. J. Haraway, 1991; K. Hayles, 1999), shows how tools are always entwined with the personal capacity for both envisioning the world and acting within it.

Empirically, I foreground the personal as a way to understand digitality's work in the city in my study of travelers' use of smartphone apps for travel (chapter 7). By illustrating how an individual traveler engages with these technologies in everyday life, I highlight the many ways in which promise and mess alternate at a personal level, with apps, environments, infrastructures, and other people all engaging with the subject's desires and actions. This is where I see the appeal of apps' promises of certainty and solvability, and where I identify a pattern in which digitality intensifies desires that it is unable to fulfill, leaving travelers both disappointed in technologies and poorly equipped to manage without them. I argue these travelers' experiences are important in themselves, but I am also using this personal angle to understand the experience of the promise and the mess more broadly. When a city department of transportation, too, encounters technologies that promise certainty and solvability, and then deploy them with messy results, I see the pattern as analogous to the personal experience of the travelers. DOTs, of course, are also made up of people with thoughts, emotions, and senses, but the simplicity of a single person, a smartphone, and a 30-minute trip offers the clarity that is typically lost in studies of institutional programs that interact with dozens of other systems and stakeholders over a long-term implementation. Some studies do approach organizations through a personal lens, but more often research becomes more and more estranged from interior personal experience as their subjects become larger. This is the case, for example, with much of the smart cities literature, which fails to see how the visions and values of urban technologies are produced and circulated among particular affected individuals.

At the same time, promises are more than transcendent ideals or immaterial desires, which make for slippery research subjects. Promises are artifacts that appear in a particular place and affect a person in a certain way. In my research, some of these artifacts are documents, the agency plans and corporate pitches where we would expect to find the promise. But what makes the promise of *digitality* especially potent is that the digital *in itself* operates as a kind of idealized vision (G. C. Bowker & Star, 1999; Franklin, 2015b; A. Mackenzie, 2006). The promise then can also be found in code. This is the task of my study of datafication of mobility through new data standards (chapter 6). Data is an abstraction of some real phenomenon, and so its measured *values* say something about what aspects of that phenomenon are or are not *of value* to someone. Moreover, the categories and structures of data say something about how someone envisions the circumstances and purposes of their use. Software more broadly also makes more or less explicit promises. If, as one definition has it, algorithms are "encoded procedures for transforming input data into a *desired* output" (Gillespie, 2014, p. 167, emphasis added), then they can tell us something of the desires of the person who wrote it. Digitality equally illustrates messiness, with, for example, its multiparty development processes, layers of interfacing systems, distributed infrastructures, and indeterminate use. But part of what I will show is how because of its quantification, its smoothing out of the world's rough edges, digitality's promise is especially appealing. Digitality offers a mathematical purity where entities are unambiguous and variables can be solved for. Even as digital data travels into increasingly messy encounters with categories, interfaces, and analog phenomena on the ground, this quantifiability remains as an ideal. Further, the apparent immateriality of the digital adds to this sense that it is inherently transcendent. This makes the digital a particularly potent promising agent. From a more grounded perspective, the digital is also a promise in that using it involves an ongoing experience of anticipating solutions: the software will return a desired output; the app will tell you the fastest route in current traffic; your ride will arrive in four minutes. Digital tools promise with a directness and frequency not seen in, say, a hammer. When studying how they actually exist in everyday practice, then, the researcher is always thrown back on their idealized intentions.

I want to show the danger of these digital ideals. Before introducing this danger, let me make a final observation. A unifying theme of the theories I use to understand the personal and the digital is its rejection of the liberal subject. This figure is rational, disembodied, and without context, a sovereign subject who interacts with others but is in ontologically independent of them. He (it is usually by default a man) is the subject of Kant's ethics, the basis for centuries of liberal economic and political theories, and even appears as the "user" in contemporary human-computer interaction studies. Like much of the theory I use in this dissertation, the posthumanism and personal autonomy introduced above share a rejection of the liberal subject, which they challenge on two fronts: its rationality, and its independence. They remind us that people are not calculating machines, but rather desire, decide, and act based on senses and feelings that defy logical representation. Further, these subjects do not simply *engage* with artifacts, environments, and other people; they are co-constituted with them. These affective and relational views, with long lineages in the humanities and social thought, are what is so often missing in digital visions.

Certainty, solvability, and their dangers

My research examines the promises of digitality in order to foreground the work of desire when asking what technologies do in the city, and studies its mess to show how this work is not abstract or uniform, but situated in networks of people and things. In highlighting personal values and relations among people, both the promise and the mess offer ways to wrestle with political concerns. In the conclusion, I will suggest how the promise might be productively used to more actively engage with politics, and also how we might learn to live well with the mess by embracing the materiality and agency that digitality obscures. The main focus of this work, however, is on the danger of digitality's promises. In particular, I argue these promises lead us to look for a better city only in digital tools—and in the rationalized, bounded, individualized view of the city they promote—but fail to teach us how to live well with the mess. Indeed, and most alarmingly, they often teach us that we do not *need* to live with the mess. I built this argument around the two primary promises that my study finds in digitality: certainty and solvability.

In chapter 2, I will explore how the impulses to know more and to fix problems are central in planning theory and practice, not to mention the human experience in general. Here I am especially interested in certainty and solvability as potentialities—the conditions in which something *could be known* or *could be solved* at some point in the future, rather than the presence of facts and fixes here and now. This potentiality aligns with the anticipatory nature of the promise, and it helps explain how certainty and solvability work through assurances that might not reconcile with actual present experience. My research shows how these promises are comforting. They help us to avoid the anxieties of the unruly city by offering clarity: here is what is happening, and here is what is to be done. We will see again and again in this study how digitality is especially well suited to these promises, how its cold calculation offers warm comfort.

As I suggested above, data and algorithms have visions built into them. The observation that translating the messy world with its ambiguous values into seemingly objective numbers is appealing is not a new one. In 1903, Georg Simmel saw the "reduction of qualitative values to quantitative terms" according to an ideal "of transforming the world into an arithmetical problem and of fixing every one of its parts in a mathematical formula" (Simmel, 2002, p. 13). Simmel was concerned about the erosion of humanity represented by this new "character of calculability," but a century later, the computer programmer Ellen Ullman remarked on the joy of the transformation:

> We give ourselves over to the sheer fun of the technical, to the nearly sexual pleasure of the clicking thought-stream. Some part of me mourns, but I know there is no other way: human needs must cross the line into code. They must pass through this semipermeable membrane where urgency, fear, and hope are filtered out, and only reason travels across. There is no other way. Real, death-inducing viruses do not travel here. Actual human confusions cannot live here. Everything we want accomplished, everything the system is to provide, must be denatured in its crossing to the machine, or else the system will die. (Ullman, 1997, p. 15)

Filtering out everything but reason is what allows us to imagine that certainty and solvability are achievable. It is this simplification, this way of either transcending or taming the mess, that attracts planners to visions of data-driven transportation systems and travelers to app-mediated mobility. Such simplifications are necessary for making sense of and acting in the world, and I do not want to argue that digital mobility technologies are not useful. But these promises have dangers, both in how they play out in practice and in the ideals they promote.

The first danger is that the promises will intensify our unhappiness when they fail to deliver. My study of travelers and apps (chapter 7) illustrates this well. As travelers get more information from their phones, they expect more in turn. In this cycle, a gap persists between what travelers want and what their tools are able to provide for them. The apps respond to this gap with further promises of more and more accurate information, but of course their knowledge can never be complete. Despite recognizing that they have access to more information and more transportation resources than they did just a few years ago, travelers report feeling recurring frustrations or anxieties when they cannot find certainty or when trip challenges persist. The problem here is not that promises are not fully realized, but rather that they do not teach us what to do when faced with a reality that fails to live up to its ideal. Digitality offers only itself as an answer, and so we do not learn how to look elsewhere. In particular, I find that many travelers lose trust in their own selves as resources for getting around. I find parallel situation among planners, who continue to seek more data-driven certainty as they become less tolerant of acting without it, but find that mobility challenges persist even with more data.

The second issue with digitality's promises of certainty and solvability is that, regardless of what promises are actually realized or how people interact with them, the world they imagine is not one we ought to long for. In short, they imagine the eradication of the messes of politics and materiality. Following a long history of technocratic governance, the promises of new mobility often implicitly propose the digital as a simpler alternative to political conflict and the difficult reconciliation of incompatible views. My research shows how planners' visions for mobility technologies reveal an eagerness to bypass transportation interventions that require confronting tradeoffs and disagreement (chapter 5), and my study of the regulation of bikeshare systems (chapter 6) shows how cities imagine using digital tools to bound potentially conflictual behaviors on the street. In chapter 2, I will examine a tension between certainty and agency, since actors engaging with each other according to their own wishes is fundamentally indeterminate. What is troubling is that the erasure of agency is not an incidental byproduct of promises of certainty, it is central to its appeal. Similarly, the promise of digitality's solvability works in part by envisioning a transcendence of material constraints. New mobility is filled with promises that *spatial* problems of physical movement through varied and dynamic urban environments can be solved through tools for the transmission and manipulation of *information*. The focus is on new real-time bus arrival information rather than new bus service, or on systems for reporting bike locations rather than building bike lanes and racks. The subjects of my study know well that transportation is messier than this, but repeatedly invoking as desirable a vision in which agency and materiality are obstacles rather than resources is dangerous. We need ways to wrestle with the messiness of people and things in the city, since this is where possibilities for real change are located, and digitality does not offer them.

Naming each of these dangers—the intolerance for the promises' shortcomings in practice and the misleading ideals of apoliticism and immateriality—echoes of the critique of the liberal subject, who is viewed as too abstract, rationalist, and individualistic. My frequent turn to the mess in this project is an effort to replace this figure with the affective, relational, and particularized subject we find in a wide range of theory and in my empirical observations. We know that the liberal subject implied in digital schema is wrong in the sense of being inaccurate in comparison to the real world, but myths and models need not be true to be useful. The more important claim is that the vision of the rationalist transcendence of the mess is wrong in the sense that it leads us towards an unsatisfying life. The political purpose of the mess is to be open, and to develop the personal capacities for engaging with this collective indeterminacy. But to avoid openness becoming randomness, we need visions that drive us forward and give us a reference to measure where we are. The point then is not to abandon promises, nor to defend willful ignorance or the making of more problems. The argument is not that digitality is bad, or that wanting to be more certain or solve a problem is bad, or even that digitality is always incapable of delivering on these promises. Rather, the argument is that digitality's promise of certainty and solvability is *dangerous*. It has the potential to be harmful, and so it requires careful handling. The harm is that it will teach an intolerance for the agency and materiality that offer alternative visions for making a better city. And the care required to handle it must come from somewhere other than digital technologies.

The plan of the work

My empirical basis for studying the promise and the mess of digitality in the city is new mobility. For my purposes, new mobility refers to apps and associated systems for accessing services like ridehailing and bikeshare and for providing travelers with real-time information, as well as transportation planners' engagements with these tools, both in practice and in visions for future mobility. The main components of my research project are a phenomenological study of Seattle seniors' and young professionals' app-based mobility practices (chapter 7), analyses of data specifications and their relation to local mobility policies (chapter 6), and a study of the urban transportation field's hopes and fears for new mobility as articulated in professional communication (chapter 5). Primary data collection methods include interviews, focus groups, conference attendance, document analyses, and an online study of software development.

These new mobility technologies are a case of the digitization of the city. It offers a few advantages for researching this broader phenomenon in which digital technologies do more and more in the city. First, mobility is a mundane everyday activity. It is regular, both in the sense of its ordinariness and its recurrence. This regularity offers frequent openings for observing digital interactions among a wide range of subjects. At the same time, mobility has structures—physical infrastructures, regulations, transportation service networks—whose development and operation are the subjects of occasional but deliberate consideration by public officials, private providers, and travelers themselves. These offer openings for observing how digitality and mobility are imagined to interact in the service of some ideal of the public. An advantage of studying new mobility specifically is its newness. Many of the apps and services have emerged in the past decade or so, and the focused conversation about them within the transportation field is even more recent. The period of my fieldwork, mostly from summer 2018 through the eve of the Covid-19 lockdowns in March, 2020, saw a burst of activity among transportation professionals imagining and developing the tools of new mobility, which offered invaluable research material. Yet at the same time, I was not limited to studying speculation and visions, since enough tools had been in place long enough to have generated routine practices. More generally, new mobility's situation within the enormous and long-established field of urban transportation provides useful points of comparison when asking what the digital does differently.

The research questions driving the study come primarily from my theoretical framework, rather than from concerns specific to the empirical case. I build the work around three questions:

RQ1. What is the relationship between the promise of digitality and the messiness of urban mobility?

RQ2. How do digital mobility technologies envision ordering relations within a heterogeneous urban public?

RQ3. How are travelers' desires and agency coproduced with mobility apps?

The first and broadest question is clearly a product of the overall theoretical framing of the work. In asking about the relationship between digitality and mobility, it is interested in the frictions that tidy digitality encounters within the mess of actual practice, but also in the origins and power of the promise itself. This is where I identify the promise certainty and solvability and examine its tensions with agency and materiality. This question guides the entire project, but especially the study of visions for new mobility among transportation professionals. RQ2 takes up the issue of politics by asking how digital structures are hoped to order the messiness of people's competing values and unpredictable behaviors. I investigate this through the development of mobility data specifications and associated regulations, where certain planners' visions for what urban mobility ought to look like are translated into code. The third question brings the personal into sharper focus by bringing together desire and agency, the two elements of personal autonomy. Rather than asking whether apps enable or impede the exercise of autonomy, the question here is how digitality is integrated within it. Answering this question with a study of travelers' app usage foregrounds the personal dimensions of the promise that are applicable throughout the project.

The dissertation continues by laying out the theoretical groundwork in more detail, then details the case of new mobility and my research approach before then presenting the findings of my research. The chapters are organized as follows.

The theoretical foundations of the project are split over two chapters. Chapter 2 begins by making my case for a theoretical bifocal that can see the promise and the mess together. The bifocal allows us to see both broad structures and particular actions, and to see the world as it actually exists without losing sight of what we want it to be. This is the view that I argue is missing from much of the scholarship on digital urbanism. The main focus of the chapter is to examine the promise. I show how the promise is affective and relational, and how it works by connecting a pre-existing desire to an object expected to satisfy it. A key point of this concept is that the promise serves an essential social role, giving us ways to make sense of the world and sort through its contradictions. Although the promise can be escapist, it need not be; it is also where we can identify and confront the things that give meaning to life. Along those lines, the chapter examines digitality's promises of certainty and solvability to understand, first, how digital technologies are especially well suited for them, and second, how they work by envisioning a problematic transcendence of agency and materiality.

That messiness, and various means of viewing and managing it, are the subject of chapter 3. The chapter offers the second lens of the theoretical bifocal through a collection of theories that begin to take us more closely to the empirical material of the case. It starts with a view of the mess as a system to be ordered, focusing on infrastructures and platforms as two technical means of doing so. This work is grounded in science and technology studies, whose core tenets receive a brief introduction here. Both infrastructures and platforms deal with mechanisms for connecting heterogeneous elements, and I focus on the political dimensions of these forms of inclusion. Infrastructure offers an ends-focused vision of universal service provision, and platforms envision open-ended participation that is constrained enough to maintain central visibility. Both of these, and their uneasy fusion, will figure in the promise of new mobility. While that STS-inspired work foregrounds materiality, the second half of the chapter examines messiness from the personal perspective of subjectivity. The two theories here, posthumanism and personal autonomy, claim that the subject must be seen as co-constituted with technologies and with social relations. They foreground desires and agency in ways that are helpful for understanding where technological promises come from and how they become messy. As a whole, the chapter identifies the technological and personal sources of messiness and introduces some of the systems that work to contain it.

Chapter 4 then turns to the research, laying out my approach in some detail. It justifies my methodological framing, derived from phenomenology, actor-network theory, and case study research, as well suited to the three research questions. I then provide some context for the contemporary new mobility scene, both generally in North America and grounded more specifically in Seattle. I bound my study within new mobility by identifying research subjects—technologies and services, professionals and organizations, and everyday travelers—that both speak to the themes of my questions and are practical research subjects. The chapter also includes detailed descriptions of my methods of data collection and analysis.

Chapters 5 – 7 are the three empirical chapters, which correspond to the three components of my study and, more roughly, to the three research questions. Chapter 5 serves as both an introduction to the field of new mobility as the research subject and as a critical examination of its promises. Using industry materials from conferences and publications envisioning how data and smartphones can bring about accessible, equitable, and safe urban transportation, it shows how the promise of new mobility attaches longstanding visions of urban transportation to emerging digital objects. I examine the mechanisms by which digital information is envisioned to fix political and infrastructural problems, linking tools for data visibility and manipulation to desires for certainty and solvability. This study focuses on an anticipated future rather than current practices, and it emphasizes how these promises give cover for avoiding confrontation with actually existing transportation interventions—such as the reconfiguration of rights-of-way, new transit services, land use reforms, and behavior changes—that demand more difficult political and infrastructural work.

Chapter 6 stays with the perspectives of transportation planners but turns to their existing efforts to use datafication to deliver certainty and solvability. I do this by studying the development and use of data specifications, which connect the mess of mobility to the idealized structures through which it is represented. Part of the story here is about the inevitable complications of translating a vision—in this case, "develop a data structure for monitoring and controlling shared mobility services"—into the specific lists and categories that data requires. My study of this development illustrates the values and conflicts that appear when software contributors must decide what aspects of mobility should be visible to whom. At the same time, this chapter emphasizes that within these seemingly endless efforts among planners to see and contain so much of the mobility on the street through datafication is a gradual erosion of other ways of understanding and acting in the city, specifically those that foreground people and their relations. I illustrate this absence with examples of Seattle using data to regulate dockless bikeshare systems, which are imagined as open-ended platforms, to serve identified public interests as an infrastructure does. In these cases, the availability of digitality begins to reshape the kinds of urban mobility that planners envision delivering.

Chapter 7 presents my study of travelers' experience of their mobility with smartphone apps. Based on interviews and focus groups with 40 participants, I report on how these travelers use apps, but more importantly how their desires for a certain kind of trip and their situated experiences are integrated with these technologies. I find apps involved in an intolerance for surprise and a loss of traveler's confidence in their own abilities. Participants report a comfort when apps give them accurate information, and an unease when they do not. They also showed, in various ways, how apps allow them to imagine solving the problem of getting from A to B without engaging with the unpredictable obstacles on the street. Some are more reliant on these digital tools than others, but all of them inevitably found themselves in situations where the screen was insufficient, and they needed to rely on something else—their bodies, a vehicle, environmental awareness, other people—to solve a mobility challenge. These resources are often downplayed in apps that offer themselves as solutions, but every traveler knows that ultimately surprises are inevitable, and the apps can't move for them. In travelers' oscillation between the promise of the digital and the mess of mobility, I find lessons for interacting with digitality's promise more generally. Namely, expecting the app to provide complete information in real time and to solve the challenges of negotiating movement through an unpredictable environment is dangerous when we do not also develop a capacity for dealing with its shortcomings. And the more technologies promise we don't have to develop such capacities, the less we do.

Finally, chapter 8 concludes the work. It first summarizes the research and its key themes, drawing connections between components of the study, before reflecting on the limits of the perspective that digitality offers us. After mounting a sustained critique of digitality throughout the dissertation, the final chapter then opens a door to a more hopeful vision. Continuing with the promise-mess bifocal, I argue that planners and urban inhabitants alike need ways to repoliticize the promise and to live well with the mess. Repoliticizing the promise involves avoiding the temptation to use imaginaries as a way to escape reality, but to instead do the more generative work of deliberately engaging with its complexities and contradictions. Living well with the mess requires dealing with the uncertainty-generating agency of other people and reckoning with the materiality that precludes so many easy digital solutions. This takes practice. I offer a brief survey of theories that invite us to attend to the present, to find joy in learning and acting within unfamiliar situations, and to draw on trust and relations as an antidote to the individualized search for certainty. I use this framing to challenge planning to more carefully engage the promise and the mess of digitality alongside the political and spatial work it has long been doing. Seeing digitality differently in this way can be more difficult, but is, I argue, ultimately more productive.

CHAPTER 2

The Promise

These two chapters lay the theoretical groundwork for my study of the promise and the mess of new mobility. Before examining the promise, in this chapter, and the mess, in the next, I begin in the following section by making a case for a theoretical bifocal, seeing the promise and the mess together. The promise is a vision based in desire, and the mess is concrete experiences of the present. Focusing on the promise—a tendency found in both utopian visions of technological solutions and dystopian structural critiques of technological domination—is a way to deal with collective values and desires, but this view smooths out the particularities of embodied experience and personal difference that are at once the promise's origin and its imperfect realization. Studying the mess—as found in ethnographic or ANT-inspired accounts of actual practice—foregrounds the agency and materiality so often missing in the promise, but risks losing the political valence of the promise's normative charge. Studying both of these together, particularly by using one to illuminate the other, is a central aim of this project.

In the section on the promise, I develop my conception of the promise with thought from affect theory (Ahmed, 2010; Berlant, 2011) and technology studies (Dourish & Bell, 2011; Mosco, 2004). I set up the promise as a more-than-rational anticipation that attaches a pre-existing desire to an object expected to deliver it. Because the promise is an orientation to the future, it survives experiences of the present that conflict with it. In this way, the promise is conservative, and is better at preserving visions and desires than transforming them. A key function of the promise is to transcend the messiness and ordinariness of everyday life, but I also emphasize that the promise's distance from reality can be a way to wrestle with politics, rather than escape them.

Too often, however, digitality's promises do not make such engagements. My work claims that much of what digital technologies do in the city is *promise*, and especially that they promise certainty and solvability. The third section of the chapter clarifies the ideas of certainty and solvability using studies of governance and techno-solutionism. I focus especially on the subjective dimensions of certainty and solvability—the ways these are experienced *by someone* as the soothing of anxieties of ignorance or brokenness. Moreover, to imagine knowing or fixing it all requires some detachment from the situated messiness of reality, versions of Haraway's (1988, p. 581) "god trick of seeing everything from nowhere." Dourish and Bell's (2011) book *Divining a Digital Future* makes a similar point by punning on "divining" to mean both seeing the future and transcending the mundane. Again, such transcendent visions are where we can find meaning and value, and so measuring their correspondence with reality is often besides the point. Much of my research will show how certainty and solvability are never fully achieved, but more than this, my argument is that promising them distracts us from engaging with the more challenging work of reconciling our desires with the resistant agency and complex relations found among people and things. That mess is the subject of the next chapter.

A theoretical bifocal

What do I mean by the promise and the mess? And how can we see through them together? The promise exists in imaginations and narratives, and offers an ideal located in the future. It is straightforward, with the simplicity of a good story. The mess are the actual actors and actions observable in present reality. It is complex and irreducible. While understanding the mess is a matter of description or explanation, the promise is where we find desires and values, and so it invites at least implicitly an evaluative political stance. I set these up as two poles, but my aim here is to show how they depend on one other. When the promise sets an expectation that a particular action will bring about some desirable outcome, it motivates the activity that constitutes the mess. Conversely, it is our embodied, collective, messy experiences of those everyday particularities that generates the desire for their continuation or transformation that becomes the basis for the promise. Understanding how technology works in the city requires a theoretical bifocal that is capable of seeing desired futures and situated experience together. This is the work of the dissertation. The promise and the mess follow the lines of related dichotomies: abstract and concrete, general and specific, ideal and real, future and present, normative and descriptive, theory and practice. Framed in these ways, we can see that any good research should move between such poles. Such a bifocal can be especially revealing for technologies, and digital technologies in particular, since these concrete artifacts are the subjects of so much imaginative thinking, and even carry within them visions for the social order they hope to achieve. Viewing promise and mess at once can allow us to see how these visions are projections of actual grounded experience while avoiding the myopia of descriptivist accounts that cannot focus on the broader values and aspirations that give those experiences meaning. Through this bifocal, we can see both what the world is and what we believe it ought to be.

The use of such a theoretical bifocal is not just an academic tool, it is present in our everyday lives, where we alternate between desiring and imagining on the one hand and sensing and acting on the other. In my research, transportation planners are both envisioning future mobility and dealing with actually existing bikes and buses. Tech companies, too, move between these registers, with VC pitches and the idealism of early product design working alongside code debugging and in-situ user studies. Travelers planning a journey will imagine their future trip, expecting that it will not always go according to plan, and then they walk to the bus stop, or reserve the bike, or take the next exit. Certain actors or occasions might find more time with one than the other, but in ordinary human life stories and practice are always close to one another. My study shows how encounters with digitality, with its uniquely immanent idealism, foreground the ways that people do not operate either in the imagined world of the promise or in the actual mess of the city, but are constantly moving back and forth between ideal and the real.

Urban planning is particularly well suited for studying technologies through both lenses. As a professional practice, planning sits between the imagined future of comprehensive plans or development proposals and the actual city of town halls and current land use analyses. In practice and in scholarship, planning works through this tension between the future and the present, and between the ideal and the real. The framing of the city as plural and unknowable has a long history, and this irreducible mess is often positioned as dooming modernist impulses of panoptic ordering and control (de Certeau, 1984; Jacobs, 1961; Lofland, 1973; Sandercock, 1998b). Moreover, those impulses are argued to be wrongheaded in themselves, regardless of their feasibility. James Holston (1998) joins critics like these in observing that “the project of modernist planning is to transform an unwanted present by means of an imagined future” (p. 40), and that such airy utopias invariably founder once they accumulate concrete context in the non-ideal world.

The "utopian paradox" he describes is that is that a vision of the future either "remains without substance and thus disconnected from the conditions that generate a desire for it; or, in gaining history, it exacerbates the very issues it intends to negate" (p. 46). But he goes on to argue that abandoning futurism is counterproductive, since imagination is a site of desire and criticism that are the foundation for change. He says that

> without a utopian factor, plans remain locked in the prison house of unacceptable existing conditions. Is not the elimination of the desire for a different future as oppressive as the modernist perversion of it? To exclude the imaginary and its inherently critical perspective in that way is to condemn planning to accommodations of the status quo, and I reject such paralysis. Hence, a difficult question remains: if the notion of alternative futures is both indispensable and yet, in its utopian form, perverse, what kind of intervention in the city could construct a sense of emergence without imposing a teleology that disembodies the present in favor of a utopian difference? (Holston, 1998, p. 46)

His proposed alternative to modernist futures is ethnographic rather than utopian. This ethnography, however, is emphatically not limited to description; it is an ethnography of desire, of the emergent drives that push citizens at local scales towards a different way of being. It sees insurgent practices that exist within the systems of order but simultaneously disrupt its order, and in doing so they transform not just what that system is, but what it wants to be (Holston, 1998). As planning theorist Charles Hoch (1996, p. 13) says, "the plan does not shape action, but intention." Following this line of thought, the point is not to abandon imaginative ideals or to cast all promises as false. The task instead is, first, to recognize how the ideal and the real co-produce one another other, and second, to evaluate *both* the utopian desires and the ethnographic experience to ask if they are serving our purposes.

Some parallel work of seeing promises and mess together can be found within technology studies. STS for the most part has directed our attention to the messiness of actual technological practice. Much of the foundational STS work (Bijker et al., 1989;

Hughes, 1987) has set out to challenge ideas of technological determinism, which STS scholars fault for seeing technologies as decontextualized forces that will either solve or cause sweeping problems. STS has used situated and descriptive studies of technology production and use to take these utopias and dystopias to show that that "the practice of any technology in the world is never quite as simple, straightforward, or idealized as it is imagined to be" (Dourish & Bell, 2011, p. 4). Describing this messiness can be a way to reveal the "trouble" when technologies "become too removed from the complications of daily life and the arc of history" (Ames, 2019, p. 25), as implausible techno-fantasies divert attention and resources from more grounded responses to social problems (Norton, 2021).

Too often, however, the work of describing the mess loses sight of the desires driving these actions, and with it the urgency of a normative stance. The visions of optimism or pessimism that such descriptions complicate might be oversimplified, but they are nonetheless recognizable statements of someone's values, and so bringing the promise back into view gives us openings for developing a normative stance on what the world ought to be in addition to a grounded account of what it is. While other fields have critically analyzed technologies through broad structural lenses, STS's narrower accounts are often faulted for their apoliticism. For example, Rosi Braidotti, a theorist of posthumanism, notes a "rather bizarre and highly problematic division of labour ... between science and technology studies on the one hand, and political analyses of advanced capitalism on the other," and seeks a theory "that includes both scientific and technological complexity and its implications for political subjectivity, political economy and forms of governance" (Braidotti, 2013, pp. 42–43).

More firmly within STS, Sheila Jasanoff (2015, 2016), among others, has faulted STS for offering detailed accounts of institutionally complex and historically contingent production and use of technologies but failing to engage the ways that power and desire that animate these. The corrective she and Sang-Hyun Kim offer, meant to connect the descriptive work of STS with the more activist charge of work in political and cultural theory, is "sociotechnical imaginaries," which they define as "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff, 2015, p. 5). Sociotechnical imaginaries, they say,

> occupy the theoretically undeveloped space between the idealistic collective imaginations identified by social and political theorists and the hybrid but politically neutered networks or assemblages with which STS scholars often describe reality. Our definition pulls together the normativity of the imagination with the materiality of networks. (Jasanoff, 2015, p. 19)

This "normativity of the imagination," like Holston's "desire for a different future," is helpful for opening a critical examination of the values, whether individual or collective, that attend technological practices. Note that in Jasanoff's definition, sociotechnical imaginaries are not solely *imaginary*, but are "publicly performed," gaining a situated presence that can be observed. These imaginaries are not narratives or discourses in a purely mental realm, but they have action and materiality. One ethnography of a technological intervention identifies such "lived fictions" where the designers and administrators "coordinate their thoughts, emotions, and activity in part through collectively realized fictions, dreams, myths, and even fantasies" (Sims, 2017, p. 9). At a different scale, Lucy Suchman (2007) argues in her study of interactions with technologies that a person's plan for such interaction is not separate from and prior to the actual encounter, but is itself a part of the situated action, and emerges from it. Visions of what will or ought to happen in our engagements with technologies are not immaterial, but are located in the mess of actual practice, and are available for study there.

Along the same lines, Dourish and Bell (2011) make seeing "myth and mess" of digital technologies together as their explicit goal. They see their subject, the development of ubiquitous computing in the 1980s and 90s, as "at once a technological and an imaginative effort" (p. 3), and set out to examine "the tensions between those two very different vantage points" (p. 5). In one sense, they take a typical STS tack in pointing out technologies' inevitable encounters with the mess of everyday life—both its material components and socio-political contests—to show that the mess always complicates the realization of technologies' simpler promises. At the same time, however, they insist that we need to pay attention to the myth,

> the stories that motivate and celebrate the development of the ubicomp agenda. They are the ideas that give it shape and meaning. They are ideas about what technology can do for people, the places it will go, and the needs it will address. While we might not often see technology in mythical terms, it is a useful strategy to uncover the ideas that shape our technological world. (Dourish & Bell, 2011, p. 4)

Their argument for studying the myth draws on Mosco's (2004) work on the mythology of digital technologies, which I return to later in the chapter. Mosco argues that we need myths in order to make the challenges and contradictions of life more manageable. The point is not to document where technological promises fall short in reality, but to understand "what myths mean to the people who produce and believe in them, and what they reveal about the society that sustains them" (Mosco, 2004, p. 31).

In this study, my attention to the promise of new mobility shows desires for certainty and for solvability that I argue are at odds with the messiness of the actual city, which demands better ways of dealing with pluralism, agency, and materiality. These are the political questions that descriptivism does not see. My attention to the actual practices of new mobility shows more than the ways that technologies do not know as much or fix as much as they claim. Studying this mess also shows us the origins of the desires that animate digitality's promises and the ways various actors respond to the gaps between this vision and reality. Keeping both of these in view together allows us to take a critical stance while recognizing the grounded origins of these visions. The remainder of the chapter examines how the promise works in its general form and with digitality.

Theorizing the promise

I develop the idea of the promise from literature dealing with anticipation, optimism, desire, and myth. A promise is a collective anticipation that a desired future will be realized through some specific intervention. I am of course focused on technological interventions, and the next section will examine the ideas of certainty and solvability that I argue digital technologies promise. More generally, however, the pattern of the promise shares several features. As an *anticipation*, the promise works across temporalities of present and future, dealing with present concerns and the imagined future in which they are addressed. This work operates on an affective level, meaning that the promise is not a state of affairs that can be represented abstractly, but an immanent experience of a certain feeling or atmosphere. I call this the *more than rational* dimension of the promise, and emphasizing it discourages us from focusing narrowly on a descriptive evaluation of the degree to which a given promise has been realized to instead recognize the less tangible desires that attract us to the promise and sustain it. To be affected necessarily means to be changed, but promises have as much to do with continuity as they do with transformation. Promises might imagine different worlds, but they do not confront us with different desires. Because its vision gains power by speaking to some existing yearning, the promise is an *affirmation* that that desire is fundamentally correct. Furthermore, promises are produced collectively, and they take effort to sustain. When the promise is inevitably challenged by actual experience, work of *maintenance* is required to protect the values and visions that created it, even if the specific intervention promoting them has failed. This makes the promise resilient and conservative, so that it seems to operate on a separate plane from messy reality. This *transcendent* quality, finally, can be seen as a form of escapism, a denial of reality that is damaging, or at best unproductive. Alternatively, this transcendence can become the very site where we can engage with real concerns, giving us handles for grappling with the slippery mess of actual experience. It is through this latter frame that I find the promise useful for studying mobility technologies, as I discuss at the end of the section.

This section draws out these dimensions of the promise using two literatures. The first is work in affect theory, mostly from a humanities tradition, which helps us to understand how our orientation to the future works in ways beyond the language of representation. The second is recent empirical work from information and technology studies, together with the theories of socio-technical change they build on.

A more-than-rational anticipation

The promise is anticipatory, affective, and shared. It is necessarily oriented to a future, a state that has no concrete presence except in a present imagination of it. As such, it is a link between something that does not (yet) exist and something that does. The temporality of the promise operates in what Hetherington (2016) calls the "future perfect" tense, where the present is always anticipating a future for which it is merely a necessary precursor: today is what *will have been* before a better tomorrow. Ben Anderson (2010, p. 793) invites us to see how the future is not a "a blank or a telos," but, because it is anticipated, is "made present and becomes a cause for action." Anticipating the future in these frames involves both an uncertainty and an imperative to act: "Anticipatory regimes offer a future that may or may not arrive, is always uncertain and yet is necessarily coming and so therefore always demanding a response" (Adams et al., 2009, p. 249). The futures described in these accounts are often undesirable (e.g., terrorist attacks, climate change), which support a particular kind anticipatory governance of avoidance. The framing of promise, in contrast, not only works in a more positive register, it also connotes assurance. The promise in its general form then already has the elements of certainty (a specified future will arrive) and solvability (it will be better than the present) that I will show are at the heart of the particular promise of digitality.

Further, anticipation is "an affective state" (Adams et al., 2009, p. 247), in which a given future has "affectively imbued representations that move and mobilize" (Anderson, 2010, p. 785). For the promise, this means that the rationalism of a calculative forecast or a legal contract between parties is inadequate to explain the attractiveness of the promise or the effort that goes into sustaining it. Seeing the origins of the promise in desire, instead, shows how it differs from a prediction or an agreement. Desire is affective, if by affect we mean "the name we give to those forces—visceral forces beneath, alongside, or generally *other than* conscious knowing, vital forces insisting beyond emotion—that can serve to drive us toward movement, toward thought and extension" (Gregg & Seigworth, 2010, p. 1). When a yearning for some condition—a feeling of happiness, a state of stability, or a relief from pain, perhaps—becomes attached to a thing that promises to deliver it, the desiring subject is taken, however briefly, out of the present reality into an envisioned future state, and the thing takes on a power and meaning that exceeds its material properties.

At the same time, affect theory insists that affect is embodied, not imaginary or immaterial. Brian Massumi (1995, p. 96) describes affect as "virtual synaesthetic perspectives anchored in … the actually existing, particular things that embody them." In this way, affect links the immanence of bodies and objects with a less easily represented sensibility or vibrancy. This "non-cognitive" or "pre-conscious" way of sensing and knowing (N. J. Thrift, 2008) allow us to recognize that that the drive towards the promise and the experience of it are *more than rational*, a phrase I use to summarize affect theory's corrective to social sciences' accounts of phenomena built on representational and calculative models. When Michelle Murphy, for example, points out that the abstractions of "the economy" like GDP do not just offer a simplified representation of the world, but also "propagate imaginaries, lure feeling, and hence have supernatural effects in surplus of their rational precepts" (Murphy, 2017, p. 24), she is arguing that we must understand economic rhetoric affectively. Geographers and planners working in this affective turn have taken up affect theory's linking of the conscious and the unconscious as well as the social and material to examine how spaces have feelings, attachments, or atmospheres that operate beyond the rational logics of finance and governance (Buser, 2014; Marotta & Cummings, 2019).

Sara Ahmed (2010) and Lauren Berlant (2011) can help us to see how ideas of anticipation and affect illuminate the working of the promise. In similar ways, each describes processes by which some desire becomes attached to a thing that allows us to imagine that desire being fulfilled. Ahmed does this with the idea of "happiness." She observes that "some things become happy for us, if we imagine they will bring happiness to us" (Ahmed, 2010, p. 26). In other words, the happiness is anticipatory; the judgment about an object being happy is made before it brings happiness, but in the expectation that it will do so. Ahmed is interested in how this state of expectation can make happiness simultaneously present and absent, a condition she says is dangerous for the complacency it inspires. Lauren Berlant (2011) makes a similar argument about "cruel optimism." Beginning from the claim that the present is first of all an affective perception, she talks about "an object of desire" as "a cluster of promises," through which the subject can imagine receiving or becoming something in proximity to the object (p. 23). "In optimism," she says, "the subject leans toward promises contained within the present moment of the encounter with her object" (p. 24), and in this leaning-towards is an affective experience in which the desire attaches to the object. Both Ahmed and Berlant are connecting something imagined to a concrete experience in the present, and are interested in the power and danger of the gap between them.

Understanding the promise as an affective orientation to the future means understanding it as relational. To be affected requires some kind of encounter, and so affect exists not as a thing within a body, but as a something emergent from relations among them (Anderson, 2014; N. Thrift, 2004). Or as Ahmed (2004, p. 120) puts it, affect is like capital in that it "is produced only as an effect of its circulation." In this way, she claims, affect is a way of binding individuals and communities, so that not only are communities created by shared affects of their members, but also "the individual subject comes into being through its very alignment with the collective" (Ahmed, 2004, p. 128). In *The Promise of Happiness*, Ahmed locates happiness not in the person who feels happy or the object that brings happiness, but in the relation between them (Ahmed, 2010). For a promise to work, it must be in some way shared between actors. This is from one angle a hopeful image of collectivity, but Ahmed is wary of the stultifying effects of these relations, since they can become a trap that discourages any personal admission of dissenting unhappiness. Being out of alignment with a promise is a kind of rupture from the social world, she says, but in this rupture she sees a hopeful figure. She calls these moments when someone becomes a stranger to the collective orientation towards an object as good a condition of "affect alienation." The affect alien is hopeful because she breaks free of the "lines that have already been given" (p. 48), and so can "make room for possibility, for chance" (p. 20). In practice, however, promises do not encourage making room for new ways of thought or for dealing with disagreement, but tend instead to reward harmony, reincorporate offshoots, and subsume dissent, as the next section will show.

Applying this perspective on the promise to some recent research in information studies can help explain the attractions to certain artifacts, organizations, and practices, and the work that is done to sustain belief in their transformative power. Information scholar Morgan Ames (2019) provides an example of what she calls a "charismatic technology" in her study of the low-cost laptop distributed worldwide by the One Laptop Per Child (OLPC) initiative. With a charismatic technology, she says, "what is important is not what the object is but how it invokes the imagination through what it promises to do" (p. 21). For OLPC, the immodest promise was that the laptop was the best chance to "eliminate poverty, create peace, and work on the environment," according to founder Nicholas Negroponte (quoted in Ames, 2019, p. 17). Ames describes how the charismatic OLPC laptop has captured a preexisting social imaginary of funders and administrators, an imaginary in which children are curious and self-directed learners their education is sufficient to achieve global development goals, and attached it to the machine. OLPC shows how a specific artifact can embody a promise, but promises are also located in more broadly distributed actors and practices. Christo Sims (2017), in his ethnographic study of a new middle school billed as a "school for digital kids," argues that the excitement surrounding the school's innovative pedagogy built on networked, technologically enabled learning is generated by a longstanding "yearning" for societal transformation through schools. That transformation is anticipated but never achieved, and so the vision of it remains available to drive the operation of the school. In their promises, these reforms generate their own affective atmospheres of enchantment and transcendence by imbuing certain objects—the laptop, the curriculum—with the desires that already existed outside of them.

Since promises are relational, we can also see how they have the power to pull together disparate actors. In her study of entrepreneurialism in China, Sylvia Lindtner (2020) examines the "promise" of the maker movement through what she calls the "socialist pitch," which she finds present in national economic development literature, everyday office support functions, and many sites in between. The socialist pitch promises that anyone can intervene at scale, attaching personal career ambitions and individual desires for fulfilment to larger visions of national economic and technological greatness. The socialist pitch works by connecting visions of a better future for China as a whole to the yearnings for participation and empowerment held at a personal scale (Lindtner, 2020). Similarly, in Lilly Irani's ethnography of rhetorics of entrepreneurialism in India, the individual entrepreneur hears a promise of agency and creative expression that moves him to participate in a national economic development project (Irani, 2019). In examples like these, promises work by organizing anticipated futures around already existing orientations, and so they *affect* people, moving them to act in a certain way.

In summary, promises work affectively to invite us to anticipate the future satisfaction of some personally held desire through a present encounter with an object or practice. The next section will show how this setup resists transformative change.

Affirmation and maintenance

A promise is a statement of values, and its task is to preserve these values against threats from reality's disappointments and from competing desires. The role of the promise is not solely to anticipate a future in which a certain desire is fulfilled; it must also reassure us that the desire itself is a good one, and will be preserved. In Ames's study of "charismatic technologies," she says that the power of this "unchallenging familiarity" is that "even as it promises certain benefits, it simultaneously confirms that the ideological worldview of its audience is already right" (Ames, 2019, p. 23). The promise, in other words, is that the world will change so that you don't have to.

Berlant writes that "the subject leans toward promises contained within the present moment of the encounter with her object" (Berlant, 2011, p. 24), and that in this "leaning towards," some essence of the self becomes located in the object of desire:

> When we talk about an object of desire, we are really talking about a cluster of promises we want someone or something to make to us and make possible for us. This cluster of promises could seem embedded in a person, a thing, an institution, a text, a norm, a bunch of cells, smells, a good idea—whatever. To phrase "the object of desire" as a cluster of promises is to allow us to encounter what's incoherent or enigmatic in our attachments, not as confirmation of our irrationality but as an explanation of our sense of our endurance in the object, insofar as proximity to the object means proximity to the cluster of things that the object promises. (Berlant, 2011, p. 23)

As we have already seen, in any aspiration for something that does not yet exist is a desire that already does. Berlant's notion of "our endurance in the object" points to the preservation of self as what motivates our efforts to conserve these objects of desire, even when they have failed to deliver on their promises. There is a circularity here, seen in reciprocal processes in which promises maintain our sense of ourselves and we in turn work to maintain the promise. Berlant goes on to discuss the endurance of optimism:

> Any object of optimism promises to guarantee the endurance of something, the survival of something, the flourishing of something, and above all the protection of the desire that made this object or scene powerful enough to have magnetized an attachment to it. When these relations of proximity and approximate exchange happen, the hope is that what misses the mark and disappoints won't much threaten anything in the ongoing reproduction of life, but will allow zones of optimism a kind of compromised endurance. In these zones, the hope is that the labor of maintaining optimism will not be negated by the work of world-maintenance as such and will allow the flirtation with *some* good-life sweetness to continue. (Berlant, 2011, p. 48)

This flirtation, or anticipation, is so often what makes the messy world bearable despite its disappointments. For Berlant, the continuation of this pattern is dangerous. Her interest is in "problematic" attachments of desires to objects that are nonetheless difficult to let go of, the origin of the "cruel optimism" that gives her book its title, and she is concerned that so much of our experience of the present is organized around fantasies of a better life to come that we lose sight of present crises.

The conservatism of promises is thus dangerous in more than one way. One is that promising objects leave problematic desires unchallenged, and so perpetuate arrangements and perspectives that perhaps ought to be challenged. By directing those familiar desires towards a given object, the promise can "induce conventionality" (Berlant, 2011, p. 2) with "the comfort of repetition" (Ahmed, 2010, p. 48). Empirical studies of practices surrounding technologies hyped as bringing about a new order show that within these apparently transformative phenomena are reassurances that the values and beliefs contained within those systems can continue (Ames, 2019; Sims, 2017). At the same time, the promise preempts any criticisms of those values, reinforcing its vision as the natural realization of those things we've always wanted. Meanwhile, the anticipatory quality of the promise works to assure those who are quite consciously dissatisfied with the status quo that happiness will come, in due time. For Ahmed, the "promissory nature" of a happiness that is always imagined but never quite arrives is the key to its power; a happiness whose anticipation persists cannot be discredited by an unhappy reality. Such reassuring anticipation encourages a tolerance of stasis among both those who hold power and those who are immiserated.

The conservation of desires and of promises is active work. In Berlant's words quoted above, when promises fail to materialize, we undertake a "labor of maintaining optimism" that is distinct from "the work of world-maintenance." While the latter is invested in the messy work of the promising object's encounter with reality, the former invests in the idealized endurance of the underlying beliefs. Ahmed similarly argues that the promise of happiness must be preserved even, or especially, when happiness itself is not. She identifies a power in the distance between the happy object and the subject's lack of happiness:

> Indeed, the very promise of happiness may acquire its force by not being given by the objects that are attributed as happiness-causes. The happy object circulates even in the absence of happiness by filling a certain gap; we anticipate that the happy object will cause happiness, such that it becomes a prop that sustains the fantasy that happiness is what would follow if only we could have 'it.' The happy object, in other words, is a gap-filler. The promise of the object is always in this specific sense ahead of us. (Ahmed, 2010, p. 32)

In perpetually affirming desires while holding their fulfilment just out of reach—what I call a "yes but not yet"—the promise offers comfort in a world that does not. Negotiating this tension between the promise and practice, ideal and real, mythology and mess, takes effort, since these stories must be maintained when they are worn down by the messiness of reality. As they become "brittle" with the accumulation of disappointments, they are "prone to breakdown and in constant need of repair" (Ames, 2019, p. 108). In Ames's study, once OLPC laptops were no longer merely a charismatic vision but were realized as actual devices in a Paraguayan classroom, they were often broken, used for entertainment rather than education, or simply unimpressive. The trajectory in Sims's (2017) ethnography of a middle school built around a much-hyped technologically innovative pedagogy is similar. Despite the reformist interventions, sixth graders continue to ignore teachers' instructions, misbehave at recess, and otherwise act like ordinary twelve-year-olds. The responses of teachers and administrators begin to make the school look less reformist and more conventional. In each case, the interventions are not necessarily absolute failures, but they inevitably diverge from their visions as they accrue real experience. Both of these scholars then describe the specific practices that maintain idealism in the face of such shortcomings. Those invested in the myth of the intervention's transformation go to great lengths to demonstrate some small version of the idealized promise, a performance aimed at the funders and supporters who can “realize the collective experience of having good intentions and being cutting edge” through “seeming verifications of the project’s idealized potential” (Sims, 2017, p. 104), even when undermined by the project’s actual experience. Similarly, Lindtner uses Sara Ahmed to describe the performance of what she calls “happiness labor” in the Chinese maker movement. To keep workers engaged in their projects, happiness labor “produces a feeling of optimism and hope despite the proliferating sense of rising precarity” (Lindtner, 2020, p. 216). This labor and other performances of success show that the existence of these promises is not automatic or inevitable. Instead, the myths must be created, circulated, nurtured, and repaired, and that work is messy.

In those examples, promises are undermined when they fail to realize their lofty goals. Promises are also threatened by challenges from those who do not share their vision, or indeed by any political conflict. Transformative promises that radically challenge the deeply held beliefs of the people needed to carry it out would likely stumble. In speaking to some beliefs, however, the promise must either avoid conflicting views or subsume them. A promise envisions an outcome, not a process. Its danger is not just that it fails to engage with the messiness of realizing the vision, but more importantly that it overlooks the processes of arriving at *this* vision, but not others, as the outcome we believe ought to be realized. These are political processes, and often the very appeal of the promise is its avoidance of this mess.

Researchers have observed this in practice. As Sims (2017, p. 170) puts it, the cycle of creating and maintaining promises of reform generates “a politicized buffer zone that helps absorb and fix volatile energies while leaving the sources of those volatilities intact”, and so the maintenance of the promise requires a smoothing out of disagreements. Observers of this practice in specific technological projects have followed Ahmed and

Berlant in recognizing the promise's flattening of disagreement as a problem. In her study of entrepreneurialism in India, Lilly Irani observes:

> The culture of innovation ... derided "ideological" people—those whose commitments took too much time to negotiate. Political desire—whether left or right—could drive the work of innovation, revealing new paths forward or possible impediments to success. But political desire that halted the progress of the project itself had to be calmed or expelled. (Irani, 2019, p. 133)

She goes on to show the ways that the wider entrepreneurial culture of this work "subsumes hope...critique, mutual aid, and desires for better, more just worlds" into a single vision of what it means to enact individual or collective desires (Irani, 2019, p. 213). Lindtner too notes the "subsumption of hope and of yearnings for alternatives" (Lindtner, 2020, p. 31) among Chinese tech firms. Each identifies, first, a gap between the anticipated emancipatory future that moves participants and the perpetuation of existing paradigms of value capture that actually ensues, and second, the practices in which any consequent dissent is preempted or incorporated back into the dominant promise. In a different way, Kate Crawford (2016) has suggested that part of the appeal of algorithms is that they hide processes of resolving disagreements among input data to deliver a single unambiguous output. We will see below the role this absorption of politics plays in the promise of solvability.

Technologies can fail, and specific promises can fail, but the underlying visions and values must be preserved. This conservatism will appear clearly in my study of new mobility's promises, which attaches old desires to new tools while sidestepping the political and material messiness that might threaten them. The mess always returns, but the danger of the promise is that it tells us we don't have to confront it. Instead, it reassures us that this desire is the correct one, and that we can always continue looking forward to its eventual arrival.

Transcending contradictions

This introduction to the promise might be painting a rather critical picture of promises as tools for capturing and misdirecting desires, justifying complacency, stifling radical movements, or foreclosing politics. These are real dangers, but I want to also keep in mind the productive utility of the promise. Before moving on to digitality's particular promises of certainty and solvability, let me briefly address the question of whether we ought to see the promise as simply a delusional fantasy, or as something that serves a more meaningful function.

Vincent Mosco's (2004) book *The Digital Sublime* makes a case for the latter. We saw above that Lauren Berlant sees optimism as cruel for directing people to an imagined better life instead of confronting their actual lived unhappiness, but Mosco is more sanguine about this kind of thinking. The empirical content of the book is focused on technological promises of computers and the internet in late 1990s and early 2000s. Mosco sees these stories—information technologies bringing about the end of history or the end of geography, for example—as myths, newer versions of the kinds of transcendent stories that have featured across human cultures for millennia. Like a myth, the promise of a new technology is not simply that it will solve some particular problem or make a life marginally easier, but that they will allow us to rise above the messy and mundane. Amidst the conflict or just the dullness of everyday reality, these stories allow us to aspire to something grander (Dourish & Bell, 2011). In the stories from tech companies and investors that spread throughout society at the turn of the millennium, the rapid expansion of computer networks promised a rupture with the old ways of living for a new and better society, one that is yet to arrive. The technological hype of this era was characterized by what Graham (2004a) calls a "dazzling light" discourse in which information and communication technologies promise to deliver us from the confines of materiality and the messiness of urban life to a new, virtual utopia of frictionless communication. He and other geographers worked to show that this virtual utopia could never be achieved on the ground (S. Graham & Marvin, 1996; Kinsley, 2014; Sui, 1998). For Mosco, however, the point of a myth is not whether it can be realized, but what beliefs it circulates in its telling and retelling. These myths “promise...the sublime” with “stories that animate individuals and societies by providing paths to transcendence that lift people out of the banality of everyday life” (Mosco, 2004, p. 3). It is thus in the very nature of the myth that the story it offers is not realistic or feasible; by envisioning something that is not ordinary, but divine, it makes mundane life livable.

Mosco is taking this framework of myths as transcendence from Claude Lévi-Strauss, Roland Barthes, Joseph Campbell, and other scholars of mythology. He makes the observation from this work that myths allow us to “deal with contradictions in social life that can never be fully resolved,” contradictions that include desires for individuality and community, or for familiarity and novelty (Mosco, 2004, p. 28). It is precisely in their distance from reality, with its irresolvable conflicts and paradoxes, that myths are able to tell us that life can be manageable. “Making a new world has far more allure than extending an old one,” (p. 21) Mosco says, since this new world transcends the mundane mess that forces tradeoffs and confrontations. Holston’s critique of utopian planning, mentioned above, is that “it does not admit or develop productively the paradoxes of its imagined future. Instead, it attempts to be a plan without contradiction, without conflict” (Holston, 1998, p. 46). This is true, and this depoliticizing function of technological promises appears clearly throughout my study. But for Mosco, dealing with contradictions is precisely the point. Citing Lévi-Strauss, he says that

> the inability to figure out how to “have our cake and eat it too” leads people to embrace myths that help them to deal with the irreconcilable. Myths do not always

> provide a satisfactory response; indeed, their basic message is not that contradictions are resolvable, rather, that they are scalable. We cannot solve life's fundamental divisions, but myths tell us that we can talk about them in ways that are manageable. (Mosco, 2004, p. 28)

Myths then can be used to either avoid or to confront. For Mosco, mythmaking "exacts a price by tempting us to use myths about the future to avoid present conflicts and create a false sense of social cohesion" (p. 15). This caution echoes the arguments of Ahmed and Berlant, who each worry that imagining something better in the future allows a denial of the actual present, and also of the actual means of achieving a better future. But this avoidance is not inherent to myths, promises, or plans, only to certain instances of them. Mosco is hopeful that an examination of the myth can be a way to replace the view of myths as a "post-political" concealing of difference

> with the view of myth as pre-political. Myths can be viewed as an early step in a process that, when examined with a critical eye, can restore with every critical retelling a political grounding that myths appear to leave out. In essence, myths can foreclose politics, can serve to depoliticize speech, but they can also open the door to a restoration of politics, to a deepening of political understanding. (Mosco, 2004, p. 16)

This possibility, however, is undermined by the desire to avoid politics, a temptation that myths offer in their work of transcending messiness and contradictions. Using these promises as a tool of disruption rather than of stabilization takes intention and effort.

Several tensions and contradictions of urban transportation will be made apparent in my study of new mobility: between the personal convenience of door-to-door service and the collective burdens of traffic; between infrastructure that serves everyone and infrastructure that is cost-effective; between the reliability of fixed services and the flexibility of improvisation; between data-based decision-making and personal privacy; between the personal convenience of cars and the environmental benefits of no cars; and so on. There are few opportunities for win-win interventions here, and the promises currently circulating in transportation planning are good at downplaying the tradeoffs. In its more excessive hucksterism, new mobility is a "have your cake and eat it too" pitch, and lets us imagine a world where the easy flow of information will translate into the easy flow of people. But Mosco's view suggests that it is in these myths, not only in the immanent mess, where we can identify and sort through these tensions.

In an important sense, the purpose of the promise is to remain separate from the mess, to transcend it. Myths offer a way to escape both ordinary mundanity and irresolvable contradictions. Realizing the promise, then, can be less important than maintaining it on a separate plane. Dourish and Bell (2011) show how studying the mess is one way to reveal the differences and tensions that the single telling of the myth obscures, collapsing the unifying function of the myth. But often, we find that just as the promise survives even when it is not fulfilled, the messiness of practice does little to undermine the work of the myth. If we see that "myths are neither true nor false, but living or dead" (Mosco, 2004, p. 29), then the purpose of studying the mess is not to test the truth of the myth, but to investigate its health. My study of new mobility will show where its promises are not realized. More than that, however, my goal is to use myth and mess together to see this promise an opening to politics—to questions of how to share space and resources, who should be visible to whom, or how to rely on other people to meet our needs, for example—rather than its closure.

Digitality's promise of certainty and solvability

I argue that understanding the role of digitality in the city requires understanding that digitality *promises*, and my study of urban mobility focuses on two things I find that digitality promises: certainty and solvability. Desires for these are what become attached to specific technological objects—the artifacts and practices of digital sensors, data, and software. I will briefly introduce these ideas here, then refer to them frequently as they appear in the empirical chapters. Longings to know more and to eliminate problems are familiar aspects of human life, but digitality, with its basis in quantification, is especially magnetic for these desires. I will not argue that certainty or solvability are in themselves bad, and neither will I argue that desires for them are unachievable with digital technologies. Instead, I want to show the danger of promising them.

That danger is twofold. First, because certainty and solvability are never completely achievable, living with their absence is part of the human condition. We need not be complacent, willing to tolerate all ignorance or all problems all of the time, but living well requires learning to manage the everyday work of incomplete learning, acting under uncertainty, enduring brokenness, and making do with incomplete responses to our troubles. Promises of certainty and solvability not only fail to teach us these skills; they teach us *not* to tolerate such messiness. Second, promises of certainty and solvability are built on visions in which individual agency and political conflict are either absent or contained. Agency, whether of humans or things, threatens predictability. Admitting values and desires beyond rational calculation introduces differences that cannot be resolved technically. These visions can be coherent only when they assume a view of people that is individualized, rational, and abstract—the liberal subject that much of the theory I use has worked to debunk. In practice, of course, we constantly confront the limits of certainty and solvability, and, in my research, no one claims to believe that these will be completely achieved, through digital tools or any other means. We live in the mess, and so we know, intuitively, that agency and materiality complicate our visions. But promising certainty and solvability is dangerous when it lures us into these patterns of thought and reinforces these desires that do not help us find ways to live better.

This section uses literature from planning theory, development studies, and technology studies that helps establish what I mean by certainty and solvability. They are big ideas, and my survey is selective. The two often go hand in hand, as gaining certainty is expected to help solve a problem. I frame each as an anticipation—expecting that something *can be* known or *can be* solved, even if it is not right now—which resonates with the broader idea of the promise. Further, each is understood as a property of a subject, rather than of an object in the world, and this subjectivity is most apparent in the discomfort seen in the absence of knowledge or solutions. Versions of these ideas undergird modern technocratic governance, and show up more or less explicitly in a long history of urban planning literature. Here, however, I am especially interested in more recent work examining how the expansions of digitality, with its quantified representations, promises unique modes of certainty and solvability that are particularly alluring in their scale and abstraction.

Certainty

In discussing certainty, I am interested not in the content or accuracy of knowledge as much as the assurance of the availability of that knowledge. This certainty is not *knowing* something, but *knowing that* something is known, or can be. This distinction turns us away from positivist questions of how completely facts of the world can be revealed to us and towards an affective view of what anxiety or comfort we feel in relation to those facts. Certainty shows up in two places in my study. First, promises have a certainty; they tell us that a certain anticipated future will arrive, rather than some other future. This certainty might be contingent, such that this vision is not guaranteed but will be realized only if we take proper actions. My study shows how the promise of new mobility offers assurance that goals of urban mobility will be achieved as a result of specific digital interventions. Second, digitality is in itself an epistemological promise of certainty. Its data and algorithms show us more of the world than we could otherwise know, and make predictions about a future that does not yet exist. The certainty here is about specifics of urban mobility. For planners, it might be the current locations of shared bikes or the impact of a new traffic signal; for travelers it is the location of the Uber coming to pick you up or the estimated arrival time of the next bus. Certainty deals with knowing what is and what will be, and digitality offers both of these. The epistemologies of big data have been subject to much-deserved scrutiny in recent years, pointing out the limits and biases of what can be known from the expansion of the scope and scale of digital observations (Amoore & Piotukh, 2015; boyd & Crawford, 2012; Gitelman, 2013; Kwan, 2016; Thatcher, 2014). Here, however, I want to look at certainty as a goal in itself. My interest then is not about whether, when, and to what degree digitality has a meaningful correspondence with reality, but why we ask it to, and what happens when we do.

The discomfort of not knowing has a long history in planning. Certainty in planning can relate to monitoring what is happening now, forecasting what will happen in the future, or predicting the impacts of an intervention. The modernist planning paradigm that emerged in the post-war period revolves around the expertise of the planner, who is expected to accurately describe the city as it is and to anticipate how it will change under specified circumstances. This certainty, it is imagined, will then allow for the achievement of social progress (Rydin, 2007; Sandercock, 1998a). Planning epistemologies since then have accepted sources of knowledge beyond the rationalist planner and his datasets, and have come to view cities as systems with greater complexity and therefore a greater capacity for surprise. Still, the planner's preoccupation with eliminating uncertainty persists. For example, one story of big data in the city is that the world is indeed more complex than those modernist models, but that more data and better analytical tools will still allow us to know and predict with greater certainty (Kitchin, 2014). Scenario planning has a slightly different approach. It takes the unpredictability of the future as a given, but then works to define possible contingencies and specify more certain actions in response to them (Kwakkel et al., 2016; Zapata & Kaza, 2015). For the anticipatory logics that Anderson (2010) observes shaping contemporary governance, the premise is that the uncertainty of the future is a problem. Present action is a way to contain the number of plausible future contingencies, for example by installing backup generators to prepare for the continuation of electricity during a storm or by arresting suspicious individuals to preempt a terrorist attack. For anticipatory governance, the best way to be certain about the future is to control it, to leave nothing to chance. Within the digital epistemologies of big data, reducing the uncertainty of complex systems simply requires more complex models. In these ways, planning today recognizes uncertainty, complexity, and messiness, but sees them as a problem to be eliminated as much as possible.

Science and governance tend to take an epistemological view of uncertainty as a measure of a gap between the knowable facts of the world and what is actually known to an observer. This uncertainty can be measured and managed, and is an obstacle to be overcome, specifically by attaining more knowledge to reveal the secrets of the world. A constructivist view, by contrast, locates uncertainty in the subject, who is situated within particular cultures and values that produce an orientation to something as risky (Jasanoff, 1999). In this framing, uncertainty is not an objective fact, but something that matters to a specified subject in a sense that is more affective. The condition of lacking certainty can be understood as not just an absence of knowledge, but as a felt presence of instability or anxiety that reflects the unfulfilled expectation of having that knowledge. Uncertainty then has an affective dimension distinct from the rational-cognitive questions asked of and answered by data. Fear, anxiety, hope, and assurance are essential to this picture, and these are located within subjects. In this view, certainty is a fantasy driven by fear (Clegg, 2010). Such affects of uncertainty are identifiable in urban planning too, with theorists arguing that "planners are haunted by uncertainty" (Beauregard, 2021, p. 217), that "planners hate uncertainty as much as most other people do, and they spend their working lives trying to reduce it" (Christensen, 1985, p. 63), or that planners work to respond to the "fear of the undecidable and unknown" by seeking "to provide, or at least give the illusion of, certainty towards a safe tomorrow" (Gunder, 2008, pp. 187–188).

In planning and in other fields oriented towards building a better future we can see "the palpable sense that things could be (all) right if only we anticipate them properly" (Adams et al., 2009, p. 255). The corollary is that without proper anticipation, things might not be OK. Affect in general has been argued to be a "fertile new field of persuasion and manipulation" by powerful state or corporate interests (N. Thrift, 2004, p. 71), and the anxieties of uncertainty too have been seen as an object of control. In one case study of informal development, uncertainty among street vendors are argued to be "an emotive field through which municipal officials govern" (Tucker, 2017, p. 736). A study of the redevelopment of Portland's Pearl District makes a similar claim that planners' and developers' renderings of the redeveloped neighborhood work by capturing atmospheric affects of uncertainty and reattaching them to the imagined stability of an envisioned place (Marotta & Cummings, 2019). Uncertainty then has a vulnerability.

Epistemologically, we know that perfect knowledge of everything is impossible. Wanting something that cannot ultimately be achieved is problematic in itself. Uncertainty identifies an "inherent unknowability, which in turn induces society to crave and then seek to generate further constructs of certainty, even if these are mere fantasies and illusions" (Gunder, 2008, p. 186). My empirical work on travelers will show how seeking and finding greater access to information simply produces more awareness of, and then desire for, the information that is not available. This leads to the perpetuation rather than the satisfaction of the desire for certainty, and feeds the anxiety of uncertainty. In addition, seeking certainty can even be an obstacle to learning, supporting Berlant's (2011) claim that wanting something can get in the way of actually getting it. Responding to the what he describes as the social sciences' relentless pursuit of certainty, psychologist Joshua Clegg (2010) points out that, in the classical scientific tradition, it is uncertainty, and not its elimination, that is generative of knowledge. Rather than see variability or unpredictability as obstacles to accurate modeling that should either be overcome or tolerated, he argues for a reinvigoration of the view of science that sees "the mystery inherent in otherness" as "a necessary condition for genuine, surprising, illuminating knowledge" (p. 249). Certainty is closed, and uncertainty is open.

With this in mind, I want to follow this literature a step further to suggest not just that certainty is impossible or counterproductive, but that it is often undesirable. Part of the reason for this is the conflict between predictability and agency. If "unpredictability is not a measurement error; it is a function of genuine possibility, of agency" then we find "a tension between, on the one hand, our need to recognize agency and genuine possibility and, on the other, our desire to perfectly and adequately represent our world" (Clegg, 2010, p. 247). Assuming the fundamental indeterminacy of human action is desirable, as opposed to the predetermination of all behavior, then the desire for certainty poses a problem. Struggles with this tension are not new, running from ancient efforts to reconcile free will with omniscient deities through to contemporary suspicions that you don't really have much choice since Google "knows everything" you'll do. In practice, this is not a zero-sum proposition, in which increased predictability necessarily means more control. Nevertheless, we often find wanting more certainty means wanting less possibility. Certainty, in this view, requires a contraction of agency, and uncertainty is other people.

Connecting certainty to agency returns us to the understanding of certainty as a constructed experience, rather than being a measurable fact. Beauregard (2021) calls uncertainty a "socio-material condition," by which he means it is located not within a person or an observed phenomenon, but in the relations among them. Desiring certainty then means desiring something about the behavior of other people; it is political. Peter Marris's (1996) examination of the "politics of uncertainty" observes that each person develops a cognitive model "to predict and control, but we are also controlled by it, because to use it we must conform to its complex, specific rules." Furthermore, this drive for certainty produces a "competitive struggle for autonomy, as each tries to protect his or her freedom of action while constraining others" (p. 3). He goes on to observe that that control over uncertainty is an increasingly important kind of power, and one that is unevenly distributed in society. People with greater power are not only better able to reduce uncertainty by manipulating the world around them, they are better resourced to deal with unforeseen events. Moreover, this capacity comes at the expense of the ability of those with fewer social and economic resources to manage their own uncertainty. For Marris, the response is not to expand certainty, but to expand the "reliable relationships and freedom of action" required "to manage uncertainty successfully" (p. 83). He is interested in the certainty found in reciprocity, where people meet the expectations they have for one another, and worries we find ourselves in a negative spiral of competitive individualism and social uncertainty in which the relations we need to manage the inherent surprises of life are undermined. Similarly, Pink, Laneni, and Horst's (2018) work on personal relations with digital data offers "trust" as an alternative to certainty. Trust "entails feeling and knowing enough to be able to take the next step," and is "part of a mode of living in a world of uncertainties that 'feels right', a sense of control in a space of uncertainty" (Pink et al., 2018, p. 3). Within planning theory, Beauregard (2021) takes up Marris's idea of reciprocity to argue that planning ought to mitigate uncertainty not with better models, but with stronger social networks.

People want more certainty, are anxious or fearful without it, and so continue to seek it out. The cycle continues, alternating between senses of satisfaction and lack. My research shows this clearly among both planners and travelers. If the only problem with certainty were that it is incomplete, however, then the increase in information that digitality offers would only improve the situation. If, on the other hand, we see the drive for more accurate knowledge as reason to constrain the agency of various actors, then we find a different reason to be troubled by the implications of certainty for the foreclosure of possibilities. We will see hints of this tradeoff in the visions of new mobility circulating among planners and mobility tech companies. Without saying explicitly that they want to dictate travel behaviors, practices like the development of data specifications often favor digital visibility over the preservation of travelers' choices. Finally, a different concern about certainty is that it temps us into substituting better knowledge for trust in other people, or even trust in the self, as a resource for managing the inevitable surprises of life. In a simple example, travelers' comfort in the 5-star rating of their Uber driver asks less of their willingness to trust a stranger. This study will show again and again how travelers turn to the promised certainty of digital information as a substitute for relying on either themselves or other people. Certainty is not in itself a bad thing, but the promise of certainty is dangerous when it threatens erodes our embrace or even our tolerance of social actors' agency and relationality.

Solvability

Digitality's promise of solvability follows closely from the promise of certainty. Indeed, in examining new mobility, we will see how the step between securing better knowledge and an expectation of solving a problem is often abbreviated. A connection between knowledge and action lies at the center of many professional fields, and planning theory and practice have long taken interest in how an intervention to solve a problem begins with knowledge of both what the problem is and where it might be responsive to intervention (Campbell, 2012; Friedmann, 1987). A 1979 practitioner's guide for planning says that its "central aim…is to muster the best knowledge, skill, and imagination in solving complex problems and in making the solutions work" (quoted in Marcuse, 2016, p. 119). The certainty described above is often a goal in itself, a means of mitigating the general anxiety of not knowing. But the desire for certainty can also focus more specifically on an identified problem, and represents a desire to know how to solve it or even just *that* it can be solved. I identify "solvability" as the second promise of digitality, and it is important to note that this is not the same thing as promising a *solution*. Solvability means that a problem *has* a solution, even if that solution has not been implemented or even specified. It is a potential, a view of what can be done, and so it fits with the anticipatory quality of the promise. Solvability then has as much to do with how the problem is framed as it does with the elimination of that problem. In positioning itself as the solution, digitality is promising that the problem is matched to the tools available, even if the work of solving is still to be done. This potentiality gives a promise of solvability more resilience than a promised solution: it is more difficult to dispute an actual intervention's success or failure after the fact than to argue that a problem hypothetically *could* be solved given the right circumstances.

These ideas are well established in both the international development literature and in more recent critical studies of technology. Development studies have examined the persistent struggles of governments and NGOs to address global poverty and other complex social issues (Ferguson, 1994; Li, 2007; T. Mitchell, 2002; N. S. Rose, 1999; Scott, 1998). I take two main ideas from this work. First, seeing a problem as solvable requires framing it in a certain way, and therefore *not* seeing it in other, more challenging ways. Such framing typically means a bracketing out of various forms of messiness, especially politics. The second, corresponding idea is that after framing a problem in this particular way, we are then led to a particular set of solutions, and not others.

The key insight regarding problem framing is that rather than beginning with an understanding of a problem and then seeking an appropriate solution, we often begin with the available solutions and then find, manipulate, or create problems that match. This begins with a simplification of complex problems into something more manageable. Echoing Scott's (1998, p. 11) argument that "certain forms of knowledge and control require a narrowing of vision," Nikolas Rose describes how the monitoring and controlling functions of governance require viewing phenomena as bounded systems. He says that governance

> becomes possible only through discursive mechanisms that represent the domain to be governed as an intelligible field with specifiable limits and particular characteristics, and whose component parts are linked together in some more or less systematic manner by forces, attractions and coexistences. This is a matter of defining boundaries, rendering that within them visible, assembling information about that which is included and devising techniques to mobilize the forces and entities thus revealed. For example, before one can seek to manage a domain such as an economy it is first necessary to conceptualize a set of bounded processes and relations as an economy which is amenable to management. (N. S. Rose, 1999, p. 33)

Tania Li (2007), in her ethnography of development practices in Indonesia, develops this notion of being "amenable to management" into her idea of "rendering technical," in which messy social problems become legible technical problems. When rendering technical, experts

> exclude the structure of political-economic relations from their diagnoses and prescriptions. ... Experts are trained to frame problems in technical terms. This is their job. Their claim to expertise depends on their capacity to diagnose problems in ways that match the kinds of solution that fall within their repertoire. (p. 7)

Li goes on to make the second point, which is that defining problems in this way sets up the expert and his tools as the only feasible solution. One result is an exclusion of politics, as the answer becomes a question of empirical experimentation and the identification of facts rather a deliberation among competing values. James Ferguson's (1994) study of development in Lesotho let to his influential claim that such projects are an "anti-politics machine" that de-politicize both the poverty that is the target problem and the governmental interventions that are positioned as its solution. By "reducing poverty to a technical problem, and by promising technical solutions," development achieves the "trick [of] the suspension of politics from even the most sensitive political operations." Inherently political interventions are launched "under cover of a neutral, technical mission to which no one can object" (p. 256). The concern in this literature is not just that the technical responses will fail to solve these problems, but that they hide the social and political nature of both the problems and solutions. As Ferguson puts it, "it may be that what is most important about a 'development' project is not so much what it fails to do but what it does do," namely perpetuate, in its failure, a justification for the ongoing expansion of institutional power (Ferguson, 1994, p. 254).

Many of the criticisms of such solutions have focused on practices of quantification, which help show how solvability is connected to digitality. The role of digital data is to "substitute differences in kind for differences in degree, collapsing qualitative difference into enumeration and action" (Amoore & Piotukh, 2015, p. 350), but modern computers are not required for such quantification. Mitchell's (2002) study of colonial Egypt focuses on practices of "calculability," which transplanted power from the popular knowledge in the field to the maps and records in the bureaucrat's office. Similarly, Merry's (2016, p. 27) critique of the "seductions of quantification" targets social indicators, which set out to "[translate] social life into commensurable categories so that different events become instances of the same thing," and claims that their supposed neutrality leads us to distrust solutions that appear comparatively ideological.

Digitality allows for the acceleration of such categorization and quantification. Internet critic Evgeny Morozov (2013) popularized the term “solutionism” to argue against “recasting all complex social situations either as neatly defined problems with definite, computable solutions or as transparent and self-evident processes that can be easily optimized—if only the right algorithms are in place!” (p. 5). Referencing Li’s work, he points out that tech companies’ hyped “solutions” often rest on a narrow and superficial understanding of a problem. Often, the solutions revolve around practices of “datafication,” the rendering of ever more of life as digital data (Langlois & Elmer, 2019; Mayer-Schönberger & Cukier, 2013), which I return to in the next chapter when examining their function in digital platforms. Datafication makes difference in the world both more legible and more manipulable. Haraway (1991, p. 164) describes this as “the translation of the world into a problem of coding, a search for a common language in which all resistance to instrumental control disappears and all heterogeneity can be submitted to disassembly, reassembly, investment, and exchange.” Franklin’s theorization of digitality claims that “the logic under which social worlds are reconceptualized as information-processing systems” is, simply, “control” (Franklin, 2015b, p. xv).

In these views is more than the familiar epistemological question of how quantitative and qualitative ways of knowing see differently. Their more pressing claim is that the translation of the world into a quantified representations leads to beliefs, first, that the world can be manipulated as easily as the numbers representing it, and second, that such manipulation is as apolitical and indisputable as mathematics. James C. Scott (1998) makes this connection between ways of seeing and forms of control the center of his criticism of the state. He describes how “state activities aim at transforming the population, space, and nature under their jurisdiction into the closed systems that offer no surprises and that can best be observed and controlled” (p. 82) particularly through the use of categories, which “are not merely means to make their environment legible; they are an authoritative tune to which most of the population must dance” (p. 83).

Throughout this literature, we learn that the incompleteness of these regimes of visibility and control—whether due to technical or political obstacles—does not necessarily undermine either the promise or the power of the actor making it. Ferguson’s (1994) argument that a solution’s failure often serves paradoxically to perpetuate that solution is echoed both in the theory of the promise and its maintenance, examined above, as well as in studies of cycles of techno-solutionism. When a technology fails, its shortcomings and unintended consequences are framed as simply new problem for a closely related technology to solve (Ames, 2019; Sims, 2017). Like Ahmed’s happy object that never arrives, the perseverance of a problem sustains the universe of institutions, policies, products, and other solutions aimed at it. We will see in new mobility how, among local officials and mobility providers, a failed intervention becomes the basis for a new technological solution, or among travelers, an app’s shortcoming is imagined to be fixable with a better app. The process can continue because seeing a problem as *able to be solved* in the near or distant future is not the same thing as *solving* the problem right now.

My study of digitality in mobility, however, is not primarily interested in determining the degree to which digital tools do or do not solve mobility problems, or even in the adverse consequences of such interventions. Instead, I want to show the dangers of this envisioning of solvability in itself. Expecting that these digital tools can solve the problems of mobility requires Scott’s “narrowing of vision,” excluding not just politics, but numerous other technical solutions. We will see often how new mobility turns to information solutions—sensors, data, software—when the well-known infrastructural solutions—expanded bike lanes, increased bus service, denser land use—are out of reach. Such infrastructure has been around long enough that we know well how difficult it is, but the allure of digitality is its promise that it will be easier. Morozov (2013) points out that the problem when technology defines the problem is not just that we look to the wrong solutions, but that we have found the wrong problems. For new mobility, this means, for example, the focusing on the problem of knowing the length of the wait for the bus, which information technologies can solve, rather than the problem of the length of the wait for the bus, which they cannot. More than this avoidance of more difficult interventions, however, the promise of solvability is problematic when it asks us to imagine the world is controllable. Calling a situation “controllable” invites inquiries into what is being controlled and by whom, obviously political questions that “solvable,” with its connotation of mathematical neutrality, sidesteps. As with certainty, desiring solvability often means wishing that someone else had less agency. In new mobility, this means imagining that travelers will use shared bikes to ride to a transit center instead of driving to work, or that business owners will not protest the loss of street parking to a bike lane. Continuing of a long tradition of technocratic visions within transportation specifically and government generally, the promise of new mobility is not only that new technologies offer solutions to problems, but that such solutions will in fact be successfully put into practice without encountering undue obstacles. Such a vision might or might not succeed on its own terms, but it will almost certainly fail to teach us how to how to live with people with different visions. The promise is that we won’t have to.

Conclusion: The appeal and the danger

This chapter has established the promise as a value-laden vision of an arriving future, pointing at once to a pre-existing desire and to an object imagined to satisfy it. Promises are a way to preserve the values they represent in the face of grounded experiences that challenge them. This is both their appeal and their danger. Promises can be a way to escape the conflicts and contradictions of social life—a sometimes useful function—or a way to make working through them more manageable. In an effort towards the latter, my examination of the promises of certainty and solvability has sought to illuminate tensions between desires to know everything and solve problems on the one hand and an embrace of political possibility on the other. I have suggested that new mobility, and digitality generally, promises certainty and solvability, and the examples of the empirical chapters will present my evidence for this claim. Here, however, I have argued that these promises are dangerous insofar as they tempt us into imagining a world free of difference, agency, and other threats to more complete knowledge and tidier solutions. Even if we were to accept those visions uncritically, a further danger is that promises do not tell us what to do when they are not fulfilled, leading us to turn to more promises in an ultimately unsatisfying cycle. In chapter 8 I will consider how the promise can be productively used as a way to engage with politics and difference, but the majority of my study of new mobility is focused on illustrating the dangers of promises that tempt us towards an unproductive escapism.

Before doing so, however, we will turn to the mess. I began this chapter by arguing that we need to see the promise and the mess together, since the promise is where we can grapple with values and desires, but the mess is where the situated differences of actual practice that those visions overlook. That is the subject of the next chapter.

CHAPTER 3

The Mess

In the previous chapter, I argued that one shortcoming of the promise—both in its circulation among social actors and in the study of it—is that it overlooks the grounded particularities of the people and things where it is generated and realized. If, as Mosco (2004, p. 6) claims, "it is when technologies…enter the prosaic world of banality—when they lose their role as sources of utopian visions—that they become important forces for social and economic change," then we need to see the mess to understand the difference new mobility technologies make. Inevitably, we will see that the transformation is not exactly as promised. But the mess important not just because it is where the promise fails, but also because it is where the promise recirculates. Here we can see the conditions that generate desires for certain technological responses and the ongoing work of keeping these visions alive within contexts of mundane experience. Seeing only through the lens of the promise then risks both overstating the power of technological structures to bring about change and understating the ways its visions are reproduced in countless everyday interactions. My study will see through the lens of the mess to show how, for example, planners' work of translating visions for micromobility use into data specifications requires the resolution of implicit contractions, and how travelers' experiences of accessing real-time information through their apps intensifies desires that perpetuate digitality's promise.

Aside from its utility as an analytical tool, however, I want to make a normative argument in this research for an embrace of the mess as necessary for urban politics. Cities reveal the complexity of agents in connected networks of people and things acting on myriad shifting desires. This is messy. Living well together means living with the indeterminacy of these relations, and ideally working through them, not against them, to move towards a future that is in some way better than the present. (I explore this idea further in the concluding chapter.) My caution about promises of certainty and solvability is that they teach us that the city can be improved by bracketing out difference and agency instead of by embracing them. This chapter returns frequently to two dimensions of messiness, materiality and agency, that often show up as obstacles to promises' realizations but ought instead to be seen as resources for making the city better. Materiality deals especially with technological artifacts, but also with human embodiment. Agency draws attention to the behaviors of people who act based on desires, but also the agency of objects. Together, these elements turn us away from the easy abstractions that underly so many promises.

This chapter deals with materiality and agency in two parts. The first, which examines infrastructures, platforms, and the connections between them, begins from the perspective of the system. It examines how people have used technological systems to order the messiness of social relations. This ordering of the mess is itself a kind of promise, and so again we find utility in this theoretical bifocal. Infrastructures envision a material coherence that solves a specific problem—the provision of some service equally to citizens. Platforms are a way of capturing the agency of users and making it legible within defined bounds, and are less interested in solving a problem than in delivering the certainty of quantified visibility. In my research, new mobility is a case of both infrastructure and platforms. Besides this empirical relevance, these frames are ways to illustrate more concretely the promises and practices of complex sociotechnical systems. This is a familiar approach from STS.

The second part looks more closely at the subject, examining theories that have challenged the abstract separateness of the liberal subject by putting her into relation with technologies and with other people. The first literature examines the technological subject using theories of posthumanism and technological mediation that seek to integrate technological artifacts at a fundamental level into the person we observe sensing and acting in the world. The second examines feminist philosophies of autonomy, which serve both to highlight the complexity of personal desires and to argue that personal desires and agency are always situated in social relations. The literature in this section paints a relational picture of subjectivity that is all but absent in visions of new mobility. Its ideas are especially applicable to my study of travelers, where I will examine how travel apps have become integrated into not just what people do, but what they want. But they are also a statement of the kind of relational view that I argue we ought to value and protect in the city, since its elimination would require a kind of domination.

Ordering systems

Although the title of this chapter is "the mess," this section theorizes the mess by examining an opposing concept—order. In arguing that digitality makes promises of certainty and solvability in the city, I see technologies as ways of carving order out of a complex and unpredictable world. I focus on two sources of disorder: the concrete artifacts whose materiality often resists the manipulations imagined in abstract visions, and the agency of people driven by plural and non-representational desires. This section turns to this messiness by introducing two technological approaches to ordering it, infrastructures and platforms. Each of these types of technological systems make promises that resonate with someone's ideal of how social relations ought to be organized. Infrastructures commonly promise that they will deliver a service reliably and universally, envisioning that anyone can *access* such services—energy, water, mobility, communication—to support their lives. This vision centers a distributive paradigm interested in the equitable allocation of resources. Platforms, by contrast, often promise their users that anyone can *participate* by making contributions—developing programs, posting content, or entering a market exchange—that are their own, rather than being determined by the platform. They further promise that regardless of the specific content of those contributions, their value will be concentrated in the platform itself. Compared to infrastructures, then, platforms are at once more open and more controlled. In rough terms, infrastructures promise solvability in their ends-oriented work of delivering goods, while platforms promise the certainty of data-driven visibility and predictability of user activity. These promises are not universal to all infrastructures or all platforms, but are common visions that guide their technical development. Both infrastructures and platforms also offer ample opportunity to observe the frictions between such promises and the messiness of actual production and use where they encounter the messiness of materiality and agency.

Recent work in media studies has claimed that seeing infrastructures and platforms together is increasingly necessary for understanding the roles of new digital technologies. Plantin, Lagoze, Edwards, and Sandvig (2018) point out that "both infrastructure and platform refer to structures that underlie or support something more salient" (p. 294). Their argument for using both of these frames is both descriptive and analytical. Empirically, they observe the increasing overlaps of these two fields as infrastructures have become more like platforms, with services controlled by corporations pursuing financial interests, at the same time that platforms like Google and Facebook have become ubiquitous, essential, and taken-for-granted like infrastructures. At the same time, they also argue that seeing digital networks as infrastructures and seeing them as platforms each offers something that the other does not. A platform lens illuminates issues of centralized private value capture and rapid development, while an infrastructure lens can "reassert the importance of widely available, universal, and relatively stable infrastructure as a foundation of social justice" (p. 307).

The literature in this section will show how urban studies has interacted with both infrastructures and platforms, but has much less often viewed them together. Urban planning, in particular, deals with concrete infrastructure far more than digital media. Clearly, however, each of these two frames has a direct empirical relevance to my case. New mobility can be seen as the intersection of transportation infrastructures and new smartphone-based digital platforms, and this study deals with roads and bus networks together with interfaces and data protocols. This section will introduce the differences between these paradigms—in particular the more stubborn materiality of infrastructures and the platform's greater attention to participant agency—that later chapters will show to be a source of friction in the planners' and travelers' realizations of new mobility's promise. In addition to this empirical utility, the discussion of infrastructures and platforms serves as examples of the kind of theoretical bifocals, seeing promise and mess together, that I argue are necessary for understanding what digitality does in the city. When these technological systems see the messiness of materiality and agency, they envision and implement ways to order it that in practice are always incomplete.

Infrastructure

For decades now, infrastructure studies has worked to foreground the social dimensions infrastructure rather than seeing only its technical functioning. Infrastructure in this view is not just a thing, but also "describe[s] a sensibility: a way of thinking and acting in the world capable of moving between the separate registers of technical and social action" (Jackson et al., 2007). I want to selectively draw out two points from this expansive literature. The first is to use infrastructure to introduce a core theme of materiality from STS, which argues that objects have agency, and artifacts have politics. Material artifacts embody promises—visions of specific social arrangements—and are the mechanisms by which those promises are realized in the world. Equally important, artifacts are the mess that challenges the realization of idealized technical visions. The messiness emerges because technical objects are inevitably situated in particular contexts extending beyond the boundaries of the designed system, and because they have an agency that so often escapes direct control. The second point to take from this work is that infrastructures are relations among people, and these relations point to both visions and practices. Infrastructures by nature work to connect disparate elements in a single system, and to facilitate some subsequent activity. These are political tasks, orderings of difference that contain within them the anticipation of a desirable future. I use the notion of the "modern infrastructural ideal" (S. Graham & Marvin, 2001) as an example of such a political vision taking shape in technical objects. From this brief overview, I develop the idea that material objects (and this includes digital data and algorithms) in infrastructural arrangements are sites where promises for social relations are articulated and where they become imperfectly realized.

Sociotechnical relations

Understanding the promise of infrastructures requires a brief introduction to ideas of sociotechnical relations that form the groundwork for science and technology studies. These ideas show us that social situations and visions shape technological systems, and that the artifacts of those systems continue to shape relations after their development.

For decades now, the fundamental claim of STS has been that the technical and the social are co-produced. Thomas Hughes, the early STS scholar who first popularized the term "sociotechnical," claimed that technological systems "are both socially constructed and society shaping" (Hughes, 1987, p. 45). Hughes and others illustrated this through thorough histories of the development of "large technological systems," electric power networks in Hughes's case, that showed them to be not self-contained or straightforward technical achievements, but contingent stories that emerged from choices of people and organizations situated in particular social and historical contexts (Bijker et al., 1989; Hughes, 1983). These accounts resist seeing anything in isolation: an improvement to a telephone is shaped by characteristics of its constituent parts, the telephone company is entwined with regulators and suppliers, the telephone customers use the tool in an unexpected way that feeds back into development, and so on (Callon, 1980; Fischer, 1992), with social and technical blurred in a "seamless web" (Hughes, 1986). These historical studies of large technical systems formed the basis of the "social construction of technology" (SCOT) framework that situates accounts of invention, engineering, and product development within their particular historical, institutional, and political contexts (Bijker, 1993; Bijker et al., 1989). Much of what is now called infrastructure studies has retained this interest the connectedness of technological artifacts and people making and using them (Sandvig, 2013).

The SCOT literature develops this sociotechnical picture through histories that trace the development and diffusion of specific technologies. Although my own study of the development of new mobility's data specifications (chapter 6) echoes this work, I will not give it a full summary here. Instead, I want to emphasize one key point, which deals with interventions to make disparate technologies compatible with one another. Hughes's (1987) commonly used description of the pattern of technological developments describes new technologies moving into wider and more diverse contexts, where they evolve in diverging directions. As they do, their original creator becomes a smaller and smaller figure, with less control over the extension, adaptation, and use of the technology. If this diffusion continues, then networks connecting these components will become inefficient or impossible. To gain the benefits of connection, disparate versions and uses of the technology must be re-integrated. These moments "often brings into sharp relief conflicts and incompatibilities with neighboring or alternative systems, and may be the site of particularly intense battles" over technical standards, institutional roles, and norms of use (Jackson et al., 2007). That consolidation can happen either by a single company acquiring competitors and eliminating their versions of the technology, or through gateways, what Jackson et al. (2007) call "technologies, organizational solutions, and/or protocols for interconnection that allow for mobility, conversation, and traffic between otherwise incompatible systems." Gateways can be imposed or de facto standards, such as railroad gauges or internet protocols, or they can be adaptors and converters that translate between heterogeneous systems. In this way, the development of technical systems is constantly working to contain the messiness of users, uses, and materials that differ from the initial vision.

SCOT's empirical illustrations of the inherently social origins of technological development challenges the alleged assumptions that technologies are naturally occurring phenomena whose discovery impacts a fundamentally separate social sphere. In this emphasis on people, however, other scholars have seen a problematic erasure of the things themselves. Without resorting to technological determinism, they argue that human actors are not the only ones with agency in technological systems. The analysis of human and non-human actors together, one of the fundamental tenets of actor-network theory, claims that artifacts *do* things. Michel Callon, an ANT pioneer, illustrates this in his study of the French development of an electric car:

> There are consumers, social movements, and ministries. But it would be wrong to limit the inventory. There are also accumulators, fuel cells, electrodes, electrons, catalysts, and electrolytes, for, if the electrons did not play their part of if the catalysts became contaminated, the result would be no less disastrous than if the users rejected the new vehicle, the new regulations were not enforced, or Renault stubbornly decided to develop [a gas car]. (Callon, 1987, p. 80)

For ANT, seeing people and things together is important not just for understanding how technologies are developed and disseminated, as Hughes and others had studied. More than that, this connectedness, the networks of human and non-human actors, is constitutive of the very thing we call the "social." For Latour (2005), references to "society" or "the social" are usually sloppy analytic shorthand for what are really associations—continual actions of connection, always coming and going, among different kinds of actors. Where sociologists are charged with putting forth immaterial and self-contained "social forces" while treating material objects as merely the background against which such forces play out, ANT foregrounds the non-human actors and claims that they are the stuff that holds these relations together (Latour, 2005). The fuel cells and electrodes are not just the result of social activities, they are mechanisms through which people can relate to each and those relations can endure. In this inversion, "technology is society made durable" (Latour, 1990).

Latour's development of ANT illustrates the agency of objects with mundane examples like an automatic door-closer or a speed bump, artifacts whose materiality—springs and asphalt, say—shape how people act (Johnson, 1988; Latour, 2005). His idea of *delegation* argues that artifacts are simply substitutes for people. Delegation avoids the numerous practical challenges of hiring a porter to open and close a door by replacing him with a simple mechanical device that does so automatically. Thus technologies are not just made *by* people, as the SCOT literature shows us, but they also replace human action, and then shape it (Johnson, 1988). The examples are ordinary, but the politics of this substitution come into focus when we recognize that we can "delegate to nonhumans not only force as we have known it for centuries but also values, duties, and ethics" (Latour, 1992, p. 232).

ANT, however, has been criticized for being descriptive about the work of human and non-human actors but failing to engage in normative political positions on power and values, despite Latour's insistence to the contrary. The question of how politics are inscribed in artifacts has been taken up most famously by Langdon Winner (1980, 1989, 1993), who is not explicitly an ANT scholar but has been enormously influential within STS more generally. He claims that the SCOT approach that dominated early STS work is useful for studying the social and political origins of technologies, but has been uninterested in its social and political consequences (Winner, 1993). The key to understanding those consequences, he says, is artifacts. In asking whether "artifacts have politics" (Winner, 1980), he answers that they do in two ways. First, and more obvious, are artifacts made to settle some political dispute, as factory machinery that replaces workers and therefore avoids labor negotiations. Less apparent, he says, are "what can be called inherently political technologies, man-made systems that appear to require, or to be strongly compatible with, particular kinds of political relationships" (p. 123). A nuclear power plant calls for a more authoritarian mode of control than household solar panels, for example.

Winner's most-cited example of an artifact having politics comes from urban planning (Winner, 1980). He tells the story of Robert Moses's bridges, based on Robert Caro's biography, in which Moses built the bridges over his Long Island parkways to Jones Beach too low for buses to pass beneath them. Moses did this deliberately, in this story, to prevent public transit, which would carry Black and Puerto Rican residents too poor to own cars, from accessing the beach. Robert Caro documents Moses's power among certain people over a defined historical period, Winner says, but

> the most important and enduring results of his work are his technologies, the vast engineering projects that give New York much of its present form. For generations after Moses has gone and the alliances he forged have fallen apart, his public works, especially the highways and bridges he built to favor the use of the automobile over the development of mass transit, will continue to shape that city. (Winner, 1980, p. 124)

The story of the bridges has been disputed on both historical and analytical grounds, with scholars arguing that the tale is a bit too tidy and that Winner's telling of it forecloses other interpretations (Joerges, 1999; Woolgar, 1991; Woolgar & Cooper, 1999). Nevertheless, Winner's broader point that material artifacts are "linked to specific ways or organizing power and authority" (1980, p. 131) and that such organizations endure with the artifact has become a core tenet of technology studies.

These are familiar ideas from STS that have now become the basis for generations of theorizing and research on sociotechnical relations. In the context of my study, what is important in the idea that "the things we call 'technologies' are ways of building order in our world" (Winner, 1980, p. 127) is that material objects contain within them the visions of the people who create them, and they continue to realize that promise, more or less successfully, as they travel through the messy world of other people and objects. Technological artifacts, then, are at once promise and mess, even when we are tempted to see only one or the other.

Infrastructural ideals and practices

Infrastructure studies largely falls beneath the STS umbrella, and this work applies the sociotechnical framework of STS to the production and use of infrastructures. Because of their distributive nature, infrastructures are helpful in seeing how technologies structure relations. They embed certain visions, but also enact them, partially, in their use. We can see in this work that infrastructures lend themselves to visions focused on the allocation of resources.

Like Moses's bridges, all infrastructures envision social relations, and recognizing this calls us to look beyond their technical functioning to understand how they enact relations of power and exclusion. As Susan Leigh Star reminds us, such analyses are critical but often overlooked: "Study a city and neglect its sewers and power supplies (as many have), and you miss essential aspects of distributional justice and planning power" (Star, 1999, p. 379). In pointing out the connection between technical and social ordering, Hughes (1987, p. 46) says that "one of the primary characteristics of a system builder is the ability to construct or to force unity from diversity, centralization in the face of pluralism, and coherence from chaos." The work of ordering messiness is always imperfect, but before examining where this coherence breaks down, it is worth understanding the unitary vision of the system builder. Here I focus on one such vision, what geographers Stephen Graham and Simon Marvin call the "modern infrastructural ideal."

Urban studies and planning has often viewed infrastructure from a political-economic point of view, especially in its concern with the distribution of resources. Graham and Marvin's influential book *Splintering Urbanism* (2001) was among the earliest calls for urban studies to see infrastructures in an STS-tinted light as not just hidden, technical operations, but as material sites for critical engagement with questions of political power and global economies. Their argument revolves around the modern infrastructural ideal: an integrated and standardized provision of infrastructural services to all citizens. This paradigm, which their history, focused in the Global North, locates in the century or so preceding the 1960s, centers the state as the singular provider of infrastructure and sees the public as a homogeneous mass for receiving infrastructural services. These infrastructure plans are comprehensive and rational, with a utopian view of integrating the parts of the city into a whole as a well-functioning machine. Hassmann's Paris is their paradigmatic example of a state's unitary view of urban functions and its infrastructural interventions aimed at domesticated improvements to urban life. Graham and Marvin's framing resonates with other accounts of the modern state's approach to governance, including the techno-rational progress described by "authoritarian high modernism" (Scott, 1998), the social-reform idealism of early twentieth century urban utopian planning (Fishman, 1977), and the rational-comprehensive model of modernist urban planning (Sandercock, 1998a).

Just as some of these planning histories narrate the disintegration of any notion of a singular public interest beginning in the 1960s, Graham and Marvin's account describes an accelerating "splintering" of the modernist infrastructural ideal in the final decades of the twentieth century. Shaped by distrust of government and liberal market rationales, infrastructures began to be characterized by competitive providers and segmentation of customers. Rather than aspiring to provide a common service to all members of the public, splintered infrastructures from highways and sewers to electric and internet service follow the paths of marketplace profitability. The state withdraws from its role as infrastructure provider, and "the public" become customers, exchanging money for services. The result is cities in which infrastructures provide premium service to some and subpar resources to others, as Graham and Marvin illustrate with examples including electronic toll roads and private security. Relevant to my project is their emphasis on information technologies as enabling this splintering through tools for the automatic identification and sorting of the city's inhabitants (S. Graham & Marvin, 2001). In this telling, modernist infrastructures represent a particular social promise—a central authority providing standard services equitably to all—while information technologies embody a different promise based on differentiation and market exchange.

Graham and Marvin's championing of the publicness of infrastructure resonates in subsequent literature within the "infrastructural turn" in urban studies, which also keeps alive the foundational premise that urban infrastructures are inherently political (Wiig et al., 2022). However, their story recalling a public that was once served comprehensively and universally by a central authority has been questioned on empirical grounds. Some authors have pointed out that state capacity has always been inconsistent, infrastructures have always served narrow interests, and, in a lesson from the urbanism of the Global South, the fragmentation of cities is hardly new (Coutard, 2008; MacKillop & Boudreau, 2008; Zérah, 2008). Evaluating this empirical support is not necessary for my broader point, which is that infrastructures are technologies that make promises, and those promises typically envision particular arrangements with separate producers and users of services. But understanding that actual grounded experiences of infrastructural promises—whether universal or splintered—will challenge the realization of these visions is another reminder that understanding the role of technologies in society requires examining the promises and the mess together.

Susan Leigh Star and Karen Ruhleder's (1996) seminal work on infrastructure studies offers a perspective for seeing both global visions and local practices. It does this with a relational framing. Rather than examining the *production* of large technical systems, the SCOT-influenced approach that helps us to identify the public ideals behind the development of a road network, infrastructure studies examines the continual production of a technology in its *use*. Star and Ruhleder argue that this is made difficult by infrastructure's tendency to disappear into the background when we focus only on the human activity that takes place upon it. By examining the conditions during which infrastructure emerges into the foreground, what Bowker (1994) calls an "infrastructural inversion," they ask "*when*—not *what*—is an infrastructure" (Star & Ruhleder, 1996, p.

113). The empirical context for their question is a study of networked information technologies within a dispersed collaboration of scientists. They are interested in whether change happens through transformations of large-scale structures, like computer systems, or through the local ad-hoc adaptations of users. Within such organizational situations, the authors worry that allowing infrastructures to fade into the background works to "obscure the ambiguous nature of tools and technologies for different groups, leading to de facto standardization of a single, powerful group's agenda" (p. 114). In other words, the vision of the tool has become invisible. Examining the relation between specific use and general affordances gives them an answer to their question of "when is an infrastructure":

> *An infrastructure occurs when the tension between local and global is resolved.* That is, an infrastructure occurs when local practices are afforded by a larger-scale technology, which can then be used in a natural, ready-to-hand fashion. It becomes transparent as local variations are folded into organizational changes, and becomes an unambiguous home—for somebody. This is not a physical location nor a permanent one, but a working relation—since no home is universal. (Star & Ruhleder, 1996, p. 114)

In this tension between universal standards and particular practices, infrastructures become "a working relation" that supports some activities and resists others. The core observation of their work, then, is that "infrastructure appears only as a relational property, not as a thing stripped of use," (Star & Ruhleder, 1996, p. 113). This relationship connects the messiness of particular situations of use to the more centralized and coherent vision represented by the system's affordances. The relationship is sometimes smooth and even invisible, and sometimes leads to frictions and breakdowns.

Such relational views of infrastructure are characteristic of what Plantin et al. (2018) call the "phenomenology and sociology of infrastructures," in distinction to the studies of the development of large technical systems. This work uses ethnographic approaches to understand the practices and relationships supported by infrastructures without losing sight of the material objects itself. Where the accounts of large technical systems tend to focus on the macro scale, infrastructure studies invites inquiries at the micro and meso scales (Parks & Starosielski, 2015). Brian Larkin (2013, p. 239) points out that "infrastructures are matter that enable the movement of other matter. Their peculiar ontology lies in the facts that they are things and also the relation between things." Larkin, an anthropologist, suggests that infrastructures can help ethnographers to see entire systems, rather than only local practices (see also Angelo & Hentschel, 2015), but also argues that anthropology can illuminate dimensions of infrastructure beyond the material or political. Infrastructure for him is semiotic, aesthetic, poetic, and embodied in ways that echo the affective dimensions of the promise:

> Roads and railways are not just technical objects then but also operate on the level of fantasy and desire. They encode the dreams of individuals and societies and are the vehicles whereby those fantasies are transmitted and made emotionally real. (Larkin, 2013, p. 333)

Much of the literature in this vein has come from the Global South, where formal infrastructures for the provision of basic services are absent or else highly apparent by virtue of their inconsistency (S. Graham & McFarlane, 2015; McFarlane & Rutherford, 2008). Infrastructures and their relations of use become easy to foreground in such circumstances. AbdouMaliq Simone observes that in informal Johannesburg, people themselves are infrastructure. They perform infrastructurally by necessity of survival through events and relations that are "radically open, flexible, and provisional" (Simone, 2004). Ash Amin (2014) similarly sees infrastructure as a "gathering force" for community struggle and recognition. This literature uses infrastructures as a way to work across ethnographic and political-economic scales.

Infrastructures help us to see a general point that technical objects are simultaneously promise and mess, and also that infrastructures, in particular, are objects that mediate relations among people. This relationality makes infrastructures' relevance to politics apparent in ways that it is not for many other technologies. We also see that because infrastructures deal with the delivery of services, their promises focus on questions of who receives and who provides those services. Platforms, as we will see, share this focus on managing connections to order heterogeneous elements, but are interested in what users contribute, not just what they receive.

Platforms

The study of digital platforms is much more recent and more narrowly focused than infrastructure studies. In general, work in internet studies is not a direct continuation of STS's projects, but also incorporates a mostly separate tradition of media and communication studies. Media theorist Christian Sandvig's (2013) argument for seeing the internet as infrastructure picks up the work of "relationists," the STS-influenced scholars showing the social processes within technical infrastructures, and puts it into conversation with the "new materialists" from media and cultural studies. He describes these literatures coming from opposite directions to meet in the same place:

> The relationists wanted to break away and brand intangible social practices so that they appeared just as important and solid as technical practices and objects. Following in the traditions of STS, they tended to start with a technology and gently or roughly lead their readers to exclaim, 'Oh, look: it's actually cultural!' (or political, or social, or economic). ... [The new materialists] are making the opposite transit. Starting in media studies and communication, they have long been concerned with the airy expanse of culture, but they want to lead the reader through an analysis of a communicative experience to eventually exclaim, 'Oh, look: It's actually material!' (or technical, or spatial). (Sandvig, 2013, p. 100)

This section introduces the digital platform, a particular technical and organizational form of networked digital communication. Platforms make a promise—supporting the activity of disparate actors in ways bring them together into a mutually beneficial network, without predetermining or controlling that activity—and they have a specific technical structure that embodies that vision. They envision bringing some degree of order to the messy business of human agency, and so deal with a tension between openness and control. The first part of this section introduces the tension of the platform's promise using literature in digital and internet studies. The second part then turns to the city, and the emerging subfield of "platform urbanism," to position the material and personal messiness of the city as a site to examine where this promise is or is not realized. Platforms are modes of relations constrained by strict technical requirements and corporate rules that are nevertheless indeterminate and plural. Situating platforms in the city helps show that their data, APIs, and user interfaces come into being, like any technology, in a web of existing infrastructures, artifacts, institutions, relations, and desires.

Structures: The promise of "a raised level surface"

Platforms have been a topic of study within media and information studies since the late 2000s, led by Montfort and Bogost's (2009) book on Atari's home video games from the 1980s. Introducing a theme that has continued in platform studies, they examine the relationship between the technical structures of the console and the creative cultural expression of the games designed for it. Critical studies of digital platforms picked up steam in the 2010s as more activity on what we refer to generally as "the internet" began to take place on platforms. In its technical usage, a platform refers to a digital system designed to be extended by outside programmers beyond its initial development. Marc Andreessen, the well-known Silicon Valley investor and innovator, emphasizes programmability in his definition of platform:

> a 'platform' is a system that can be reprogrammed and therefore customized by outside developers—users—and in that way, adapted to countless needs and niches that the platform's original developers could not have possibly contemplated, much less had time to accommodate. (Andreessen, 2007; quoted in Helmond, 2015, p. 3)

Microsoft Windows is a platform in this sense since it is built with the expectation that developers outside of Microsoft will create applications that run on Windows. Programmable platforms became common on the internet by the mid to late 2000s with the growth of "web 2.0" sites like Facebook and Flickr that allowed users to build applications that exchange data with the core platform (Helmond, 2015). However, the term "platform" in common usage quickly expanded beyond a technical sense requiring the development of new software to include a broader notion of user participation that extends a core system in unanticipated directions. The platform "user" is not necessarily a developer, but is nonetheless a creator, not just a consumer. This wider scope includes platforms for users to post and view media content (Facebook, YouTube), sell goods (Amazon, eBay), and hire gig labor (Uber, TaskRabbit, DoorDash), among others (Langley & Leyshon, 2017).

Calling these disparate systems "platforms" is a political move, Tarleton Gillespie (2010) argues. The image of a platform evokes a "'raised level surface' designed to facilitate some activity that will subsequently take place" (p. 350). The platform is anticipatory, directing attention to what it will enable rather than what it is. It says nothing in itself, but offers the foundation on which anyone can stand and be heard. In this image, it is egalitarian and grassroots, inviting any kind of participation and validating the popular will. It is also neutral, so that the platform merely sets the stage but does not write the script. Gillespie demonstrates how the discourse of "platforms" works to allow new media companies to evade legal accountability for the content of the platforms while also inspiring hopes for more democratic cultures and markets made possible with the demise of more active media gatekeepers (Gillespie, 2010). Gillespie's work shows the platform to be a promise: anyone can participate as they like, and can connect with others.

Much of the platform studies scholarship has focused on challenging this narrative of openness, showing platforms instead to be sites of control. The authors of *The Platform*

Society, an influential book positioning platforms as producers of social structures, define a platform as "a programmable digital architecture designed to organize interactions between users—not just end users but also corporate entities and public bodies" (van Dijck et al., 2018, p. 4). Echoing a theme of infrastructure studies, these and other authors emphasize the politics inherent in any tool that organizes people and publics. This literature generally begins from one of two scales: the macro political-economic scale of capitalism, corporations, and the state; or the micro scale of everyday behavior and encounters with the intermediated artifacts of the platform (Schwarz, 2017). The capitalist critiques see new digital platforms as more or less familiar forms of capitalist exploitation, with tendencies towards winner-take-all monopolies. Platforms in this view are capitalism's attempt to maintain growth by monetizing digital data about social relations (Srnicek, 2017), a centralized extraction of revenue from disparate economic circulations (Langley & Leyshon, 2017), a mode of automated governance (Schwarz, 2017), or a cause for new approaches to regulation to protect public interests (Nash et al., 2017).

Understanding the platform's operations across scales requires examining how they deal with connection and control, which offers a bridge to infrastructure studies (Plantin et al., 2018). As discussed above, as infrastructural technologies diverge through the contributions of heterogeneous actors, disparate parts must be connected through gateways, including standards and adapters. Infrastructures in this way are interoperable but decentralized; they are networks with no single point of control (Jackson et al., 2007). This, roughly, is a description of the internet. Computers, servers, and digital resources are developed independently using a variety of hardware and software, but information can be exchanged according to open protocols (e.g., TCP/IP, HTTP) that allow access for anyone to exchange data across networks without any centralized distribution (Galloway, 2004).

The internet that is sometimes called the "open web" works this way, but increasingly these protocols have become merely the substrate of the more centralized model represented by platforms. Platforms are typically built on APIs ("application programming interfaces"), which provide for interoperable data exchanges among disparate programs (A. Mackenzie, 2018). However, the API is centrally controlled by the individual platform, usually one with an interest in its own profit. This is the internet's shift from "open web" to "walled gardens" (Helmond, 2015). Outside actors are free to create new programs, but they must do so in a way that is compatible with a specific platform. While internet standards like HTTP or POP are open, widely used, and change very slowly, APIs for something like Google Maps or WhatsApp are proprietary, narrowly defined, and can change at the whim of their corporate owners. Many such APIs make it technically difficult for programs built for one platform to easily switch to another. A similar lock-in dynamic is at play with other, less technical kinds of platform participation, like building a network on LinkedIn or driving for Uber. The digital platform is thus easier to contribute to than many infrastructures (compare posting to Facebook with setting up your own server, or driving for Uber and building a subway line), and in that sense it is more open. At the same time, it has a center with greater power to define the terms of participation.

Anne Helmond (2015) uses the API to illustrate what she calls the "platformization" of the web—the shift from web *sites*, which use HTML and internet protocols to deliver human-readable content, to *platforms*, whose content must be legible to both humans and to the platform. Platformization for Helmond has a "dual logic" of "social media platforms' expansion into the rest of the web and, simultaneously, their drive to make external web and app data platform-ready" (Helmond, 2015, p. 8). In her example, the Facebook "share" and "like" buttons are integrated into websites outside of facebook.com, but are made visible to the Facebook platform through APIs. Successful integration of these APIs require websites to be "platform ready," by using more structured data formats (e.g., XML rather than HTML), embedding certain code, and sharing more data with Facebook (Helmond, 2015). In this way, the platform "decentralises data collection and recentralises data processing and economic valorisation" (Gerlitz & Helmond, 2013, p. 1361), so that all of the web can in some sense be part of Facebook even though Facebook need produce neither the code nor the content of this expanded domain.

Helmond (2015) calls this making the web "platform ready," and sees it as a specific instance of what Tarleton Gillespie (2014) describes as making data "algorithm ready"—the often overlooked and sometimes labor-intensive practices of preparing data to be an input into a specified procedure. This points to broader themes of critical digital scholarship around the generation, exchange, and analysis of digital data. The age of "big data" is founded on processes of "datafication" (Mayer-Schönberger & Cukier, 2013) in which once ephemeral everyday practices now leave digital traces, "rendering what previously would have been informal exchanges into much more formalized rules of engagement" (Schwarz, 2017, p. 377; see also Amoore & Piotukh, 2015; Langlois & Elmer, 2019). This formalization—for purposes of data sensing, collection, transmission, storage, manipulation, analysis, etc.—requires certain structuring, which necessarily involves orderings and exclusions. Classes must be defined and mapped imperfectly to actual phenomena (G. C. Bowker & Star, 1999), and even "unstructured" data must be massaged and manipulated in preparation for digital storage and use (Gitelman, 2013). Criticisms of platforms often note their datafication of everyday life and the centralization of this data in the hands of a few corporate actors (Srnicek, 2017; Thatcher et al., 2016; Zuboff, 2019). For the platform, however, it is equally important to recognize that the initial structuring of this data to make it legible to the API and the platform has its own power and exclusions. I examine this in the study of data specifications in chapter 6, which examines the choices software contributors face in defining data formats.

Compared to infrastructures, platforms are more likely to see users as participants who contribute something to the network—e.g., a program, a post, a ride—rather than as simply consumers of a service. Indeed, these contributions and their data are the source of the value that the platforms promise. Moreover, platforms do not *want* to control the contributions; they want the openness of users' agency, which produces value in unexpected ways. However, ceding control is messy, and platforms seek to order this messiness through technical constraints that ensure that heterogeneous platform participation will be legible, and its value captured, in a standardized network. Platforms promise an openness and control simultaneously, a way of tapping the energy of indeterminate agency but also ordering its chaos for the benefit the platform's center.

Participation: The messiness of platform urbanism

While studies of platforms at the macro scale have critically examined technical architectures and corporate agendas, platforms must also be understood from the everyday scale of personal encounter. These interactive and participatory dimensions of platforms have been analyzed since the earliest days of platform studies, but are sometimes overshadowed by corporate or technical lenses. The participatory lens means that understanding a platform requires not just seeing its structure, but examining "the relations among devices, people, and the urban" in which platforms are embedded (Fields et al., 2020, p. 465). Such an approach is generally more useful to my study than the broader political-economic critiques because it destabilizes the digital promise as a self-contained object to show instead how people encounter and enact the promises of these structures on the ground. Geography and urban studies have been especially effective at situating platform politics within contexts of everyday relations, looking beyond data on screens to see people's attitudes and behaviors. The emerging literature engaging with "platform urbanism" (Barns, 2020; Leszczynski, 2019a; Richardson, 2020a; Rodgers & Moore, 2018) builds on infrastructure studies together with existing work in geography that had sought to articulate relations between the urban and the digital (Ash et al., 2018; Kitchin & Dodge, 2011). In examining the "emergent, irreducible, co-generative dynamics between platforms and the urban" (Rodgers & Moore, 2018), this literature has extended the platform lens beyond digital concerns of APIs and programs to consider the spatial and social manifestations of these digital arrangements.

Like infrastructure, platforms are relational. As suggested above, however, the activity that takes place on a platform is personal and social in ways that using tap water or driving on a road is not, leading Sarah Barns (2019, p. 2) to call them "highly participatory ecosystems of interaction." Her use of "ecosystems" is meant to suggest that platforms are not easily bounded; like infrastructures (Sandvig, 2013), platforms build on and connect to one another, and cannot be seen in isolation (van Dijck et al., 2018). Geographers remind us that these relations are always spatially situated. The platform then is not just a digital specification or a company, but, as Richardson (2020a) puts it, a "flexible spatial arrangement." She argues that platforms organize relations "not through new physical infrastructures, but instead through novel technologies of coordination" applied to existing infrastructures (p. 460). Such literature echoes precedent studies of the relational nature of infrastructure, while also doing the work of spatializing the seemingly abstract information flows of platform data.

There is an ambivalence in this literature when it comes to evaluating participation in platforms. The paradox of platforms is that they are "flat and level" and "vertical and stratified," built as both network and hierarchy (Krivỳ, 2018, n.p.). It is difficult, then, to say that these arrangements are unambiguously supportive of a democratic public or not. Van Dijck and co-authors (2018) see platforms as an increasingly important site for struggles among competing value systems, especially those of public and corporate interests. The "platform ecosystem," they argue,

> is moored in paradoxes: it looks egalitarian yet is hierarchical; it is almost entirely corporate, but it appears to serve public value; it seems neutral and agnostic, but its architecture carries a particular set of ideological values; its effects appear local, while its scope and impact are global; it appears to replace "top-down" "big government" with "bottom-up" "customer empowerment," yet it is doing so by means of a highly centralized structure which remains opaque to its users. (van Dijck et al., 2018, p. 12)

Some scholars focus on the ways that "digital platforms may seem to create individual freedom, [but] they in part do so by concealing the pushing, nudging and pulling that set the context and boundaries for that individual freedom" (Törnberg & Uitermark, 2020, p. 9). Butt et al. (2016) argue that participation in platforms is that of a user rather than a citizen, fostering individualistic consumers propping up a corporate agenda. The problem, they argue, is not just the neoliberal goals of the platform, but the situation in which "the ability to *architect* networks is becoming increasingly withheld from a general public who merely get to *inhabit* networks" (Butt et al., 2016, p. 740).

Yes, platforms exert control over their participants, directing and constraining behavior in ways that accrue value to platform owners, and these arguments appear frequently in the platform urbanism literature (Langley & Leyshon, 2017; Langlois & Elmer, 2019; Schwarz, 2017; Srnicek, 2017). But a different branch of the literature reminds us that users "are not 'puppets' of the techno-commercial dynamics inscribed in a platform" (van Dijck et al., 2018, p. 11). This tack, which focuses on the frictions and agency within these structures (G. Rose, 2017), has proven useful for my project because it recognizes that promises—whether based in hope or fear—are never realized wholesale.

These promises matter most insofar as they interact with the actual people who produce and interact with them, not as abstract ideals. Platform urbanism studies attentive to these everyday encounters situate digitality within both materiality and agency. They argue that platforms directing exchanges in cities must engage with the messiness of urban infrastructures, and that they act with, through, and against the affect and embodiment of individual subjects (Barns, 2019, 2020; Bissell, 2020; Leszczynski, 2019a, 2019b; Shepard, 2013).

Agnieszka Leszczynski's (2019a) call for a "minor theory" (Katz, 1996) of platform urbanism is a good example of this turn. Rather than continue the "dystopian critiques of the universal capitalist and/or neoliberal essence of platforms and the platform-mediated city," (p. 190), she points out that "urban environments are not a priori vacant *tabulae rasae* into which platforms and their capitalist machinations descend from a disembodied ether" (p. 195). By viewing platforms with Sarah Barns as sites of "mundane connectivity and interaction" that begin not with totalizing narratives of dispossession but with "everyday interactions of smartphone-equipped urban subjects" (Barns, 2018), Leszczynski returns at least some measure of control to users, inhabitants, and participants. With vignettes of platform "glitches," the moments when the platform does not perform as anticipated, she seeks to counter the danger of capitalist critiques "desensitiz[ing] us to the everyday instances where platform urbanism is neither frictionless nor inevitably successful" (Leszczynski, 2019a, p. 195). Looking at the mundane and messy can avoid the "defeatist" structural analyses to reveal possibilities at a smaller scale:

> Working from the empirical, glitchy specificities of actually-existing platform/city interfaces up rather than from dialectics of production/reproduction and accumulation/dispossession down engenders a more hopeful theorization of platform urbanism by divesting us as scholars from ideological resignations to platform urban dystopia as sole possible outcome of intensifying integrations of platforms and cities. (Leszczynski, 2019a, p. 202)

Affect is an important lens for this kind of work. Bissell (2020) and Leszczynski (2019b) have each used individual experiences of urban platforms—food delivery and navigation apps—to show that these are more than technical or economic exchanges, but they affect people, mobilizing certain embodied sensibilities of, for example, trust or anxiety. Bissell in particular emphasizes the ambivalence of platform users to show that the imagined manifestations of platforms, whether utopian or dystopian, are neither universal nor inevitable.

For these authors, then, the urban is neither the backdrop against which platforms perform their work nor the imperiled target of platform domination. Rather, it is the mud that digital exchange slogs through. The city is where platform participation is enacted—food is delivered, driving directions are followed, Airbnbs are rented—and where its inseparability from asphalt, lock boxes, kitchen staff, personal whims, and decent wifi is revealed. In this, the city is the mess that platforms (among many other structures) work to order, often successfully. It reveals the frictions between the vision represented by digitality and the practices of the surrounding materiality and individual agency.

Subjectivity

Materiality and agency are sources of messiness, the plural particularities that can never be fully accounted for in the promise's visions or controlled by the ordering apparatuses of infrastructures and platforms. This section introduces theories that help us understand the nature of this messiness. They show that the messiness of materiality and agency is not simply a product of their differences—the fact that each instance of some category of object or each action taken by some person will vary in meaningful but incalculable ways from the others. Much more than that, the messiness is a product of their relationality, the condition in which an object or an action cannot be isolated from countless others that enable, constrain, direct, or, more fundamentally, co-constitute it. Promises are by nature abstractions, and so it is not surprising that they simplify or overlook entirely this relationality; enabling us to envision a world more clearly is their core function. The trouble, however, is that when we mistake this map for the territory, we lose sight of the relations—social and technical—that constitute our lived experience. Certainty and solvability especially favor seeing elements as ontologically separate, so that we can predict what they will do and decide how to intervene. This leads us to mistake a tool, rather than a tool-person hybrid, as the means to a desired end, or to mistake those desires as self-given and stable drives rather than as the fluid products of encounters with other people and things.

While the ordering systems of infrastructure and platforms discussed above deal with a systems scale, this section turns more clearly to the personal. It addresses two categories of theories: philosophies of technology, especially ideas of posthuman subjectivity and sociotechnical mediation, and philosophies autonomy, focusing on theorizations of desire and feminist relationality. Rather than focus on how human values shape technology, as SCOT does, the technological theories in this section ask how tools shape what it means to be human. Further, rather than describe how artifacts are constitutive of *social* relations, as ANT and infrastructure studies do, these theories are more likely to focus on the embodied experiences of *individuals*. The work in autonomy is useful for taking the question of agency that has been raised by various technological theories and connecting it to an evaluation of desire, which is the animating force behind the promise. Autonomy also introduces a moral dimension that is lacking in descriptive ANT work.

The rejection of the liberal subject is the common thread connecting much of this work. The liberal subject deals with ideas of abstraction and individualism; it is a frame that suits certain ideals better than any reality. Efforts to see the subject differently are not just a project for academic theorists, but have real applications in our practical engagements with technological development. In her book on the regulation of networked technologies, law scholar Julie Cohen (2012) argues not only that that legal notions of liberty based on an autonomous individual are blind to how "the social and political agency that manifests in everyday practice is constrained and contingent in myriad ways." (p. 50), but that efforts to limit such constraints on individuals are missing the fundamental connectedness of subjects:

> Human being and human societies are constituted by webs of cultural and material connections. Our beliefs, goals, and capabilities are shaped by the cultural products that we encounter, the tools that we use, and the framing expectations of social institutions. Those processes play out in concrete contexts, involving real spaces and artifacts that we encounter as embodied beings. (Cohen, 2012, p. 5)

For Cohen, the individuality and abstraction of the liberal subject have led to specific legal approaches to internet technologies that are inadequate for the ways these technologies actually shape out individual and collective experiences on the ground.

Put together, the theories in this section will help us to understand both why urban mobility looks so different on the street than in the visions of digital promises and why we should not want to eliminate that messiness, since it is the stuff that constitutes the self as a subject. Although this relationality frustrates the promise, the promise's visions are themselves a part of the mix, and we will see in the empirical work, especially the traveler study, how they intensify desires for certainty and solvability that are changing subjects' understanding of themselves.

The technological subject

Imagining that technologies are instruments of certainty and solvability can blind us to the ways that such knowledge and control is always bound up with human materiality and agency. In this section, I introduce theories that can help us see people and technologies as co-constitutive. Rather than seeing technologies as a separate force for controlling or empowering people, these theories see the human subject as always already technological. The ideas of feminist posthumanism challenge the abstract separateness of the liberal humanist subject, while theories of sociotechnical mediation and the interface focus more closely on the question of how human desires and behaviors are shaped by technologies. They differ in their particular emphases, but all of them point to the ways that technologies are always mixed up with the agency of particular situated humans. This suggests that promises of technology solving a problem risk overlooking the embeddedness of the tool in a human subject, locating the solution in a technology instead of in a technologically constituted human.

The posthuman cyborg

Posthumanism, especially as developed within feminist theory, is a response to the humanist ideas that ascended to dominance in Western thought beginning in the Renaissance and has taken various forms in the philosophies of the Enlightenment, political liberalism, existentialism, phenomenology, and more. Despite their differences, these views recirculate a few themes that have become targets of thought. One is that its image of the "human" is an abstraction, an unmarked ideal that ignores difference. This human abstraction is implicitly given as a white man, and in treating this specific form as the exemplar of the human, humanism excludes the vast majority of humanity (Braidotti, 2013). Relatedly, humanism's treatment of the body is abstract, referring not to a specific bodies situated in a time in place, but a general human body that exists primarily as an object of discourse (K. Hayles, 1999). Humanism gives primacy to rational thought, in the Enlightenment, or, in twentieth century existentialist thought, to a sensing body, but overlooks embodied difference among subjects. Finally, humanism assumes an essential division between subjects and objects (Behrent, 2013; Verbeek, 2011). The conscious, acting subject is the center of the humanist perspective, and is viewed with a fundamentally sovereign independence. To its critics, at least, humanism sees the natural world, human artifacts, and even other people as external to the formation of this subject.

Posthumanism, by contrast, sees this view of subjectivity as inadequate for understanding how people form within and relate to their worlds, and so seeks to develop "a theory of subjectivity as both materialist and relational" (Braidotti, 2013, pp. 51–52). In collapsing the humanist self-other dialectic, posthumanism is a project of blurring boundaries. Donna Haraway's (1991) theory of the cyborg, "a hybrid of machine and organism" (p. 149), is perhaps the most influential expression of this blurring. Her cyborg manifesto attacks two categories of boundaries. The first is her observation of the "breakdowns" of distinctions between humans and animals, between organisms and machines, and between physical and non-physical that contemporary advances in science and technology, from evolutionary theory to computers, have made untenable (pp. 151–153). The second is the boundary between the materiality of tools and lived reality on the one hand and the myths, fictions, and discourses they sustain on the other, a version of my call for a theoretical bifocal that sees both promise and mess. Haraway's argument is not just ontological, but political. She claims that the feminist and progressive impulses towards "deepened dualisms" forces them to see "an imagined organic body" as the only site of resistance to technological and societal domination, but that a cyborg perspective opens up "other forms of power and pleasure in technologically mediated societies" (p. 154). More than pointing out that technologies "are possible means of great human satisfaction, as well as a matrix of complex domination," Haraway's stronger argument is that seeing them separately from the human organism, instead of being "in communication with all of our parts," blinds us to the possibilities of both domination and liberation that the cyborg offers (p. 181).

Much of feminist posthumanism echoes Haraway's cyborg, and its development at the same time as the modern expansion of technologies transforming all aspects of life is not coincidental. Such changes, especially in the advances in digital computation, have invited speculation that the human body and mind can be replaced by machines, or fears that some essential human capability is lost in its relation to technologies. According to Katherine Hayles (1999; 2010), who has given some of the best theorizations of posthumanism, these views simply reinscribe the humanist conception of sovereign subject of humanism. Rejecting this view

> does not really mean the end of humanity. It signals instead the end of a certain conception of the human, a conception that may have applied, at best, to that fraction of humanity who had the wealth, power, and leisure to conceptualize themselves as autonomous beings exercising their will through individual agency and choice. (K. Hayles, 1999, p. 286)

For Hayles, emerging technologies simply reveal a social and material interdependence that has always been the basic condition of human life "embedded in a material world of great complexity...on which we depend for our continued survival" (N. K. Hayles, 2010, p. 5), but has been invisible in a liberal humanist view that sees an individual reasoning mind as the sole site of human existence. Technologies in this view can be good or bad, but they are not external to the human condition. This separation, she says, is a source of unnecessary anxiety:

> As long as the human subject is envisioned as an autonomous self with unambiguous boundaries, the human-computer interface can only be parsed as a division between the solidity of real life on one side and the illusion of virtual reality on the other, thus obscuring the far-reaching changes initiated by the development of virtual technologies. Only if one thinks of the subject as an autonomous self independent of the environment is one likely to experience the panic performed by [technology pessimists]. This view of the self authorizes the fear that if the boundaries are breached at all, there will be nothing to stop the self's complete

> dissolution. By contrast, when the human is seen as part of a distributed system, the full expression of human capability can be seen precisely to *depend* on the splice rather than being imperiled by it. (K. Hayles, 1999, p. 290)

In response to the disembodied rationalism of the liberal subject, Hayles and other posthumanists draw our attention to the materiality of the human experience. Importantly, this materiality is located in both bodies and machines. The recognition of the relation between them is essential to understanding how we think, not just in the computer age but for thousands of years. Materiality thus has meaning; it "marks a junction between physical reality and human intention" in what she calls "the constructions of matter that matter for human meaning" (N. K. Hayles, 2010, p. 3). Hayles's work locates intention, meaning and desire in, for example, embodied practices of nineteenth-century telegraph operators (N. K. Hayles, 2012a) or computer code written as an author writes a text (N. K. Hayles, 2012b). Throughout her work, Hayles insists that human thought, action, and meaning is and always has been emergent from relations between bodies and machines, ideas that echo throughout posthuman thought (Barad, 2006; Braidotti, 2013; D. J. Haraway, 1991).

Posthumanism has also challenged the imagined social independence of the liberal human subject, developing a relational perspective that echoes in the discussion of autonomy below, but I have focused here on its blurring of human and technological boundaries. This is also the focus of the following discussion of theories of sociotechnical mediation.

Mediation and interfaces

Coming from a different lineage than that of posthumanism, philosophies of technology have for a long time circled around the questions of whether, how, and to what degree technologies direct or restrict human agency. Rather than asking, as SCOT does, how technologies are *products* of particular historically situated human activities, these theories begin with a technological object and ask how it *shapes* what a person does. For many critics, technologies threaten to oppress the individual will, making them dominating forces like capitalism or the state. Views of technologies from twentieth century critics like Jacques Ellul, Karl Jaspers, and Martin Heidegger saw them as threatening something essential to the human experience, using an imposed rationalist order to alienate us from our true selves (Behrent, 2013; Verbeek, 2011). A different set of views, what Feenberg (1991) calls the "instrumentalist theories," see technologies as merely the neutral tools, whether designed well or poorly, that serve someone's independently derived purpose.

Without saying so explicitly, both of these views reinforce a separateness of the human subject and a technological object, which either serves or obstructs a true human will. This division is apparent in many familiar criticisms that see digital technologies as ordering social life, which either conforms or resists. Lessig argues that software restricts people just as laws do; it "constrain[s] some behavior [and] makes certain values impossible" (Lessig, 2006, p. 125). Woolgar is concerned that designers do not just *imagine* an ideal user, they attempt to *create* this person through "a set of design (and other) activities which attempt to define and delimit the user's possible actions," in this way working to "configure the user" (Woolgar, 1990, p. 61). A robust literature, much of it using Foucauldian biopolitics or Deleuze's (1992)"societies of control" thesis, have seen digitality as a tool for controlling human behavior, either through either direct manipulation or softer nudging (Cheney-Lippold, 2011; Franklin, 2015b; Galloway, 2004; Krivỳ, 2016; Pasquale, 2015; Sadowski & Pasquale, 2015). Within the digital geographies and smart cities literatures, software is often seen as automatically producing space and directing human interaction within it (Dodge et al., 2009; S. D. N. Graham, 2005; Kitchin & Dodge, 2005; N. Thrift & French, 2002; M. Zook & Graham, 2018).

Writing from a posthumanist perspective, Gillian Rose (2017) faults such accounts for theorizing the agencies of technologies and humans separately, with human agency appearing "as a supplement" (p. 782) or "as excessive to—that is, distinct from—the agency of digital technologies" (p. 783). Rather than locating human agency only in acts of resistance or evasion, she says, we need to "theorize a posthuman form of agency by pulling it through—rather than leaving it as a supplement to—an account of digital mediation" (p. 783). Doing so allows us to recognize that any change in the world we can envision must be enacted through people and tools together.

One way to avoid separating the agency of objects and people is through views of technological mediation. Verbeek, for example, asks us not to imagine technologies as external to humans, but to see

> the fundamental intertwining of these two domains. The two simply cannot be separated. Humans are technological beings, just as technologies are social entities. Technologies, after all, play a constitutive role in our daily lives. They help to shape our actions and experiences, they inform our moral decisions, and they affect the quality of our lives. When technologies are used, they inevitably help to shape the context in which they function. They help specific relations between human beings and reality to come about and coshape new practices and ways of living. (Verbeek, 2011, p. 4)

Theories like these that ask how technologies *shape* action but do not *determine* it open up a way for understanding how people have agency *and* technologies can influence behavior. Latour offers a vocabulary for this work: "In addition to 'determining' and serving as a 'backdrop for human action', things might authorize, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid, and so on" (Latour, 2005, p. 72).

Andrew Feenberg articulates this common claim that technologies contain but do not control the agency of their users. Building on de Certeau's (1984, p. 98) illustration of how a grid of city streets "organizes an ensemble of possibilities" for the walker, he argues that

> technological strategies create a framework of activity, a field of play, but they do not determine every move. Like all plans or rules, they are coarse grained compared with the actual detail of concrete activity. Furthermore, the technical system is not just a plan in the heads of a few administrators; it is a real thing with its own properties, its own logic. To the extent that this logic has not been perfectly anticipated and mastered—and it never can be—there will be breakdowns, irrationalities or imperfections in the order of the plan. (Feenberg, 1991, pp. 88–89)

These breakdowns are reminders of the contrasts between the simplicity of the myth—the "technological strategies"—and the messiness of actual practice. But in this account, that mess is nonetheless a product, in part, of a technological logic; the messy activity still takes place within an established structure and is to varying degrees shaped by it.

This view puts technologies in an "actively mediating role in the relationship between human beings and reality" (Verbeek, 2011, p. 7). Mediation means that

> a technology is not simply one of the objects of the world that a person encounters, perceives, or acts upon. A technology comes in between a person and the world, mediating the relation between the two. It changes the user's encounter with the world, alters their perception, and transforms their capacity to act. (Rosenberger, 2018, pp. 185–186)

Don Ihde (1990) examines this distinction between technologies that sit between a person and either how they perceive the world of how they act in the world. Eyeglasses and a thermometer, in different ways, each mediate how we perceive the environment. A speed bump, a very simple technology, mediates how it is possible to drive. In its presence, a car ride that is both fast and smooth becomes impossible. Technologies of perception and of action are roughly parallel to the promises of certainty and of solvability that I study. For Verbeek (2005, 2011), however, describing these mediating roles, as ANT might, is insufficient. Instead, mediation means we must see technologies as moral objects. Indeed, he goes so far as to claim that in a world saturated with technological mediation, it makes little sense to talk about human intentionality—the basis for morality—without technologies. This perspective is key to my observation in chapter 7 that travelers' desires, and not just their actions, are shaped by apps.

As these theories fold technologies more closely into human agency and morality, they point to view of technology that is subtly different than that of mediation. Haraway's cyborg is not a natural organism whose activity is mediated by machines; the cyborg is in itself a human-machine hybrid. Rather than seeing technology as sitting between the person and the world, posthumanism sees technology as part of that person in the first place. This perspective also guides theories of the interface. The interface is a threshold, a part of two otherwise separate things at once and without any existence distinct from them (Hookway, 2014). While design disciplines and human-computer interaction studies tend to see the interface as an instrument through which a technology user can achieve an objective, interface theory has positioned the interface not as an object, but as a productive relationship. Like infrastructure studies, it sees the relational nature of technological artifacts, but interface theory is especially interested in the personal, rather than the social, nature of this relation. Much of this work, directly influenced by posthumanism, has come from literary theory and the humanities, with their emphasis on the literary subject (Black, 2019; Drucker, 2011; Galloway, 2012; Hookway, 2014).

Working to erode the division between human and technology, the interface here is not an object to be designed or studied in user trials as an HCI perspective might see it, but a "zone of relation" (Hookway, 2014, p. 39) that produces certain kinds of subjectivity. Drucker is especially interested in subjectivity:

> Interface is not a thing, but a zone of affordances organized to support and provoke activities and behaviors probabilistically, rather than mechanically. [Interfaces] constrain and order the possibilities of meaning producing conditions, but do not produce any effect automatically. In fact, the very term 'user' needs to be jettisoned—since it implies an autonomy and agency independent of the

> circumstances of cognition—in favor of the ‘subject’ familiar from critical theory. (Drucker, 2011, pp. 7–8)

For Drucker and others, subjectivity helps untangle the question of agency in human-machine relations. Rather than employing a mechanistic view, with a measurable goal like efficiency maximization that is more or less determined by the effectiveness of the interface, the figure of the subject invites a fuzzier view of interpretation in which meaning is produced. This interaction is a performance in which the subject is active; it is a dynamic event rather than a thing (Drucker, 2011). A “subject” refers paradoxically to a figure who acts and to a figure who is dependent on something else. If the interface is not a thing but a relation between things, then it is “consequently difficult to assign with any precision the location within which a given decision is made, or to whom or what the authorship of power should be attributed” (Hookway, 2014, p. 23).

This is a stronger position than that of ANT, which argues that objects have agency and offers a object-mediated associations as a reconception of “society,” but does not develop a reconception of human subjectivity (Braidotti, 2013). Interface theory, and posthumanism generally, is interested in, for example, the way that “non-human material interactions exist *inside* human subjectivity, in the sense that human capacities for perception and action are always to some degree produced by our bodily engagements with features of the environment” (Black, 2019, p. 9) What is important, then, is “not how we experience technological artefacts, but rather how technological artefacts become integrated into our embodied experiences of the world around us” (Black, 2019, p. 2). This shift destabilizes the separate technological artifact as the object of interest and instead locates agency in hybrids of humans and machines. The danger of digitality’s promises of certainty and solvability, however, is that it erases the human from this picture, offering a view in which the technology alone will achieve a goal. This leaves us with an incomplete view of both people and technologies. There is no bright line separating theories of mediation and of interface, each of which challenge the separateness of people and technologies. The question at issue in these views is not the degree to which technology *controls* human agency, but the degree to which we conceive of human agency as distinct from technology in the first place.

The autonomous subject

The technological theories discussed in this chapter, from ANT and platform studies to posthumanism and interface theory, have all dealt in various ways with the question of agency, asking where among people and artifacts it is located, and sometimes asking how it can be bound and direct it. The philosophies of autonomy, introduced here, make two contributions to this theoretical foundation that are important to my study. The first and more distinct is its theorization of desire. Autonomy focuses not just on capacities to act, but on the drives that motivate a person to act, turning critical attention to the origins and authenticity of those desires. Widening this scope allows us to connect technologically mediated agency to the promise, which we have seen is always animated by some pre-existing yearning, a reaching towards something imagined to be good. By seeing both this idealized vision and the situated practice of trying to realize it, autonomy is in itself a version of a theoretical bifocal for seeing promise and mess together. The second, somewhat more familiar contribution autonomy makes to my work is to situate both desires and agency in a relational context, seeing the autonomous subject as a social product. Together, these articulate a view in which we want people to be able to reflect and act on their own desires, recognizing that this capacity both requires and generates relations with others.

Autonomy is a "multidimensional" concept (C. Mackenzie, 2014a) that has broad overlaps with related ideas of agency, liberty, individual freedom, authenticity, self-governance, and self-determination. It has featured in centuries of Western moral and political thought. Within this "constellation of related ideals" (Baynes, 2007), I focus rather narrowly on the concepts of desire and relationality, mostly from feminist philosophy, that are useful to my work. Examining these two dimensions requires a brief introduction to the Kantian foundations of autonomy, which become the departure point for contemporary critics.

The word autonomy, which means giving itself its own law, referred in ancient Greece to city-states that governed themselves, but Kant asks instead what makes a self-governing individual. His answer is a rational will. Actions based on a person's passions and desires are heteronomous—a law given by an other—and so are no different than the empirical actions found in the natural world of cause and effect. When a will is based in the laws of reason, however, it is autonomous. Kant's radical proposition is that morality is self-given, identified by a rational will rather than from God or a divine authority. This autonomous will is located in the individual, but, because it is rational, it is also universal (Formosa, 2013). An important point to note here is that Kantian autonomy has internal and external dimensions; it is both an independence from "domination by inclination or desire" as well as "independence from domination by others" (Baynes, 2007, pp. 557–558).

Critics of Kantian autonomy have targeted it for its emphasis on reason over experience or emotion, its insistence on individual rather than relational capacities, and its universalism that is blind to personal differences. This section follows two lines of thought within the philosophies of autonomy. The first sees the internal ideal of how one should act as a product of the desires of a situated, authentic self, rather than of reason alone. The second challenges Kantian individuality with a more complex picture of relational autonomy.

Internal: Authenticity of desires

Much of the work on autonomy since Kant has expanded his notion of *moral* autonomy, which is interested in how a reasoning individual can independently identify a moral action, to an idea of *personal* autonomy, which asks how a person can live her own true life by following her self-identified desires (Waldron, 2005). In particular, autonomy gained currency in moral and political philosophy during the 1970s and 80s with the work of a handful of philosophers exploring desire and free will (Christman, 1989b; Dworkin, 1988; Frankfurt, 1988). These thinkers build on Kantian foundations, but depart from Kant with a greater focus on the particulars of autonomous deliberation. This idea suggests that a person who identifies her own desires is not necessarily autonomous; she must also critically evaluate whether that desire is authentically hers. This second-order desire is the desire to have or not have a first-order desire. In the classic example, a drug addict who wants drugs might reflect autonomously to decide that he does not *want to want* the drugs. Brainwashing or hypnosis provide even starker examples of a person acting on desires that are in some sense genuinely held but that she would nonetheless reject upon some higher-level reflection. Dworkin identifies these "second-order" preferences as essential to his conception of autonomy, which he defines as "a second-order capacity of persons to reflect critically upon their first-order preferences, desires, wishes, and so forth and the capacity to accept or attempt to change these in light of higher-order preferences and values" (Dworkin, 1988, p. 20). Frankfurt's idea of the "wanton" raises much the same concern. A wanton acts on his desires without deliberation over whether he wants those desires. For Frankfurt, autonomy requires identifying "whether the desires by which we are moved to act as we do motivate us because we want them to be effective in moving us or whether they move us regardless of ourselves and even despite ourselves" (Frankfurt, 1988, p. 163). These so-called "hierarchical" models that differentiate between lower and higher order desires suggest that some desires are more reflective of a "true" self than others. Unlike Kant, whose rational basis for autonomy is universal, these framings see desires as formed in a subject's unique historical circumstances (Christman, 1989a).

This reflection on personal desires points to notions of an authentic self separate from external demands (Taylor, 1992), living a life in accordance with one's own values (Oshana, 1998), or acting out of a sense of self-worth (Benson, 1994). The hierarchical models theorize that reflection on your own desires might reveal some of those desires to be somehow not genuine, or not part of your "true" self. In other cases, this reflection will lead you to identify with your initial desire, recognizing it as authentically your own. Authenticity requires self-determination, as opposed to other-determination, in the exercise of one's will, but more than that it is interested in the affirmation of that will as being true to one's self in the first place. It is this internal dimension of authenticity that has been the focus of theorists of personal autonomy, whose work has drawn out ideas of individual identity in ways that Kant's does not. But this widening of scope from the authenticity of a particular desire to the authenticity of a self has met some resistance. Some philosophers keep close to their Kantian roots in arguing that "autonomy is more properly seen as a property of preference or desire formation than a property of whole persons or of persons' whole lives" (Christman, 1989b, p. 13). Others, including most feminist accounts, seek to shift the frame of reference from "autonomy of preferences or values to the autonomy of persons" (Oshana, 1998, p. 96), so that autonomy becomes "a whole way of living one's life" (Dworkin, 1988, p. 16). As we will see, feminist theorists push this frame further to incorporate not just a whole self, but a self in relation to others as the essential unit of autonomy.

Even focusing only on desire formation, hierarchical models have been subject to several criticisms, summarized by Mackenzie and Stoljar (1999a). One is the problem of regress. What is to say that your second-order desires are themselves genuinely held? Perhaps a third-order desire is needed to evaluate the second-order desire, but could not that too be inauthentic? And so on; the authenticity of an individual's beliefs, and of her beliefs about her beliefs, appear to be always subject to question. A second objection examines the hierarchical model's implicit assumption that we ought to prioritize a "higher" self, usually understood to be a rational self, as somehow more real or worthy than the libidinal drives that have been the focus of Freudian psychology. But why should we make this assumption?

Marina Oshana (2007) raises a different set of objections, arguing that the close association of authenticity and autonomy in these discussions risks overlooking some of the more challenging aspects of autonomy. In practical terms, she points out, people rarely engage in the kind of deliberate and conscious reflection on their own desires that is imaged by Dworkin's and Frankfurt's hierarchical accounts. Such an exercise is time-consuming and psychologically taxing, and it simply is not common in our daily experience. More than this, however, it is neither necessary nor sufficient for autonomy. This deliberation suggests a kind of clear-cut "self-fulfillment" procedure that is quite different from Oshana's messier and more ambivalent notion of autonomy. She offers examples of how a person might be authentically himself by choosing not to have autonomy, or might be autonomous without choosing a life through which he expresses his true self. In Oshana's alternative idea of authenticity, a person "is disposed to acknowledge...the features of her character and her history that anchor her identity" (p. 412). This kind of authenticity, an awareness of self even if not an endorsement of a "true self," is for Oshana the more important quality of autonomy. "When a person acknowledges her disaffectedness from certain aspects of her identity, even if this introduces ambivalence into her life, autonomy is on steadier ground" (p. 429), she says. This shift away from an individual's abstract inquiry into a true desires and towards a more substantive evaluation focused on who you want to be and why is typical of feminist accounts of autonomy (Jaggar, 1983; Stoljar, 2018).

Without wading any deeper into this rich discussion, we can note simply that desires are constitutive of the self, and that a person's desires can be fluid and contradictory. The study of app-mediated travel will show how travelers have certain desires—for more accurate information or for an easier trip, say—that apps can fulfill well or poorly, but they also have ambivalence about their desires. In some cases they do not want to want what they do, and in others their sense of themselves changes as they interact with the tools. The idea that autonomy cannot be understood in as a property of a self in isolation is the subject of the following section.

External: Self in relation

This shift from the "internalist" accounts of reasoning and reflection to an "externalist" account of actual behavior means that we can no longer imagine an isolated individual, but instead must recognize a socially constituted self. Zooming out in this way quickly reveals tensions between the value of the self as distinct desiring agent and the ways that a person is shaped by and has obligations to others. According to feminist philosophers, "those tensions are the tensions of feminism, and they come from feminism's recognition of the nature of human beings" (Nedelsky, 1989, p. 11). Situating the self within a community is a primary purpose of philosophies of relational autonomy. These theorists are careful not to deny the importance of the individual as a distinct feeling, reasoning, and acting entity; an embeddedness in social relations does not erase the self. Indeed, a core concern of feminist theory is to support the choice, freedom, and agency of women under oppressive social conditions (Friedman, 2003). Instead, feminist theorists point to a "need [for] a language of self-determination that avoids the blind literalness of the liberal concept" (Nedelsky, 1989, pp. 9–10). The goal then is to somehow champion the freedom of the individual while embracing the role of social relationships in constituting, enabling, or constraining that freedom.

Feminist theory is by no means the first to examine the relation between the individual and society, but these accounts have argued that the lived experiences of women can reveal what is missing in the abstractions of the autonomous liberal subject that feature in so much political theory. Work in developmental psychology suggests that women's and men's different experiences of giving and receiving care, beginning at a young age, shape their views of themselves as interdependent (Chodorow, 1978; Gilligan, 1982). Feminist care ethic has similarly argued that masculine conceptions of morality deal with rights and rules, approaches that favor both abstraction and individualism, but experiences of women's lives reveal alternative approaches to ethics grounded in relationships and responsibility (Held, 2005; Noddings, 2003). In political theory, feminists argue that modern political philosophy is rooted in a masculinist denial of human dependence and an assumption that individuals, and individual rationality, come prior to society, beliefs that women's experiences are less likely to support (Benhabib, 1992; Jaggar, 1983). Gender is obviously central here, but so too is the emphasis on theorizing from the messiness of everyday life, rather than rationally derived abstractions.

Accounts of relational autonomy have built on such feminist theories to situate an autonomous person in a social context, avoiding the individualistic frames that so easily come with autonomy. Mackenzie and Stoljar (1999a) distinguish between *causal* and *constitutive* conceptions of relational autonomy. Causal accounts pay attention to the specific historical conditions through which "socialization and social relationships impede or enhance autonomy," whereas constitutive accounts "[focus] on the social constitution of the agent or the social nature of the capacity of autonomy itself" (C. Mackenzie & Stoljar, 1999a, p. 22).

The causal conception, which points out that the actions of other people affect our autonomy, is sometimes called weak relational autonomy. In these views, we need other people first to develop our capacity for autonomy. Other people teach us how to think independently, and so persons are "heirs to other persons who formed and cared for them," (Baier, 1985, p. 85). You do not learn to think for yourself by yourself. At the same time, we need other people to exercise our autonomy, and other people can inhibit it. As Oshana (1998 p. 94) puts it, "in order to be autonomous, a person who is in a society must find herself within a set of relations with others that enable her to pursue her goals." Relationships that enable or constrain a person's action are often easy to identify, and appear frequently in discussions of autonomy. Feminist accounts, however, have been particularly insistent that autonomy must include not just a capacity to have self-identified preferences, but an ability to pursue them, particularly within relations of both caregiving and oppression (Friedman, 2003; Meyers, 1989; Westlund, 2009). Although nearly any account of autonomy acknowledges some form of interpersonal dependency, these views are nonetheless underemphasized in much of the literature.

Conceiving of autonomy as constitutively relational, sometimes called the strong relational account, is a more radical departure. In this view, relations with other people do not simply interact with a capacity for autonomy that is otherwise independently held. Rather, we cannot conceive of any sense of autonomy, or of identity at all, except in relation to others. This refiguration of autonomy is firmly rooted in broader feminist arguments that the self is inherently social. Jennifer Nedelsky emphasizes both the causal and constitutive components autonomy in her early call for a relational conception of autonomy:

> The necessary social dimension of the vision I am sketching comes from the insistence, first, that the capacity to find one's own law can develop only in the context of relations with others (both intimate and more broadly social) that nurture this capacity, and second, that the "content" of one's own law is comprehensible only with reference to shared social norms, values, and concepts. (Nedelsky, 1989, p. 11)

In calling autonomy an ability to "find one's own law," her use of the word "find" deliberately suggests that we do not make or choose our own law, we only discover or identify what has been generated through a lifetime in relation with others. Yet Nedelsky goes further than this in arguing that "one's own law" is not simply produced and revealed together with others, but that it is in itself relational. The claims of particular accounts differ, but arguing that autonomy is constitutively relational can point to the inescapable social embeddedness of either the self or of the self's autonomy (C. Mackenzie & Stoljar, 1999a; Oshana, 2006; Westlund, 2009).

Just as posthumanist theory sees technologies as constituting the human subject, not just interacting with it, the strong view of relational autonomy sees others as always already within the self. The weaker views, too, argue that trying to see an autonomous subject separately from social relations is not just empirically inaccurate, it is undesirable, a "thoroughly noxious concept" (Hoagland, 1988). We will see, however, that the danger of digital promises is that they tempt us into seeing this separateness. This is not because they see relationality as bad—some form of connection always appears in the vision for networked communication, after all—but simply because connectedness and agency threaten the abstractions in which certainty and solvability are imagined to be achievable. An important contribution of these relational accounts, then, is to make autonomy more grounded in the messy reality of everyday life in community. People are ambivalent; their desires are frustrated; other people affect what they think and do. In contrast to the abstract rationalism and universalism of Kantian autonomy and its derivatives, relational autonomy offers “a form of non-ideal theorizing about autonomy. ... Its starting point is nonideal agents in a nonideal world, characterized by social oppression, injustice, and inequality” (C. Mackenzie, 2014a, p. 23). Relational autonomy, like so much of feminist theory, shows us what we can learn from the mess that we cannot from abstractions.

Conclusion: Theorizing the mess of new mobility

This chapter has surveyed an expansive territory. To conclude, let me point to some of the connections between this theoretical material and the empirical content of my research.

I presented infrastructures and platforms as two different ways of ordering the mess, and both of these structures are guiding planners’ visions for how new mobility technologies will remedy the challenges of urban mobility. The infrastructural framing is well established in transportation, and its concerns are concrete: how to build things and to get them to connect in a usable network. Transportation planners also know that someone’s visions of desirable social relations shape how these systems are developed, like Moses’s bridges and like the decades of auto-centric planning that they are now hoping to undo. While planners want to build new infrastructures that better support their visions, we will see that they are also hoping to substitute some digital interventions for concrete projects. The risk is that digitality lures them into thinking they can avoid dealing with the challenges of materiality. Part of what is new about new mobility is its application of the platform paradigm to mobility. The platform is designed to accommodate the agency of its users, indeed to benefit from it, and new mobility envisions systems in which travelers go exactly where they want, whenever and however they please. But platforms also seek to bound this agency so that it remains legible to the system through specified structures for mobility data. The platform promises certainty without asking planners to predetermine travelers' moves. At the same time, those planners hang onto the infrastructural promise of solving the problem of providing a universal service. My study examines how the tensions that come with seeking visibility and control play out in data specifications and regulations for these modes. Infrastructure studies and platform studies give us frames for seeing how technologies order social relations, but these fields are also filled with empirical accounts that reveal how they work differently in practice. My study also identifies such gaps between vision and reality as a reminder that change happens not in visions alone, but on the ground.

The theories focused on the subject, posthumanism and autonomy, tell us that we should think a certain way about what happens on the ground. Posthumanism suggests that interventions focused solely on a tool—an app, a scooter, or a data standard, in my study—are missing the fundamental connectedness of human and machine. Action happens through cyborgs and interfaces, person-thing hybrids in which agency is an untraceable product of personal desires, the affordances of tools, situated environments, and social relations. The posthumanist view says that tools alone do not determine actions, but neither do people. This spells trouble for any effort to envision how a new technology will or will not change how people travel, since the answer will always be situated and particular. My study of travelers gives some of those accounts to show how apps have become integrated into the travel experience. This is where autonomy's attention to desires is especially relevant. In making a promise, an app or a plan will usually treat a desire as a given, without asking where it comes from. My research shows travelers sometimes reflecting on their own desires with ambivalence, unsure what is or is not genuinely held. More often, it shows how apps do not simply respond to desires, they produce them. As apps provide information, they invite travelers to want more. A similar pattern can be observed among planners, who begin to want more of what new mobility promises to deliver.

Autonomy's theorization of desire as ambivalent and relational is a way to understand how the promise, which is a response to and a protection of a desire, is already messy. From this, I argue that understanding what new mobility does requires understanding what we *want* it to do.

In the previous chapter, I introduced certainty and solvability as the two desires my study will show are driving new mobility. This chapter has revolved around materiality and agency. These, too, should be desired, if it makes any sense to desire something that is inescapable. Embracing the connectedness of our personal subjectivity and our social relations with technological artifacts, and seeing relationality generally as the mess in which our desires and our capacity for action are formed might make it harder to envision digitality providing certainty and solvability. When this messiness fails to reflect what we envisioned, a response to this dissonance might be sadness, anxiety, or a rush to attach to a new promise. An alternative response is to find a comfort in the mess, to see beauty in its complex indeterminacy, and to recognize that desirable change happens here too. A goal of my research then is to not only identify messiness in the promise, but to recognize the promise of the mess.

CHAPTER 4

The Research

This project examines digital technologies as promises of a better future and as tools integrated in messy socio-material relations. It seeks to situate technologies within concrete contexts of urban mobility while maintaining a critical attention to their values and visions. By seeing these together—by providing accounts of the generation, circulation, and realization of promises within the mess—I aim to open up a view of technological promises as a site to engage in rather than avoid politics.

This chapter describes my research approach. It begins with a brief introduction to the case of new mobility as well as the technologies and people who are the subjects of my study. I then describe my constructivist research paradigm and ground the study approach in methodologies from phenomenology, actor-network studies, and case study research. I show how these are well-suited for my inquiry into experiences and imaginations of new mobility at a variety of scales. I then give an account of the data collection and analysis processes that generate the material for my subsequent empirical chapters.

In other words, the chapter describes how I go about answering the research questions that I identified in chapter 1:

RQ1. What is the relationship between the promise of digitality and the messiness of urban mobility?

RQ2. How do digital mobility technologies envision ordering relations within a heterogeneous urban public?

RQ3. How are travelers' desires and agency coproduced with mobility apps?

Case and subjects: New mobility

New mobility is positioned as a case of the digitization of urbanism, an example of the growing application of digital tools—sensors and hardware, data and data structures, algorithms and applications, screens and interfaces—to common practices of inhabiting and shaping the city. It has many dimensions, which makes it a compelling but challenging research subject.

The term "new mobility" has become a way for many transportation professionals to describe a variety of loosely connected emerging transportation technologies, infrastructures, and services, including such disparate elements as self-driving cars, e-scooters, integrated transit payments, and smartphone apps for travel by transit. The term combines actual tools and practices (e.g., navigation apps, ride-hailing, bikeshare) and those that are mostly imagined (e.g., widespread automated, shared, and electric vehicles, and infrastructures to support them). SDOT's "New Mobility Playbook" calls new mobility an "emerging, technology-enabled, seamless, nearly door-to-door transportation system" (SDOT, 2017, p. 17), which is more aspirational than descriptive. There is no consistent definition, and a good deal of work in this field even omits the term altogether; references to "shared mobility" (Shared-Use Mobility Center, 2016), "emerging mobility systems" (Denver Metro Chamber et al., 2019) or "mobility in the digital age" (LADOT, 2016) are doing similar work. For my purposes, I use "new mobility" to refer to transportation tools that are mediated by networked digital technologies, including GPS sensors, smartphones, smartphone apps, and data exchanges. While such tools have long histories, they have expanded rapidly along with adoption of smartphones and the growth of ubiquitous mobile computing in the past 15 years or so.

Because new mobility is moving quickly and involves big players, it is generating a lot of conversation. Among transportation professionals and travelers alike, the newness of the field prompts people to imagine what it could become, yet it is also mature enough to have existing practices available for study. I examine the practices and promises of "new mobility" as a catch-all idea of technological progress in some detail in chapter 5. I this section, I introduce the types of travel informational and travel services offered by new mobility and identify the dimensions of new mobility that I focus on. This provides the background for the following three sections introducing subjects: the specific technologies and services, the professionals and organizations, and the travelers that I study. These are selected for their contribution to my research questions' interest in relations among people and digital artifacts. I finish the section with a note on Seattle as the focal site for much of my study.

Transportation information and services

New mobility's combination of informational and material qualities makes it well suited for my project, which is interested in frictions between abstract digitality and lived experience. Travel is a function of both information and movement. In my rough schema, *transportation information* describes where things are and how to get there. *Transportation services* are the cars, buses, bikes, feet, or other instruments for actually moving people from place to place, together with social and physical infrastructures needed operate them. In isolation, the former cannot take you anywhere, and the latter cannot take you where you intend to go. Ride-hailing makes the relationship between information and movement especially clear. Uber is a system which both provides information (an available driver is currently two blocks away from you) and transports people (that driver drives a car to you and takes you where you want to go). While many riders think of Uber as a way to get around, Uber, the company, considers itself to be a only an information broker, a data platform that people with cars use to provide mobility services. From this perspective Uber is not a *transportation* innovation (since people have given rides to strangers in exchange for money for ages), but an *information* innovation. It is simply a new kind of software program for digitally collecting, manipulating, and distributing transportation information (drivers available, rides requested, origins, destinations, routes, means of payment, user ratings). And yet, it makes little sense to talk about Uber as information technology without acknowledging the very material transformations in mobility, labor, and city streets it has brought as a mode of transportation. Indeed, it is changes to actual movement, not information, that comprise the promises or threats of the Uber revolution. Chapter 5 describes how new mobility uses advances in information technologies to promise changes in urban mobility, and examines the frictions in this translation.

Some rough typologies of information and services will lay the groundwork for the study. In categorizing transportation information, the primary distinction is between *stable* and *dynamic* information. Stable information changes rarely enough that it can be treated as constant, while dynamic information might change by the minute or vary significantly depending on conditions. A paper road map communicates only stable information; Google Maps can also communicate dynamic information about, for example, current traffic. Table 1 gives examples of stable and dynamic information in response to different kinds of questions. Some address where things are located and what their characteristics are, while others provide instructions about how to travel between things.

Table 1: Transportation information examples

	Stable	**Dynamic**
Where am I?	my home address	my current location (blue dot)
Where is [something]?	restaurant bus stop bikeshare dock	food truck's current location bus free-floating bike
What transportation is available?	a certain place's available travel modes (Lyft, buses, bikeshare)	location of Lyft real-time bus arrival estimate number of bikes in bikeshare dock
What is the status of travel infrastructure?	highway network bus routes and schedules	current highway traffic bus ridership, on-time performance bikeshare system ridership mechanical status of a shared bike
How do I get there?	shortest route from work to home	shortest route from my current location to home
How long will it take?	usual driving time	driving time in current traffic
How much will it cost?	bus fare	dynamic toll rate
What will it be like?	hill profile of bike route	Uber driver rating

My study of travelers' uses of mobility apps (chapter 7) will look at the ways travelers engage with this kind of information in some detail. I am especially interested in the expansion of *dynamic* information that new mobility technologies have enabled. Certainly the mediation of stable transportation information by digital technologies has also proliferated, as evidenced by the use of Google Maps to pinpoint the exact location of a familiar restaurant or to give turn-by-turn directions on a routine drive. Here, however, Google Maps is largely replacing one form of information—that in a street atlas, or in the driver's head—with another. Dynamic information, by contrast, is more novel. Traffic reports on the radio are a longstanding precedent, but the breadth, accuracy, and availability of dynamic travel information offered by Google Maps can be provided only with digital technologies. No matter how well you have internalized your route to work, you cannot know the exact traffic conditions for that route in this moment as well as Google does. This expanded availability of information that would not otherwise be available to travelers is a clear example of digitality's promise of certainty. Along these lines, I am interested in how new mobility not only satisfies needs but generates them, and dynamic travel information becomes a focus for this inquiry in chapter 7.

Note that these examples also include travel information that is not available to ordinary travelers, only to transportation professionals, particularly the "status of travel infrastructure" questions. Transportation systems monitoring involves an enormous universe of information in itself. King County Metro has information about bus boardings and on-time performance for the inbound Route 5 on weekday mornings. The Washington State Department of Transportation uses sensors to track current speeds on northbound I-405 between Bellevue and Lynwood. Uber has a wealth of information on every trip riders and drivers take on its platform. The companies and technologies delivering this information are for the most part out of the scope of this study, which ultimately revolves around the development and use of *app-based* mobility practices. The exception is the data that deliver real-time information on micromobility and transit to both consumer apps and agencies. The open-source specifications for these data are examined in some detail in chapter 6. While I study the uses of the data in a general sense, focusing on what cities say they want to do with these systems, I do not study information practices among professionals first-hand as I do for travelers.

Digital information is behind an ever-expanding suite of transportation modes and services. Some are new, and others are newly mediated. The typology in table 2 organizes modes of transportation around three axes: users, vehicles, and operation. *Vehicles* can be personal, meaning it belongs to and is primarily used by a single user, or shared. As discussed in chapter 5, much of the promise of new mobility revolves around facilitating the sharing of bikes, scooters, car rides, or transit, rather than owning a car.

Operation is typically by the traveler himself when using a personal vehicle (usually driving a car), but shared modes can either be operated by the traveler (e.g., a rented car or bike) or by hired labor, as with ride-hailing and transit. Finally, some modes support *individual* travel, meaning the trip supports the travel goals of a specific person (or perhaps a group) going somewhere, while others are *collective*, pooling together travelers with different goals on a single trip, as on a carpool or bus route.

Table 2: Typology of urban transportation modes

	Self-operated	**Labor-operated**
Personal vehicles	*Individual*: car, bike, walk *Collective*: carpool	
Shared vehicles	*Individual*: rental cars, car share, bikeshare, scooter share	*Individual*: taxi, ride-hailing *Collective*: public transit, private shuttles, ride-hailing pools

New mobility transportation modes are rooted in the new travel information provided by digital technologies, and this has fed the growth of shared modes in particular. Effectively communicating availability and coordinating access for taxis, rental cars, and rental bikes in motion across a city is a problem of information management and dissemination. GPS and networked mobile devices connect labor and vehicles relatively easily when such communication was previously clunky or impossible. These tools gave us Uber, which transformed how a taxi works, and then app-accessed rental bikes scattered across the city, which are meaningfully different than previous rental systems. New information technologies have not changed the fundamental operation of existing modes like driving, walking, or transit in this way, although chapter 7 will show how the availability of information about these trips does shape new travel behaviors. References to new mobility typically imply both novel app-based shared modes and the uses of digital information to improve existing modes.

There are many other relevant dimensions of travel modes that feature prominently in transportation literature, including ownership and operation by government or corporate entities, infrastructure requirements, energy and efficiency, emissions and environmental impacts, health and safety impacts, and financial costs, among others. I note when planners expect new mobility tools to address any of these dimensions, but because this is not a transportation study, I do not deal with those concerns per se. Additionally, I do not address freight and delivery traffic, although emerging digital technologies are speaking to these transportation concerns as well. And, although in chapter 5 I do address the speculative thinking that that attends nearly any mention of new mobility, the project is primarily interested in transportation and technologies that actually exist in cities today. For this reason, I omit self-driving cars, delivery drones, and other forms of mobility that are in earlier phases of development or imagination.

Technologies and services

This understanding of new mobility as both transportation information and transportation services guides my selection of certain components of new mobility. My focus is on the ways that digitality is both promise and mess, a vision for satisfying certain personal or social goals and an experience of situated use. These lead me to focus on the apps, services, and data specifications introduced here. My selection is guided by what is pervasive (e.g., Google Maps), what is novel (e.g., bike sharing), and what is available for study (e.g., the Mobility Data Specification). With the exception of data specifications, which become a subject of study in themselves, these technologies appear mostly when they are bounding my study of something else—transportation professionals or travelers.

Among the technologies and services excluded from focus are car-sharing, peer-to-peer car rentals, and traditional car rentals; taxis; on-demand transit services, including paratransit, "microtransit," and last-mile services; private company shuttles; delivery services and apps; location services provided by Yelp, Facebook, or other apps not primarily focused on navigation; apps for managing parking, transit payments, and other specialized uses; apps for long-distance or inter-city transportation providers; FitBits, running apps, and other personal fitness tools; municipal transportation management systems, such as those for traffic monitoring and transit operations; and navigation or driving technologies built into cars by their manufacturers. These are also examples of digital mediation of mobility, but my research clustered instead around the following tools, which tend to me central to either planners' visions or travelers' experiences.

Real-time navigation apps

In their essence, these apps tell someone how to get from A to B. They typically use the traveler's current location, and often also incorporate real-time information—current traffic or bus delays, for example—in their recommendations. Apps provide directions for driving, transit, walking, or cycling, and many also show options for shared bikes ride hailing. Google Maps is clearly dominant in this space, with extensive data and rich features, but Waze (owned by Google) and Apple Maps are also popular options. Navigation apps can display a complete route, or can give turn-by-turn directions during a trip. In Seattle, OneBusAway (whose development is examined in chapter 6) is a leading app for providing real-time estimates of bus arrivals, but it is not the only app to focus on real-time transit information. Finally, apps used primarily for hailing a ride or for booking a shared bike or scooter are increasingly incorporating navigation features for other modes, such as transit, into their apps. All of these apps are internet-based programs that a user encounters through a screen[1] for the purposes of planning a trip.

Micromobility

Small vehicles available for rent for point-to-point trips, most familiarly shared bikes, have recently been given the name "micromobility." The term is not widely adopted, even among transportation professionals, but I often use it here because it is easier than writing "bike and scooter share." Bikeshare systems are decades old, and began to proliferate in North American cities beginning around 2010. In those systems, municipalities install a network of docks across certain neighborhoods. Riders can rent a bike from a dock, then ride to any other dock to return the bike. Dock-based systems, typically managed and subsidized by the local government, still exist. The excitement around micromobility, however, began around 2017, when first Seattle and then other US cities were introduced to "dockless" bike share. In these systems, shared bikes are left anywhere, and can be returned anywhere. In contrast to docked systems, they are private enterprises operating independently by city permit, and riders pay per minute rather than the flat fee typical of docked systems. The role of digital technologies is also major difference. While legacy bikeshare docks could begin rentals using a key fob or a code entered into a kiosk, dockless systems are accessed using a smartphone app that identifies bike locations, initiates the locking or unlocking of the bike, and processes payments.[2] In addition, both docked and dockless systems now generate data on individual trips that is reported to the operator and, often, the local

[1] Usually a smartphone screen, although most services can also be accessed on a desktop computer.
[2] There are, or at least have been, dockless systems that riders can access without a smartphone, but this study focuses on the major players that are now all using apps.

government. In different markets, the shared bikes of these systems were quickly joined or replaced by shared e-bikes, with battery-powered pedal assistance, and shared scooters with battery-powered motors. This app-based, point-to-point rental model has also been applied to larger seated scooters and to cars (which would not be considered micromobility). Major companies operating micromobility services include Lime, Spin, Jump, and Bird. These services and data as well as the travelers and transportation professionals using them will feature prominently throughout this research.

Ride-hailing

Uber and Lyft are the best-known examples of ride-hailing, also called ride-share or transportation network companies (TNCs). There are other ride-hailing companies, some serving specific markets, but this research focuses on the two dominant players. Like micromobility, ride-hailing is accessed through a smartphone. The traveler specifies a pickup location and a destination through the app, and is matched with an available driver who provides the ride at a specified price. While there has been a great deal of research and policy attention to the labor conditions of Uber and Lyft drivers and to the impacts of ridehailing on the transportation system more broadly, my focus in this study in on the traveler and her experience of digitally mediated travel. Additionally, while significant quantities of micromobility data are becoming available to city agencies, the data generated by ridehailing mostly remains with the companies. For that reason, I do not devote much attention to the relationships between Uber or Lyft and city regulators.

Public data specifications

The last new mobility technology that I study is the most technical and the least visible to the traveler. Data specifications describe a common format for the exchange of data among disparate producers and consumers of that data. I study three specifications for different types of travel information that are essential to new mobility, each of which is open-source and available through public code repositories on GitHub. The General Transit Feed Specification (GTFS) and its real-time version organize data on scheduled or actual bus locations for use in navigation apps. The General Bikeshare Feed Specification (GBFS) does the same, but for the availability of shared bikes and scooters. The Mobility Data Specification (MDS) is also used for micromobility data, but is for use with sensitive individual trip data available only to transportation agencies and mobility providers, not the general public. These data specifications are examples of the digital back-ends of the new mobility apps and services that travelers see, and they offer an important site for understanding the digital mediation of mobility.

Professionals and organizations

In addition to the technologies themselves and the people who use them while traveling, I am interested in the professional contexts in which digital tools and mobility services are produced. This is where so much of the promise of new mobility circulates. The professional subjects who are the focus for this study include both specific people (e.g., SDOT's bikeshare program manager) and products (mostly reports and other documents), but what unites them is their situation in professional contexts of envisioning, planning, designing, producing, maintaining, or regulating urban mobility. I organize these into three often overlapping categories: transportation officials, software developers, and mobility service providers. Within each of these categories, I describe a more specific focus that supports my inquiries into new mobility's promises (RQ1) and the digital structuring of social relations (RQ2). Other than SDOT, I do not spend much time focusing on a specific department of transportation or transit agency. Also excluded from my focus are state and federal transportation policies, transportation and technology consultants, vehicle manufacturers, and the firms that deliver infrastructure projects.

Transportation officials

I often use the term "planners" loosely in reference to this category, which includes both government agencies managing transportation and the non-governmental organizations who serve them. In the former category, much of this research revolves around the work of SDOT. In the period of this study, SDOT issued its first permits for dockless bikeshare and later developed its program for scooter share. These activities, and some of the officials involved in them, offer material for a close examination of a specific relationship between digital code and transportation planners' goals for the public interest (chapter 6).

To answer the more general question of how transportation officials reconcile the promise of new mobility with their experiences on the ground (chapter 5), I turn to their statements at conferences and in published reports. SDOT appears again here, but I also use material from many other cities. In those cases, I am not as interested in the specifics of the city's situation as I am with Seattle. When looking at these visions, I use material not just from government agencies, but from non-profit organizations like the Shared Use Mobility Center, the North American Bikeshare Association, and the Open Mobility Foundation, who convene conferences and webinars with professionals from government and industry. Consultancies like Populus have also published reports engaging in these conversations.[3]

These subjects are of interest for two different reasons. First, they envision and plan mobility. Second, they produce it, through regulations, infrastructure investments, and the

[3] See appendix A for a list of many important new mobility organizations.

operation of transportation systems. Not all transportation officials do both of these things, but seeing their relation is especially helpful for my project's interest in the relation between the promise and the mess of mobility technologies.

Software contributors

The technologies listed above as subjects include plenty of software. Since my goal is to identify the desires and values these tools circulate, I look beyond the artifacts to see the circumstances in which they are produced. Studying the development practices of this software helps to reveal it as contingent product of certain people and organizations, following Tarleton Gillespie's (2014, p. 169) imperative to "unpack the warm human and institutional choices that lie behind these cold mechanisms." However, these processes within private companies were largely inaccessible to my research. Instead, most of the subjects in this category are of a specific type: contributors to the GBFS and MDS specifications. "Contributors" is a term in open-source software development that acknowledges that software is produced by many people other than programmers or others with technical knowledge. Some contributors to GBFS and MDS write and debug the code that comprises these standards, but others write documentation, request features, think through use cases, and report issues from the field. Nearly all of them are volunteering their time for these projects, and are primarily employed as transportation professionals, either by a government agency (usually a municipal DOT) a private company (usually either an app company or a micromobility operator). For these specifications, most of the contributions are publicly accessible on GitHub or Google Groups. I was also able to get first-hand accounts of the development of OneBusAway.

Ridehailing and microtransit providers

This category refers to private organizations providing mobility services, distinct from either government mobility providers (e.g., a transit agency) or the private providers of software (e.g., Google). Mostly that leaves ridehailing and micromobility providers, who deliver an app-enabled transportation service and typically have formal lines of coordination with local transportation officials. My access to this group was limited, and so their points of view appear most often in published statements and in press coverage. Representatives of these companies were also active at the conferences and webinars I attended. While these are large organizations with many activities and priorities, my study of them focuses especially on their engagements with transportation officials and software developers in envisioning and delivering mobility services.

Travelers

My sampling strategy is more considered for travelers than for other subjects of this study. Having identified the case of new mobility, there are only so many apps, transportation modes, and companies, and transportation departments to study. Travelers using these tools to get around town, on the other hand, are countless. Without seeking to generalize from a non-representative sample, I do want to be purposeful in identifying who among this disparate population I am studying.

A primary criterion for a sample in a phenomenological study is that all participants have experienced the phenomenon of interest (Creswell & Poth, 2018), but for this phenomenon that does not get us very far. The experience of using apps and app-based services for getting around the city is common to untold millions of people worldwide.[4] My study of travelers focuses on people living in the Seattle area and, for the most part, on their travel in that region. I describe some of the distinguishing characteristics of Seattle and its transportation below. But narrowing the population of travelers those in Seattle is still far too broad. Which app-using Seattle travelers should I study? My sampling strategy was shaped by two goals. First, I sought individual subjects who would be able to provide detailed accounts of phone usage in their everyday mobility, and so I chose populations who I had reason to believe would be reflective about these ordinary and often overlooked practices. Second, I sought subjects who would demonstrate some degree of contrast in the behaviors and attitudes associated with these tools, while at the same time revealing commonalities of experience. Both similarities and differences are important to my research questions, which are concerned with a tension between the uniformity of digital visions and the plurality of human experience. I examined both commonality and difference using maximum variation sampling. Ordinarily, drawing the small samples typical of a qualitative studies can offer only limited conclusions. A sample deliberately selected to be heterogeneous can help expand this scope. Maximum variation sampling is "useful for documenting uniqueness and diversity" and for finding "shared patterns that cut across cases" (Patton, 2015, p. 283). One the one hand, it reveals differences in experience that might not have appeared within a single group. On the other hand, if a finding is consistent across widely divergent cases, then it is more likely to be a reflection of a common pattern.

The two populations I identified are young professionals, especially those working in technology, and independent seniors living in retirement communities. These have a

[4] According to Google Play, the Google Maps app has been installed more than 10 billion times on Android devices alone:
https://play.google.com/store/apps/details?id=com.google.android.apps.maps&gl=US

number of commonalities and differences that I discuss below. The two divergences that guided my selection, however, were in bodily abilities and comfort with new technologies. I focused on this variation to examine how novel mobility practices mediated by smartphones might work better for the users who already live so much of their lives through screens and who move through the city with relative ease compared to those whose bodies, habits, and preferences might present more friction between data and movement. Specific informants within these two groups sometimes confirmed my assumptions and sometimes challenged them.

Young professionals

I wanted to study young professionals with the assumption that, because of their education, income, and tech familiarity, they would be a major target audience for new mobility and would include many of its earliest adopters. In addition, young professionals in Seattle have often recently moved to the city from elsewhere, and would be likely to turn to apps to learn their way around more than a long-time resident might. The experience of a new city made summer tech interns an especially appealing subject within this population. (Detail on participant recruitment is presented in the data collection section below.) I also assumed that professionals would be likely to be highly mobile, moving frequently among many different kinds of locations around the city beyond home and work. I focused largely, but not exclusively, on professionals working at tech companies. Some were developers themselves, but even the non-technical employees are to some degree products of a culture of digital solutions, and with awareness of the messy processes of software production. I expected this kind of experience would help participants notice their own app uses in ways that might escape other users.

The term “young” is used loosely here. Some participants were college-age interns or recent graduates, but many were in their mid-to-late thirties or older. The youth of this group is relevant in distinction to the seniors, but also insofar as youth implies a comfort and familiarity with the internet and mobile apps. In contrast to the seniors, the older members of the professionals group still grew up with the internet and probably got their first smartphone in early adulthood. There was still a wide range of attitudes towards technology within this group, but as a whole they had more in common with each other than with the seniors when it came to what they expected of their apps.

In short, the young-ish, tech-oriented professionals in a major city with a plethora of transportation options seem to me to be exactly the type of traveler that new mobility has in mind, and so examining the practices within this group is a way to test and complicate the new mobility’s narratives.

Seniors in retirement communities

The second population of interest are seniors. The pitch of new mobility technologies for seniors is mixed. On the one hand, seniors have a reputation for struggling with new technologies, though this is certainly often undeserved. On the other hand, because aging bodies present all kinds of obstacles to safe driving, having options to make it easier to get around without a car would seem to be especially beneficial to this group. Uber and Lyft sometimes pitch their services as serving seniors, and transit agencies often embrace transportation for the elderly as a core part of their mission. Answering the question of whether smartphone apps—with their small screens and unfamiliar interfaces—can help the elderly make their way around the city is not my primary goal, but studying these use cases is productive for my inquiry into the relation between digitality and personal movement.

I focused on independent living seniors, as opposed to those who require some degree of assistance for daily life, to avoid introducing large variations in travel needs compared to the professionals. (Studying populations with more acute medical needs would also have required additional IRB review.) I mentioned that these subjects are active—some are still working—but many of them still shared various bodily limitations. Some can't see well enough to drive at night, or use a cane, or have bad knees that flare up when walking down hills, or just know that on some days they tire easily.

I chose to study retirement communities in part for the convenience they offer in assembling several participants for a focus group, but also because of their communal nature, since I was interested in how people learn and travel together. (Professionals often have an equivalent community in their offices.) In the communities I studied, this is a fairly active group, travelling often not just for errands and doctor's appointments, but for social visits, cultural events, and hobbies. Seniors living on their own might have different habits. Perhaps half of the seniors studied had spent most of their lives elsewhere, but moved to Seattle in retirement, often to be close to their children. These subjects brought fresh eyes to the city, not unlike the summer interns.

I studied seniors at three communities: Mirabella, Horizon House, and Council House. The main variation within this population is wealth. Council House is a low-income community, while Horizon House and Mirabella are expensive. This meant that Council House participants took Uber less, but otherwise the difference did not appear much in my data. Income is not a variable that my research is primarily interested in, but surely differences would appear with further research. All three communities are centrally located in Seattle, in neighborhoods with walkable destinations, frequent transit, and congested driving. The professionals lived and worked in many of these same neighborhoods, taking the same buses and occasionally sharing Ubers with the seniors.

Seattle

Much of this research deals with new mobility tools and trends as they appear in cities and regions across North America. However, when I look for specific policy and travel practices, I focus on practices in the Seattle area. This selection of this region as my site is largely a matter of convenience, since it has been my home during research and is a place I am familiar with. However, it also offers some particular advantages as a case of technology-mediated urban mobility.

The Puget Sound region's population is wealthier, more educated, and more tech-savvy than average for an American metropolis, although this is by no means true of the entire city. Such residents offer frequent opportunities to observe new mobility apps in use, not just in a developer's imagination. Seattle is also a city with many newcomers, especially among the tech workers I study, who arrive from elsewhere and learn new habits. This kind of novelty—whether of people, environments, apps, or travel modes—is helpful in this research for foregrounding otherwise mundane activity of travel. Similarly, Seattle is home to a mix of mobility options, a variety that new mobility technologies offer to coordinate. Travelers here might make the same trip from home to work in five different ways over the course of a week, and they use apps to sort through those options. Transit, walking, and biking are all popular modes in the region, and providers of new modes like bikeshare, scooter share, and car share were continually entering and leaving the market during the research period.

Similarly, the City of Seattle and its Department of Transportation, and to a lesser extent King County Metro, consider themselves to be thoughtful and progressive in their application of digital technologies to the challenges of the city. Seattle was an early adopter of dockless bikeshare, becoming the first North American city to host such systems, in the summer of 2017, and it embraced its role as a test bed for regulation and operation of this new mode. As we will see in the study, the city has also been aggressive in its negotiations with mobility providers, offering itself to other cities as a model of directing technological innovation towards the public interest. In addition to its regulations, SDOT's plans and reports offer clear articulations of the role it imagines digital technologies playing in the city's mobility. Other cities have produced similar documents, and these form much of the material for chapter 5's examination of the promise of new mobility.

Methodological framing

The two lenses of my study, promise and mess, each present methodological challenges. I have positioned the promise as affective. Since affect deals with encounters and embodied performances that are not easily described or even consciously recognized by the person affected, researchers know it to be a slippery target for empirical observation (Bissell, 2020; Spinney, 2015). Describing the content of the promise is often straightforward—it is frequently stated directly in planning documents—but identifying the desires that animate them requires a more indirect approach. I often do this by working backwards from the specific objects of desire that emerged from my data to a supposition of the desires that their promises speak to. Why these objects? What must be desired in order for these promises, and not others, to have found fertile ground? Such an account must be to some degree speculative, but is grounded in concrete observations. The challenge of studying the mess is, of course, that it is messy. When everything is connected to everything else, the study risks becoming both too large and too unfocused. This is a known hazard of qualitative social research, and is best mitigated by clarifying the boundaries of the study. The methodological frames below offer me ways to do this. At the same time, a commitment to the particularities of a given subject risks obscuring its broader relevance, and so observation beyond its boundaries is important too.

The challenges of studying the interiority of social actors situated in complex and dynamic relations leads me to adopt a constructivist research framework. In social constructivist or interpretivist paradigms, our understanding of the world comes from other people, who produce meaning in ways that are multiple and complex (Burr, 2015; Creswell & Poth, 2018). Constructivist frameworks do not seek universal truths external to the research process or begin from pre-defined categories, as positivist research might. Rather than trying to explain or predict, it seeks "to understand how social actors recognize, produce, and reproduce social actions and how they come to share an intersubjective understanding of specific life circumstances" (Schwandt, 2007, p. 40). Such intersubjective understanding need not be universal, shared across all contexts, but is nonetheless relational, emphasizing that meaning is constructed *socially* and not individually. For research, this means that knowledge or meaning are not located *within* subjects, waiting for the researcher to "find" them, but are actively produced in the process of investigation (Guba & Lincoln, 1994). In other words, phenomena and their accounts are co-constitutive (Burr, 2015), a view consonant with the relational perspectives that pervade my theoretical framework.

Within this paradigm, my approach is guided by several methodologies, each of which supports specific methods for data collection and analysis in my project. Their distinguishing features are discussed below. What unites them are their concerns with, first, situating subjects within social and material contexts, and second, identifying the appropriate scale at which to study a phenomenon. Although I offer these as complementary contributors to a framework that is applied to the project as a whole, they do have different resonances with specific research questions: phenomenology guides my inquiry into the traveler experience (RQ3); ANT and infrastructure studies address the material structures and relations of publicness (RQ2); and case study research is the framework for my study of new mobility's promise (RQ1).

I will not give a full treatment of these theories, some of which deal with ideas already covered in the previous theory chapters. In the end, I am not overly concerned with the degree to which my study adheres to the criteria of any established tradition. The point is not to demonstrate orthodoxy, but to learn from the many others who have already taken on the task of social research. As with the rest of this work, I pick and choose among ideas that have utility for the project's purpose.

Phenomenology and interviews

My interest in personal experience is most obvious in the study of individual app use and travel behavior (RQ3), but also guides the entire work. For this reason, phenomenology, which can be understood as the study of "the common meaning for several individuals of their lived experiences of a concept or a phenomenon" (Creswell & Poth, 2018, p. 75), becomes a core methodology for the research. In my traveler study, the *phenomenon* of interest is the individual's use of a smartphone as an aid for getting somewhere in their everyday *lived experience*. I seek to understand the *meaning* travelers find in these practices—specifically whether it provides senses of possibility or limitations. Rather than study neighborhood or metropolitan scale effects as much transportation research does, my focus is at the scale of the *individual*. In my investigation of new mobility's promises (RQ1) and structures (RQ2), the individual subject is implied more than studied directly, but many of the guiding principles of phenomenology shape this inquiry as well.

The phenomenological approach is rooted in the early-twentieth-century philosophy of Edmund Husserl and later development by Maurice Merleau-Ponty and Martin

Heidegger. Its core tenet is that the reality of a given phenomenon cannot be understood independently of the perception and consciousness of the individual who experiences it. The phenomenological mantra “to the things themselves” comes from this belief that meaning is in particular experiences themselves, not in symbols and language. By identifying common meanings in different individuals’ experiences of the same phenomenon, phenomenological research seeks to reveal something of its essence. Ultimately, however, the aim is to understand not so much the phenomenon itself, but the way it is lived (Laverty, 2003). The existentialist philosophy of phenomenology has developed over decades into methodologies of phenomenology, with notable contributions from Van Manen (1990, 2016) and Moustakas (1994), that are widely used in a variety of social sciences research. It has a robust philosophical foundation as well as many critiques and derivatives, including recent interest in “post-phenomenology” within geography (Kinkaid, 2021) that offers a blurring of subject-object distinctions that is relevant to my posthumanist frame. For this study, the important point is my adoption of phenomenology’s premise that subjective meaning emerges through lived experience.

This presents something of a challenge for the researcher, who has no direct access to the interiority of research subjects. For one thing, I as the researcher am myself a subject, with my own perceptions and preconceptions through which I understand the phenomenon. I will address this challenge of reflexivity in the section on data analysis, below. Even putting this challenge aside, how can a researcher learn what someone else perceives? Most phenomenological studies use informants’ own accounts of their experiences, as generated through interviews. The interview, particularly when open-ended and in-depth, “provides a situation where the participants’ descriptions can be explored, illuminated and gently probed” (Wimpenny & Gass, 2000, p. 1487). For a phenomenology, this allows an examination of the participant’s subjective experience, as filtered through their consciousness and speech. The interview is a way to access "personal life stories (anecdotes, stories, experiences, incidents, etc.)" (Van Manen, 1990, p. 67), and Van Manen argues that such anecdotes are especially important for understanding processes of meaning-making. "Anecdotes can be understood as a methodological device in human science to make comprehensible some notion that easily eludes us" (Van Manen, 1990, p. 116), he says.[5] My conversations with travelers, detailed below, revolves around anecdotes that describe both events and the meanings associated with them.

Interviews are very widely used research method, and have known limitations. For phenomenological studies, a major limitation of the interview is the distance that remains between the researcher and phenomenon itself. This is particularly true when the research is interested in affect. Affect theory and "non-representational" theory more generally share with phenomenology a focus on embodiment and sensory experience in everyday life, rather than discourse or symbolic representation (Buser, 2014), but the affective experience is even less concrete or describable than the "meaning" of interest in phenomenology, making it a difficult research subject (Vannini, 2015). To some degree, the "affective atmospheres" (Ash, 2013) of a phenomenon can emerge through the anecdotes of meaning that subjects provide in interviews, but these offer at best partial views. A further limitation of interviews for my research is that I am asking participants to recall experiences after the fact, rather than asking for their interpretations of events as they occur. Ride-alongs and other "mobile methods" are popular in qualitative transportation studies, especially those interested in mobility affects (Bissell, 2010; Spinney, 2015). Although I do not observe participants' experiences of these phenomena directly, relying on reflective narratives is

[5] The anecdote has this in common with the myth. Each is called a "story."

still quite common and productive in phenomenological research (Creswell & Poth, 2018; Lindlof & Taylor, 2011).

Actor-network theory, infrastructure studies, and artifacts

Chapter 3 has already introduced actor-network theory (ANT) and infrastructures as theoretical frameworks for understanding the role of materiality in social relations. Here, I will focus on how these ideas shape my research approach. In each of these frames, theories about how social relations are produced or revealed in artifacts leads naturally to the imperative for a social researcher to study not just people but things. Latour's (2005) key insight with ANT is that the macro phenomena of interest to social scientists (racism, democracy, capitalism, etc.) only exist as they appear in micro, momentary instances of interactions among people and things. These actors, and their connections in networks, are what ANT asks us to study. Doing so requires tracing these associations, looking closely at a specific actor, human or non-human, and following it to whatever other actors it encounters to eventually generate an account of the broader network. The problem with ANT as a method is that it is at once extremely localized and unbounded, leading to studies with unending data collection and exhaustive descriptions. Like many researchers, I characterize my work as being informed by ANT without being a true actor-network study. The influence of ANT on my theoretical conception of urban digital artifacts will become apparent in the course of this work, as I show how these objects have agency in relations with people. Its influence on my methods is its reminder to study broad phenomena as particular instances, and especially to look for what non-human actors do.

This approach becomes somewhat more concrete, so to speak, in infrastructure studies. The idea that infrastructure could be a research method is not obvious, but the claim is that infrastructure is not just a thing to be studied, but a way to understand larger patterns of human relations (Sandvig, 2013). An analysis of infrastructure can reveal both the visions that went into its production and the experience of its use (Star, 1999; Winner, 1980). The influence of ANT in this field is apparent in its description as "a way of thinking and acting in the world capable of moving between the separate registers of technical and social action" (Jackson et al., 2007, n.p.). Infrastructure studies places more emphasis on scale and boundaries than ANT. Infrastructures are seen as always built upon and connected to one another, but they are not undifferentiated networks. They have more identifiable boundaries (between, say, a neighborhood power line and a household circuit breaker) and connections, and these become entry points for understanding how they work in a social context (Sandvig, 2013). Additionally, where ANT works at a small scale, infrastructure studies both micro-scale activity and macro-scale structures, and is especially effective at a meso-scale in between these (Parks & Starosielski, 2015). This has been productive in urban research, which similarly moves across scales. A special issue of the journal *City* brought together papers arguing that large-scale urban phenomena such as "patterns of social integration and fragmentation, uneven geographical development and collective social imaginaries" are constituted by "small-scale interactions with infrastructure," and can therefore be understood by studying them (Angelo & Hentschel, 2015, p. 306).

These methodologies guide my study of digital artifacts, including interfaces and data specifications, and mobility artifacts, such as cars, bikes, roadways, and sidewalks. True to the spirit of these theories, I do not study the artifacts in isolation, but turn to them as they relate to other actors of interest. This kind of approach, moving between people and things, is necessary to answer my question about the ways that new mobility organizes urban publics (RQ2).

Case study research and documents

Finally, I use methods from case study research to guide the project's investigation into new mobility, and especially the question of its promise (RQ1). In contrast to phenomenology or ANT, case study research does not come with its own highly developed epistemology or ontology. It is defined instead by the case, usually understood as a bounded, contemporary phenomenon in a real-life context, and by the method, which is an in-depth study with multiple sources (Creswell & Poth, 2018; Flyvbjerg, 2006; Stake, 1995; Yin, 2009). This is admittedly broad enough that "virtually every social scientific study is a case study or can be conceived as a case study...because it is an analysis of social phenomena specific to time and place" (Charles Ragin, quoted in Patton, 2015, p. 259). Nevertheless, framing this research as a case study is helpful for situating its goals and methods.

The case in case study research can be of interest in itself, or can serve to illustrate some larger phenomenon of interest. "New mobility," which I take as a case of the digitization of the city, was introduced above, where I defined its boundaries for this study. Case studies call for seeing the case in an actual context, and so phenomena outside of these boundaries remain in view. This is not a distraction, but is necessary for the case to enrich our understanding of real-world social phenomena (Flyvbjerg, 2006). Case study research calls for in-depth study that does not limit itself to single sources or methods, since it aims to generate a thorough account of a multifaceted phenomenon. Although case study definitions emphasize their depth, the scale and complexity of a case preclude the kind of singular focus that is characteristic of a phenomenological interview or an actor-network analysis. The goal is to balance detailed accounts with broader relevance (Patton, 2015).

These principles of case study research inform my interviews and artifact analyses, but it is especially useful as a frame for my analysis of professional documents and presentations, described below. Especially for professionals and organizations whose communication is often formally written or presented, documents offer access to visions and values that are not directly apparent in actually existing phenomena. In addition, the professional context of new mobility, as opposed to the traveler experience, involves an interplay among a multitude of organizational actors that is well suited to case study research.

Data collection

My methodological framework has already pointed me towards certain kinds of data collection, including interviews, analysis of artifacts, and reviews of documents. This section describes in detail how I collected data on the subjects identified above. Table 3 maps the study's methods to its subjects. The "technologies and services" subjects are listed in the table, but do not have dedicated collection methods. Instead, they show up mostly as ways to focus data collection with the travelers and professionals, and so they appear throughout the research. For example, I study Google Maps as it appears to travelers in interviews, and micromobility as it appears in professional documents.

In March, 2019, the University of Washington's Human Subjects Division reviewed my research proposal and determined that the study is exempt from human subjects regulations and requirements for ongoing review (IRB ID: STUDY00006893).

Professionals

I studied professionals by reviewing various types of published documents, examining software development practices on GitHub, attending industry conferences and events, and interviews.

Table 3: Study subjects and methods of data collection

	Interview (traveler)	**Focus group (traveler)**	**Interview (professionals)**	**Conference attendance**	**Document analysis**	**GitHub analysis**
Professionals and orgs						
Transportation officials			■ (SDOT)	■	■	
Software contributors			■ (OBA)			
Mobility providers				■	■	
Travelers						
Professionals	■					
Seniors		■	■ (Staff)			
Technologies and services						
Real-time navigation apps	■	■	■	■	■	
Micromobility	■	■	■	■	■	
Ridehailing	■	■	■	■	■	
Data specifications				■	■	■

Document review

Several types of documents provided key data for studying the visions of new mobility, and its actual operation. These can be loosely categorized as plans, policies, and reports.

Plans are documents that envision what could be, in greater or lesser detail. These are not necessarily a technical transportation plan, but are broader efforts to imagine how a certain intervention might or might not serve some value. For example, the Los Angeles Department of Transportation envisions the future of the city's digitally mediated mobility (LADOT, 2016), and Uber imagines how it can expand the reach of public transit (Uber, 2021). These kinds of statements are essential to my study of the promise of new mobility (chapter 4). They came to my attention through email lists, mentions at conferences, and browsing the websites of relevant organizations.

Policies are permits, regulations, contracts, and other documents that serve a functional purpose in directing a new mobility service. Here my focus is on SDOT's regulation of micromobility, which generated a number of useful public documents.

Finally, reports document something that has already happened, such as a city's scooter pilot, the launch of a new version of a data specification, or Uber's operations in the last year. These sometimes illustrate the messiness of implementation, but are frequently future-oriented visions as well.

These categories are fuzzy and overlapping, but naming them can illustrate the types of materials I was working with.[6] I consulted different documents at various stages throughout my research, and these shaped the direction of other data collection. My analysis focused on more formal documents, but I also absorbed information from my monitoring of industry blogs and journalism.

GitHub observation

Data collected through analysis and observation of GitHub repositories forms its own category. It is in part a kind of document review, but also an observation of social exchanges. GitHub is a popular website where people can collaborate to build and disseminate software. It offers a number of version control features attractive to developers coordinating complex projects with multiple contributors. Many GitHub repositories are publicly viewable, including those of the two data standards I studied, GBFS and MDS. Contributing to these open-source projects is somewhat restricted, but viewing them is easy for anyone with a web browser.

[6] A list of the formal documents consulted is included in appendix B.

I studied two components of these repositories. The first is the documentation of the code, which was written to be accessible to any moderately technical person who might want to understand how to use the specification at their local agency. This told me in detail how the standards worked, often with imagined use cases. The code itself, JSON schema, was also available for my review. The second component is contributor discussions. Contributors can flag issues with the code or request a new feature, and these often generate a lively back and forth. Votes on features are sometimes required by organizational bylaws, and so these discussions can become campaign sites. Even in less contentious issues, GitHub posts are where transportation professionals articulate their visions for what their technology can do, and their experiences of its shortcomings.

Many of the features and issues for these projects are tangential to my research, and so it took some effort to identify the areas where I would find useful data. I was interested in material that made visible the translation between digital data and mobility on the street. These appeared often in discussions of use cases, when contributors imagined mobility data serving a specific purpose. I also wanted to know where there were conflicts in code development, especially when they illuminated some difference in what role the code ought to be playing in the city. To find these examples, I scanned recently added features, looked for discussion threads that were particularly long, and monitored email announcements from the groups. The GitHub data collection often complemented data from conferences and documents.

Conference attendance

I attended two national industry conferences: the North American Bikeshare Association Annual Conference (September 2018, in Portland, Oregon) and the National Shared Mobility Summit (March, 2019, in Chicago), hosted by the Shared Use Mobility Center. My participation in these environments was much less active than in interviews; I collected data as an observer. At each of these conferences, I served as an event volunteer in exchange for a registration fee waiver. This also gave me an opportunity to disclose my role as a researcher to event organizers. My volunteer tasks did not interfere with my data collection, and in fact occasionally gave me access to people and conversations I might have otherwise missed.

Compared to the Shared Mobility Summit, the NABSA conference was smaller, with a narrower focus on bikeshare and scooter share. As its name suggests, the Shared Use Mobility Center is focused on shared modes, in effect anything other than a single-occupancy car. Its scope covers a good deal of the "new mobility" umbrella that is the subject of my study. Both NABSA and SUMC are situated within the cultures of city transportation planning and do not begin with a concern about digital technologies, but have inevitably come to address technologies as they have become integrated into their modes of choice. NABSA, for example, has played an important institutional role in the development of GBFS, the bikeshare data standard. Both organizations, and their conferences, convene industry players from both government and the private sector who are shaping the software and services of new mobility. In other words, these are places where visions of digitally mediated urban mobility are produced and circulated, making them productive sites for my research.

I attended plenary conference sessions to understand the broad issues driving the industry, and then chose sessions that appeared to be focused on applications of digital technologies. Many presentations and sessions—on environmental impacts, health, equity, safety, community partnerships, procurement, operations, equipment, etc.—were not directly relevant to my research questions, but provided helpful background. Instead, I focused on material that would help illustrate, first, the kind of city these professionals were envisioning, and how technologies were imagined to support that, and second, accounts of actual implementation and its resulting messiness. Besides the formal sessions, the vendor expos, hallway chats, and networking events provided further opportunity for observation. Compared to published documents, these conference presentations and conversations were particularly helpful for foregrounding tensions between transportation officials and vendors, whose conflicts can be more easily smoothed over in published reports.

I also attended a half dozen webinars hosted by various organizations between 2020 and 2021, and joined much of the 2021 SUMC conference held virtually.[7] These lacked the personal interaction of the in-person events, but otherwise served the same purposes.

Professional interviews

I conducted a few targeted interviews with transportation professionals,[8] but did not make this a core part of my data collection strategy. Often these provided background information or some clarity on a point not documented elsewhere. My research is interested in situating technologies as products of particular organizations, but I am less focused on the transportation professional as a specific *person*, as I am with the travelers. Additionally, I focus on organizational products (policies, plans, software) more than the process of production. (The exception is the data standards, whose production I studied through GitHub.) These purposes are mostly served by studying documents and conferences, which these interviews merely supplemented.

[7] These events are listed in appendix B.
[8] Their names and roles are in appendix D.

Travelers

This section is divided into descriptions of participant recruitment and the interview and focus group processes themselves. I also acknowledge the learning that occurred through my own travel. Further detail, including recruitment materials and lists of interview subjects, is available in the appendices.

Recruitment

Professionals were recruited in two ways. In the summer of 2018, I identified a convenience sample of suitable subjects among my personal network—friends and acquaintances of younger than 40 or so employed in professional roles, explicitly excluding anyone in urban planning or graduate studies—and emailed an invitation to participate in the study. Of the 37 people invited to participate, 18 volunteered to be interviewed, and I was able to schedule and complete interviews with 13 subjects.

The following summer, I conducted a broader campaign to recruit participants working specifically at tech companies, focusing on interns and others in their early to mid twenties. I recruited from two main groups, New Tech Seattle and Amazon summer interns. New Tech Seattle is an organization that provides networking opportunities for the local tech community through online communities and monthly events. In June 2019, I posted a call for participation in the organization's Facebook group (1,100 members) and on its Tech Seattle Slack channel (2,200 members). On June 11, I attended the New Tech Seattle event, a popular monthly networking event for tech workers new to the city. I made a one-minute pitch to attendees (perhaps 200 people) at an open mic during a period in the program reserved for community announcements, and I distributed flyers at the registration table. I also requested membership to the "Amazon 2019 Seattle Interns"

Facebook group (1,000 members) and posted a request for participation in mid-June.[9] Response to these efforts was underwhelming; I received interest from just six participants, and was able to conduct five interviews.

My plan was to tailor my message and recruit more participants from the 2020 Amazon summer interns, and by the end of 2019 I had been accepted to the corresponding Facebook group where I would post my call. However, the Covid-19 pandemic changed my research plans. Not only were interns no longer coming to Amazon's Seattle campus, but tech workers of any kind in the city were mostly staying home. Travel had changed dramatically. Given the divergence data from 2020 interviews would have had compared to my earlier interviews, I decided to stop traveler data collection. I had also reached theoretical saturation, with my last interviews in 2019 providing some new anecdotes but not new themes.

The recruitment at retirement communities was generally more successful. In summer, 2019, I contacted staff at six communities that appeared suitable in an internet search. I received three responses, and had an initial meeting with a staff member at each. Besides providing an entry to residents, these initial conversations became useful data sources in themselves. In particular, staff were able to share their perspectives on residents who were less mobile and less tech-savvy than those who ultimately participated in the focus groups. After these initial meetings, I worked with staff to schedule focus groups.

At Horizon House, the communications manager I had met with, Marya Purrington, helped to coordinate the focus group. She set a time, then recruited participants among those she expected would be good contributors. Five participants joined the focus group. At Mirabella, I first had a phone conversation with Erika Campbell, the resident services

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[9] Some of the recruitment materials for tech workers are included in appendix C.

director, who suggested I meet with one of her residents, who I call Mary. Mary was something of a gatekeeper, involved in organizing many community activities and acting as a go-to helper for residents learning their way around their smartphones. We met over coffee, and she suggested that she invite some of her neighbors who used things like Uber either particularly well or poorly to a focus group. Together with Erika, she invited residents through an online community, and ultimately eight participated in the focus group. At Council House, my initial meeting was with the executive director, Audrey Dunbar. She found a suitable date on the community calendar a few weeks out, and put my name on it. The invitation went to the entire community, promoted on the calendar of events with little description. I was encouraged to bring snacks to the focus group, and was told that people would find their way in. A total of nine residents joined the discussion.

The filtering of recruitment within Horizon House and Mirabella through staff and residents likely contributed to a self-selection bias. My study tended to be framed within the communities as a "smartphones and transportation" study, where I might have positioned it first as a transportation study, interested in anyone who travels around the city, and then working my way to the role smartphones do or don't play in getting around. The focus on technology likely turned off would-be participants who are not comfortable with smartphones and apps. Some of the internal recruiters narrowed in a bit too quickly on the people they thought would be a good fit. In the end, these informants were indeed articulate and thoughtful, and produced excellent data. A few of them did turn out to be technophobes, but on the whole they were more comfortable with new mobility technologies than I was led to expect of the communities as a whole. At Council House, by contrast, the more open framing and the invitation open to the entire community brought together a wider range of technological attitudes, a difference that is perhaps also attributable to the lower income of these residents.

All of the participants were self-selecting, which of course generates some bias. All subjects chose to spend an hour or so of their time talking to me with no compensation. Some likely felt that they had something notable to say about transportation apps—they already knew something they love or hate about them—while others, especially some of the summer interns, just seemed curious to talk to someone. The seniors at each of the three communities were used to people doing studies or holding info sessions, and it didn't seem unusual for them to show up in a conference room and chat with a stranger. Those from my own social networks were influenced by their personal relationships with me, which was helpful both in eliciting perspectives from people who might not otherwise choose to participate in a transportation study and in contributing to a sense of ease in the conversations. Overall, my recruitment produced participants who skewed more tech-savvy and transportation-savvy than my target populations as a whole, but for a study concerned more with generating detailed accounts of specific subjects than with the external validity of its conclusions, these articulate and engaged participants were excellent subjects.

In the end, I interviewed 18 professionals individually and 22 seniors across three focus groups.[10]

Interviews

Data collection for the professionals was through one-on-one semi-structured interviews. Interviews were conducted in person at locations chosen by the subject, often coffee shops close to their home or workplace. They each lasted between 45 and 60 minutes, five or ten of which were typically spent settling in with coffee and making small talk. I used a semi-structured interview format, which allowed me to cover the same general territory in each

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[10] For each interview and focus group participant, the name, sex, interview date, and for professionals, industry of employment and approximate age is listed in appendix D.

interview, while also allowing the flexibility to ask specific follow-up questions and pursue interesting topics as they emerge. The structure is built around the following five kinds of questions, generally asked in this order:

General travel habits: How do you get around town? What is your typical commute?

General technology habits: How would you characterize your relationship with your smartphone? What transportation apps do you have downloaded?

Descriptive: Tell me about a recent time when you used [Google Maps, Lyft, Car2Go, a Lime bike, etc.]. Where were you? Where were you going? When was it? Who were you with? What app/service did you use? How did you use it? What happened?

Rational: Why did you [do X in that particular way]? What were you trying to do? Did the tool do what you expected? Why didn't you [do Y instead]?

Emotional: What do you remember feeling about the trip at the time? Did you have any strong feelings about [Z tool], or was it not really on your mind? When you [did X], did you feel [anxious, annoyed, confused, relieved, confident, etc.]? Looking back, how do you feel about your use of [Z tool]?

Each interview began with two questions about general habits in transportation and in smartphone usage. Then the heart of the interviews revolved around three types of questions: *what* did you do (descriptive), *why* did you do it (rational), and *how did you feel* about it (emotional), each grounded as much as possible in a specific instance of the subject's use of digital tool for mobility. Of course the responses to these questions blurred and overlapped, but the ordering of these questions is intentional. The first two general questions functioned as a warm-up. They got the subject used to talking to me and began to bring forward the travel and technology phenomena of interest, while also giving me a baseline understanding of this subject's habits and attitudes. Subsequent questions were focused on specific incidents, and the progression from descriptive to more interpretive questions was intended to allow for a progressively deeper reflection on an event that might have otherwise escaped much conscious attention. Often, subjects had already given me a good idea of their rationales and attitudes when giving the initial descriptive accounts, but asking about them more directly usually elicited additional reflection. I returned to questions 3 – 5 repeatedly, as time allowed, to discuss different incidents. Usually by the end of an hour, subjects had told their most memorable stories and made their attitudes clear, and we were ready to wrap up.

A main challenge with this format and topic is keeping the conversation focused on accounts in support of my research question, avoiding tendencies to follow interesting but likely unrelated topics. My questioning aimed to keep the software itself in the foreground, and in particular the relationship between the technology's affordances and the agency and affect of the subject. I tried to avoid unproductive digressions about rush-hour traffic, late buses, and rude Uber drivers, for example.

For the 2018 interviews, I took notes by hand, then typed interview notes electronically shortly thereafter. Later interviews were recorded and transcribed. These notes were the basis for my analysis.

Focus groups

At the retirement communities, I modified my interview approach for focus groups. This was an adaptation to suit the management-coordinated availability of participants in these communities, who lived in the same place and were brought together at a single time, in contrast to the individual schedule coordination with the professionals. My goal with these was the same as with the individual interviews—eliciting accounts of specific app-mediated travel behaviors, with reflection on the rational and emotional components. However, I also wanted to follow the flow of conversation among subjects, avoiding a dynamic where it feels like each participant speaks to me separately and the others simply wait their turn. For the most part, the participants, who all knew each other, did not need much encouragement to engage with each other. As one participant would give their account, another would ask a clarifying question, or chime in with a similar story. Occasionally I needed to intervene to keep the conversation moving in the direction I wanted, or to provide some more space for a follow-up with a single participant.

As participants came into the room, I gave them a one-page survey. The resulting data provided some background context for my later analysis, but its main purpose was to prime participants to think about their apps and travel, and to give them an idea of the kinds of questions I was interested in. The survey asked a few descriptive questions about travel modes and smartphone usage and a question about smartphone attitudes. It concluded with an invitation to consider a set of questions that we would discuss as a group:

- What do you love about using transportation apps (like Google Maps) or app-based transportation services (like Uber and Lyft)?
- What frustrates you about them?
- When using these apps, have you ever felt that your smartphone was telling you to do something that didn't make sense to you?
- If something isn't working the way you expect, how do you get help?
- What do you wish were different about these tools?[11]

Having set this tone, I began the focus groups by introducing myself and asking each participant to introduce themselves with their name, the length of time they have lived in that community, and an answer to an icebreaker question (e.g., what is one thing you are excited about doing this summer). I then briefly introduced my study.

The substantive portion began with my asking for a show of hands: "Who has a smartphone? Who uses Uber or Lyft frequently?" Then, "Can anyone share a recent experience traveling by Uber or Lyft?" My handling of this first volunteer's account

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[11] The full questionnaire is available in appendix E.

required a balancing act. I wanted to demonstrate the kind of detail I was interested in by asking appropriate follow-up questions (“Walk me through that process. Where were you when you opened the app?”) and demonstrating the story pacing I was looking for. This almost always meant inviting the participant to provide more detail than they initially offered, sometimes requiring them to pause for a moment to think. At the same time, I wanted to avoid creating the impression that participants would be put in the hot seat with me interrogating them anytime they wanted to share something, which might discourage others from participating. For the initial exchanges especially, I tried to show my interest in detail without dwelling too long on a singe participant. Soon enough, I would invite more cross-participant exchanges during someone’s story, encouraging participants to build on each other (“Has anyone had a similar experience?” “Does anyone else feel differently in that situation?” “Nicole, you said you prefer taxis, what is that like for you?”). My general flow of questioning followed the descriptive, rational, and emotional sequence that I used in individual interviews, with the same inevitable blurring.

All of the senior focus groups took place after I had completed the individual interviews with professionals, and the decision to use different methods for the different populations was a matter of convenience. Overall, I found the focus group format to work well in drawing out attitudes and anecdotes from participants who might not otherwise think they had much to share. I expect this method would also elicit useful data from young professionals, and am interested to try this in future research. Likewise, one-on-one interviews would likely have allowed some more detailed story-telling with seniors, avoiding the interruptions of their fellow subjects.

During focus groups, I kept some notes on topics to return to or about specific participants to help me facilitate the conversation. The conversations were recorded and later transcribed.

Autoethnographic travel

Lastly, although I do not position myself as a subject of this study, I do want to recognize that my own experiences with phenomena of new mobility have shaped my understanding of the subject. I have never been a frequent user of ridehailing or bikesharing, but I did engage deliberately with these apps and services in the course of research. I also used OneBusAway and Google Maps regularly. I observed how the interfaces function, whether the arrival times were accurate, and how the bikes worked. For several trips by Uber or bikeshare, I took screenshots of the apps and wrote up notes about the trip, especially when something went wrong. Familiarity with these tools was necessary for me to engage with my interview subjects, asking meaningful follow-up questions and offering my own examples. It also grounded my study of the professional conversations around new mobility in an actual experience that I knew well, my own.

Data analysis

This study generated a lot of data. From interviews and focus groups, I had detailed notes or verbatim transcripts. I took field notes at conferences and webinars, and sometimes collected presentation files. I took notes and screenshots from my own app-based travel experiences. Conversations and code on GitHub, published reports and regulations, and journalistic accounts of the industry provided further material. The process of sorting through all it began with the identification of subjects and the targeted collection of data described above, intensified in the focused analysis effort described here, and continued through the writing of these chapters. In all of these stages, the focus of my analysis was directed by the research questions. This section describes my analysis as informed by grounded theory approaches.

A central question in qualitative data analysis is the degree to which the researcher's own preconceptions or existing theories should guide analysis, rather than letting themes emerge solely from the data itself. In phenomenological studies faithful to Husserl, for example, the researcher must suspend all prior notions of the phenomenon, a process called bracketing, and use only the meanings which are presented to consciousness in the encounter. However, the development of phenomenology by Merleau-Ponty, Heidegger, and many subsequent scholars has claimed that all of the histories, biases, and philosophies are themselves integral to the subject's experience of a phenomenon (Wimpenny & Gass, 2000). The researcher therefore must reflect on his own prior notions not to try to set them aside, but to embed them in the interpretation of the phenomenon (Laverty, 2003; Tuohy et al., 2013). Some forms of grounded theory, too, emphasize the neutrality of the researcher, who passively observes phenomena and applies categories that emerge naturally from the data, while others emphasize the researcher's own active presence in both data collection and analysis (Olesen, 2007; Strauss & Corbin, 1990).

I adopt an approach common among interpretivist qualitative researchers in which I acknowledge my own position, including the theories and categories I bring to the data, while also being open to new frames that emerge from the data (Finlay, 2008). I come to the phenomena of digitality in cities with a particular point of view informed by my understanding of specific scholarly debates as well as my own personal experiences and values. From this literature and my early data collection, I developed research questions grounded in ideas of digitality's promise, and the gap between its visions and practices revealed on the street. These are what bring me to my data, and they are the basis for my analytical frames. At the same time, I was careful not to begin the project with overly specific ideas about what I would find. Such rigidity can blind the researcher to data that either contradicts or simply does not align with those preconceived notions. Indeed, over the course of this research, I have sometimes needed to bracket my own expectations in order to see my material more clearly. For example, in earlier phases of my work, I was motivated by a concern that new technologies were controlling the city. I have since shied away from that claim, adopting instead a more complicated view of the coproduction of people and technologies. This perspective is well articulated in the literature, introduced in preceding chapters, but was also evident in the data from my research.

Grounded theory offers the most helpful framework and tools for balancing theories and data in my project. In grounded theory, systematic empirical research and the development of theories explaining the phenomena observed are mutually constitutive (Glaser & Strauss, 1967). Grounded theory assumes that new knowledge emerges not from the data itself, but from an ongoing comparison of data with theoretical categories. The researcher should therefore analyze early data in order to guide future data collection, initiating a mutually informing cycle that oscillates frequently between analysis and collection (Charmaz, 2004; Glaser, 1992).

As mentioned above, the material I had to work with included interview notes and various kinds of documents. Data analysis in grounded theory processes uses codes, short labels applied to empirical data that link it to a theoretical construct. Data with the same codes can then be compared within and between categories to begin developing a theoretical model (Bernard, 2000). Although grounded theory analysis often begins with "open coding" that avoids predetermining any theoretical categories (Charmaz, 2004), I acknowledge that my initial codes were shaped by my theoretical framework. Still, I did not begin with a comprehensive list of codes addressing every aspect of a complete theory. In fact, I conducted and analyzed my first traveler interviews before I had developed my ideas of autonomy, desire, and agency as guiding themes for the study. In the analysis of these interviews, I developed a set of codes from the data that drew me to larger themes. For example, codes included "time awareness" for when subjects discussed paying attention to how long a trip took and "confidence" when I interpreted them to be expressing self-assurance in their movements across town. These emergent themes helped me to develop a theoretical framework that addresses this kind of interior experience of app-mediated travel, which then guided subsequent interviews and analysis.

Coding was most intense for traveler interviews and for the transportation documents dealing with new mobility's promise. I did this analysis using Atlas.ti, the popular qualitative data analysis program. The coding process in this program involves identifying a meaningful segment of the material as a "quotation," then applying one or more codes to it. The codes connect the quotation to a broader theme, and also connected related quotations to each other. The number of codes grew quickly early in the analysis until I had developed a codebook that was adequately covering the new material I encountered. Codes also shifted, as I merged codes representing similar ideas together and split others apart. These changes meant that I often needed to return to recode earlier data after the codebook had stabilized. For example, the codes for traveler interviews changed significantly after my second round of interviews in 2019, and so I re-coded the first group of interviews using the new codes. In the end, I used 74 codes for the analysis of planning documents and 90 codes for traveler interviews.[12] The codes were an ongoing conversation between my data and my theories. They allowed me to identify patterns in the data, link common themes across sources, and evaluated the groundedness of my findings in the data itself. They then served as a guide for writing my findings, which involved further processes of focusing and refinement.

[12] My codebook is reproduced in appendix E.

Bringing the threads together

This chapter has provided both the methodological framework for my research and an account of what I actually did. These are always guided by my three research questions, which ask about the relationship between the promise and the mess of new mobility (RQ1), the role of digital structures in ordering the social relations of the city (RQ2), and the experience of autonomy—desires and agency—for travelers using app-based mobility tools (RQ3). I have described the specific technologies, practices, organizations, and people where I focus my investigation. To some degree, the subjects, methods, and even methodologies have been treated separately for each of these questions. In many cases, a question does call for its own specific tools. However, I want to emphasize an essential point of my overall approach to this research, which is that I do not see these as separate threads, but as entwined components of a whole. The promise-mess bifocal is a tool for seeing both the animating desires and the situated practices together to understand how they produce each other. Not only do my research questions speak to one another in a theoretical sense, but my subjects and methods in one corner of the project have informed my approach in another. A senior's account of miscommunication with an Uber driver, for example, was on my mind as I analyzed Uber's pitch to revolutionize public transit. The "infrastructural sensibility" guided not just my analysis of mobility data specifications, but the kinds of questions I asked an Amazon intern about how he got around when his phone had died. In that sense at least, the entire project could be considered a case study, in that it engages with different aspects of a complex phenomenon using a variety of tools. The three empirical chapters that follow present the results of this research in a way that mostly aligns with the three research questions separately, but they become even richer when viewed together.

CHAPTER 5

New Mobility

This chapter serves two purposes. First, it introduces the current practices of new mobility, the site of my research that I have positioned as a case of the digitization of the city. This descriptive account sets the essential context for the research project as a whole. The second purpose is to examine how new mobility functions not just as specific interventions, but as a promise. Using the framing of the promise introduced in chapter 2, I argue that the promise of new mobility attaches the mechanisms of emerging digital technologies to established desires among planners for certainty and solvability. Urban transportation professionals have long envisioned cities that offer easy and accessible mobility to all by transit, walking, and biking, rather than by driving private cars. This vision has proven difficult to realize. The promise of new mobility is that smartphone-equipped travelers, the expansion of mobility data, and transportation services built on these digital tools will allow cities to finally achieve this vision. More broadly, it promises that planners can have expanded and more accurate views of travel in the city, and that the problems of urban transportation can become bounded and solvable rather than sprawling and intractable. Downplayed in this promise are engagements with the messiness of the city—its enduring built environments and the agency of its people—that would challenge this ideal. However, it is in this non-digital urbanism, especially transformations in infrastructure, land use, and travel behavior, that we can find solutions that better match the challenges of mobility. The following chapters on datafication (chapter 6) and travelers (chapter 7) will examine what happens when the promise encounters messiness in practice. In this chapter, I focus on the promise itself to show how it appeals to desires for certainty and solvability while avoiding engagements with infrastructure and politics.

The empirical material for my examination of promises circulating among mobility professionals, including those within government, non-profits, and the corporate providers of digital technologies and of mobility services, is my study of their plans, reports, conference and webinar presentations, and interviews. (The promise for travelers themselves will be the subject of chapter 7.) These sources show how mobility is or is imagined to be digitized, and why. I am especially interested in the desires that animate these visions, and these are sometimes explicit and sometimes implicit. Visions for apps that will better integrate ridehailing and transit in order to reduce driving, for example, are stated clearly in various professional documents. The desire to translate problems of infrastructure or travel behavior into a more manageable problem of digital communication, however, is not stated outright. Identifying these desires often requires some amount of speculation, as I begin with the stated vision and ask what values are likely to have driven it, and which are absent.

Mosco (2004) describes technological myths following a predictable pattern: the declaration that the world as we know it is changing, the envisioning of the desirable outcome of that change, and the identification of a technology as the force responsible for that change. The promises of new mobility have fit this pattern well. In recent years, transportation professionals are pointing to the pace of technological change and saying that “it’s going to be a game changer” (according to the head of a transit authority, speaking at the SUMC conference) or that “we’re going through a great transition and a once in a lifetime opportunity" (according to guidance for communicating the "Shared Mobility Principles"). City transportation officials are also claiming that new technologies are a force of change:

> The disruptive forces of new transportation technologies…are compelling us to change our vision of the Denver region's mobility future. [We must] understand how to harness the benefits of these new technologies to enhance mobility. (Denver Metro Chamber et al., 2019)

> Transportation is undergoing a massive transformation that will change the way we conduct business. … With the ongoing explosion of technology in transportation, LADOT is committed to ensuring that everyone in our city benefits from these new mobility choices. (LADOT, 2019)

> Technology is rapidly changing, and we're going to see even more innovations. … New mobility could greatly benefit the people of Seattle, but it also brings risks. (SDOT, 2017)

In this field, new technologies are seen as the agent of change, and the work of transportation professionals is to make sure that this change leads to a desirable outcome. This chapter examines what these technologies are and what the desired change is. The first section illustrates the digitization of urban mobility using actually existing examples of technology-based changes to mobility practices. Here I also briefly introduce the technical mechanisms—location data, APIs, smartphone apps, and others—and corporate players of new mobility that have introduced these changes. The second section builds on this to examine the pitches for what these kinds of digitally mediated mobility practices are envisioned to do. It shows how the promise links *information*, which is the medium of the new digital technologies, to specific *transportation* visions for integrating modes, expanding the reach of transit networks, and allowing for city monitoring and control of urban mobility. In the third section, I draw out the specific desires that animate these promises. These are the broad goals of access, equity, sustainability, and safety, and their manifestation in visions of mobility centered on multi-modal systems discouraging private car use, that have guided urban transportation planning for decades. Less explicitly, the desire is for tools that will offer certainty and solvability in the face of the mess of urban mobility. Throughout this chapter, I want to show that any new mobility intervention is not simply a narrowly focused solution to a defined problem, but is a promise speaking to these more deeply held desires. Seeing it this way is necessary to repoliticize the promise, asking not just whether an object can succeed in realizing some vision, but whether the vision in itself is a good one. The danger I identify is not that certainty or solvability are in themselves bad, but that pursing them risks abandoning such political discussions about the shared structures and individual behaviors of urban mobility.

The actually existing digitization of mobility

Not so long ago, the practices of getting around the city could be adequately described in terms of vehicles and infrastructures, wheels and pavement. Today, any complete picture of urban mobility must also include smartphones, apps, GPS receivers, data, interfaces, and other digital information technologies. Some transportation officials have recently proclaimed that "information is the new infrastructure" (SDOT, 2017) and that "code is the new concrete" (LADOT, 2019). We know that information technologies have not eradicated the need for concrete infrastructure, as even these documents are well aware. We will see that a *desire* to escape this materiality, however, is present in many of new mobility's promises. Hyperbole aside, the claim that digital technologies are doing something new, and that their novel functions have a relevance comparable to that of more familiar infrastructures, has some truth to it. With a nod to Shelton, Zook and Wiig's (2015) call to study the "actually existing smart city," this section examines where digitization is already shaping urban mobility, rather than where it is imagined to intervene in the future. It begins with a series of illustrations before examining the digital mechanisms and organizational actors behind them. This will lay the groundwork for the subsequent examination of the promised transformations.

Five new mobility vignettes

In the following examples, digital technologies are the basis for new mobility practices.

Metro's GTFS feed: Public transit data — King County Metro operates more than 1,500 buses on some 230 routes serving thousands of stops on roads across King County. For many years, the agency has also produced a dataset, running to well over one million lines, describing each of these routes and the schedule of each bus trip in detail. The data is published in a standard format, the General Transit Feed Specification, which comprises a set of CSV files that can be read by third-party software for travelers' trip planning. Since 2015, Metro has also offered a real-time transit feed, which provides a more-or-less current picture of a given bus's actual location and its estimated deviation from the planned schedule. GTFS feeds from Metro and other transit agencies is used to plan transit trips in countless smartphone apps and web applications. Metro's critical functions today include not just building bus shelters and operating buses, but generating and disseminating bus data.

Morning commute: Real-time travel info — Travelers now use GTFS and other transportation data every day in planning and making trips around town. Consider the following fictitious but typical example. Fatima is a nurse who lives in Ballard and works at the Swedish Medical Center on First Hill. While having breakfast one morning before work, she opens Google Maps on her phone to check the traffic. She tells the app that she wants to be at work by 8am. Google Maps tells her that normal route across the Ballard Bridge is congested. The Fremont Bridge is another option, but today it looks like the best bet, surprisingly, is a route on I-5, which the app tells her will take 32 minutes. Comfortable with this option, Fatima decides she has enough time to finish her breakfast before heading out the door. Meanwhile, her husband Omar uses his phone to check OneBusAway and sees that he just missed his bus to the office. The next one won't arrive for 12 minutes. He opens the Lime app and sees on a map that there is a bike available to rent two blocks away from his house. The weather is clear, and he decides a bike ride might be nice. He reserves the bike on the app and walks out the door to where Lime tells him his bike will be.

Ride2 Eastgate: Microtransit —App-based services have led to novel approaches to public transit. The Eastgate Park & Ride, which sits next to I-90 in Bellevue, serves 15 bus routes, including many with express service to downtown Seattle. The surrounding neighborhoods are a traditional low-density suburb, putting few within an easy walk of the transit center and making feeder bus routes impractical. Driving is usually the easiest way to access these bus stops, but on weekday mornings commuters' cars have often filled the 1,600 spaces in the garage between 6 a.m. and 7 a.m. In response to the "last mile" problem of connecting a dispersed ridership to a transit hub, Metro launched the Ride2 Eastgate service. In a one-year pilot beginning in 2018, Ride2 used a private operator (first Chariot, a division of Ford, and then Hopelink) to shuttle travelers in shared vans between the park and ride and destinations within a defined service area. Using a dedicated app similar to those for Uber or Lyft, travelers requested a ride and identified their pickup or dropoff location. In some cases, they could schedule a ride in advance. The Ride2 software would generate routes on demand, aiming to keep any given traveler's wait time and travel time within specified targets, and then direct drivers to pick up passengers. Riders paid with an Orca card as they would for a bus (Rynning, 2019).

Seattle's dockless bikeshare: Micromobility — Similarly, smartphones have been the key to a new model for bikeshare. The Pronto bikeshare system, which operated in Seattle from 2014 until 2017, was typical of the bikeshare systems that expanded rapidly in cities across the U.S. in the early 2010s. It used a network of some 50 semi-permanent docks stationed throughout a few neighborhoods in the central city and U-District. Each dock had spots for parked bikes as well as a kiosk for processing payments, and usually a large map of bike routes in the area. Riders unlocked a bike using a personal key fob or by purchasing a ride at the kiosk, then return the bike to any open dock in the system. The system was administered by SDOT, with operations contracted to a private company, Motivate. Funding came from a combination of user fees, corporate sponsorships, and municipal subsidies. Shortly after Pronto shut down, Seattle became the first North American city to offer dockless bikeshare in the summer of 2017. These are operated by private companies that the city regulates but does not directly subsidize. Although docked bikeshare had long made use of data and apps to report bike and dock availability to users, smartphone-based information technologies are far more integral to dockless or “free-floating” systems. A dockless bikeshare bike can be left on any sidewalk within the defined service area. Instead of walking to a dock at a known location, a rider will usually check an app to find the nearest bike. Generally, users must download an app for the specific bikeshare provider, then set up an account and payment method. The app, rather than a dock, unlocks the bike and begins the trip, which is billed by the minute. The bike itself is equipped with a GPS receiver and cellular communication hardware, allowing it to communicate location data and availability status to the service provider and ultimately the rider.

Mobility Data Specification bike counts: Trip data — Bikeshare also generates new data for planners. In 2012, an SDOT data collection team counted people riding bikes at 50 locations across the city. Observations at each site were made on four days across the year, and at three different times each day. This labor-intensive process of 600 collection events produced data that still represents only snapshot of the typical geographic and temporal patterns of biking in the city—data that says a bike was in a given place at a given time, but not where it came from or where it went. Automatic counters at 12 locations provide daily counts with better time resolution, but with less geographic coverage. Like other city bicycle planners, SDOT wants to know where people are riding bikes to help plan new bike corridors, identify locations for safety improvements, and advocate for new cycling infrastructure. Today, the data from new micromobility systems offers more data with less effort. SDOT requires bikeshare and scooter share providers to collect time and location data for each individual trip, including its origin, destination, and periodic points along the way. This data must be regularly reported to SDOT through an API. The data conforms to the Mobility Data Specification, a format that has become the standard for data exchanges between cities and service providers. Even though the data is only from rides on bikes and scooters for hire, it nonetheless offers far more granular and more extensive picture of mobility in these modes than Seattle previously had access to. To give a sense of the scale, Seattle has published an aggregate dataset of origins and destinations in the first half of 2021 based on 672,126 individual trips.[1]

New mobility's digital mechanisms

These brief examples illustrate some of the new practices that comprise new mobility. Travelers have access to up-to-the-minute information on the status of various transportation systems, and use apps to compare, choose, and access various means of getting from A to B. New forms of mobility services, like microtransit and micromobility, are made possible by app-based communications between travelers and providers. And transit operators and transportation agencies disseminate and collect more data on more

[1] https://data.seattle.gov/Transportation/Shared-Mobility-Aggregated-Trips/uirh-29ta

kinds of trips than ever before. The major example of new mobility not directly mentioned here is ridehailing, which not only replaced many taxis hailed on the street or dispatched by radio, they rapidly expanded the common uses and users of taxi services. Together, these cover the major types of mobility digitization now underway. In these examples, familiar travel activities—operating a transit system, commuting to work, planning for cycling infrastructure—have developed in new directions because of technologies that have been adopted within the last five to 15 years. Table 4 summarizes how these new practices have been enabled by specific technologies.

Table 4. Examples of New Mobility

Example	**Existing practice**	**New practice**	**Key enabling technology**
Public transit data	Transit agencies provide infrastructure and bus services. Transit agencies communicate directly with travelers.	Transit agencies produce and disseminate data. Third-party apps deliver transit info to travelers.	Data standards, APIs, Sensors
Real-time travel info	Travelers make mode, route, and schedule decisions for their trips with limited or no real-time info.	Travelers compare options and plan individualized trips with real-time info from apps.	Data standards, APIs, Sensors, Apps
Microtransit	Commuters drive and park at transit center.	On-demand shuttles provide door-to-bus service. Travelers access through app.	Apps, Routing software
Micromobility	Shared bikes at fixed docks. Travelers access through dock/kiosk.	Shared bikes distributed widely. Travelers access through app.	Apps, Sensors
Trip data	Planners have limited visibility into bike usage.	Planners have detailed data on trip times, origins, destinations, and routes.	Sensors, Data standards

Practices like these are the basis for promises, examined later in the chapter, that new mobility is or will soon be the agent of transformations in urban mobility. I will argue that there is little radical about new mobility's promises, but here I want to emphasize that many of these technologies are actually new. The novelty of these technologies is what allows transportation professionals to envision that something is different this time, and that familiar visions can be achieved with new digital objects. These new enabling technologies are primarily *information* technologies, which facilitate the sensing, transmitting, processing, and displaying of digital data. (There have also been developments in non-information technologies, like bikes and scooters powered by lithium batteries, but they are peripheral to the main push of new mobility and my study of it.) Mobility infrastructures like roads, sidewalks, and buses have remained largely unchanged, but the digital tools are changing much more rapidly, and are inspiring new applications. The digital technologies enabling these changes include GPS and other sensors in vehicles and in smartphones, data standards governing the exchange of mobility data, various software for analyzing this data and calculating routes, and smartphone apps that communicate travel information en route. The most foundational technological developments for new mobility are those related to location data. Recent advances in location data capabilities, especially the ubiquity of the mobile computers that generate it and consume it in situ, have allowed for more information about the movement of people and vehicles in cities to be more readily shared.

The mechanisms of new mobility are an apparatus for exchanges of information among humans and machines. For example, a GPS sensor on a bus communicates with satellites to generate latitude and longitude data describing its current location. The location data is then communicated over cellular transmitter using internet protocols to a King County Metro data server, where it updates the public API for the real-time GTFS feed. The app Transit pulls the location coordinates from Metro's API onto its servers, where it becomes input data for algorithmic procedures to calculate a bus delay. The resulting arrival time estimate is sent wirelessly to a user's smartphone, where Transit's software represents the data graphically to a traveler waiting at a bus stop. With ridehailing, micromobility, real-time navigation, and other practices of new mobility, comparable flows of data generated by phones, vehicles, and infrastructure result in information consumed by a person looking at a screen. Data can be generated intentionally by a person, such as someone requesting a Lyft pickup, or automatically by a machine, like the phone generating and sending location data for the pickup. Although data flows sometimes end with a machine, as when Jump's digital infrastructure triggers the unlocking of a parked bike, much of new mobility is built on data that is ultimately represented as information to a human end user. For the moment at least, Uber's routing algorithms direct drivers, not their cars. This contrasts with many "smart city" visions of the automated operations of, for example, traffic signals or energy grids. The persistence of this human-machine connection is important to keep in mind in my discussion of digitality's promise, since it reminds us that this promise is not of a technological artifact standing on its own, but always involves the close integration of such artifacts with a person situated in a particular environment.

New mobility's organizational actors

These snapshots of actual new mobility practices are not all informational or digital, however; they also depend on new services, such as park-and-ride shuttles, and new vehicles, such as shared bikes and scooters. Some of the digital advances have easily layered on top of existing mobility models, such as the communication of bus locations. In other cases, digital technologies provide the foundation for new service models and new organizations. Micromobility and microtransit are a kind of mobility service that could not be easily operated without ubiquitous smartphones and location-based services. While dock-based bikeshare and fixed-route transit are controlled primarily by public agencies, their smartphone-enabled counterparts have become business models for a constellation of new and established private companies, many of them attracting venture capital investment. The promises of new mobility come not only from its informational capabilities, but from these organizational shifts from singular governmental entities to multiple corporate players. Because I am interested in what digital *technologies* do in the city rather than what technology *companies* do, however, my study focus more closely on the technologies themselves than on the novel organizational and operational forms built with them. For the most part, my research questions allow me to leave companies' business strategies, operational models, financing, leadership, and corporate culture out of the picture, or at least to take them as a given without further investigation. Still, some understanding the corporate context is important, since these organizations develop not just products and services, but the promises surrounding them.

In the examples above, new mobility is transportation becoming digital. From a different perspective, it can be seen as the expansion of software companies into fields beyond computer screens, so that digitality becomes more concrete. The professionals dealing with new mobility include people who design databases and people who design streetscapes; the inherent tension of the digital and the concrete in this field is apparent in the organizations at work here. Google, an information technology company, is shaping urban mobility without operating any transportation services, building road infrastructure, or purchasing vehicles. Uber, which also considers itself an information tech company, technically does not own cars or employ drivers, but it certainly seems to have a material presence on the street. More recently, a micromobility provider like Lime might own and maintain a fleet of tens of thousands of vehicles across dozens of markets, but these venture-backed companies continue to operate according to the principles of a Silicon Valley startup writing code. Those include minimal engagement with physical assets, the datafication of everything, a relentless focus on scaling the user base above profitability, rapid product iteration to learn what works in the market, and the "move fast and break things" attitude of disregard for existing norms and rules. The clash between this culture and that of transportation planners is not the focus of this study, but the tensions among promises aimed at different audiences—planners, customers, investors, regulators—are often apparent.

The types of companies involved in new mobility vary. Companies like Google already have enormous resources to invest in their mobility products, and in some cases they are joined by well-resourced mobility companies like Ford who are investing in new digital products. Uber and Lyft are each publicly traded companies with market values in the billions of dollars. Smaller companies, including the micromobility companies and a few navigation apps, have attracted large venture investments with expectations of big payouts. The profitability of transportation apps or services, however, is questionable[2]. The more likely strategy for such companies is to develop a user base or a proprietary technology that makes it an attractive acquisition target. So much of tech companies' values comes from their monetization of personal data, and, although the topic came up surprisingly rarely among transportation planners in this study, capturing valuable mobility data is likely the ultimate goal for many of these companies. In the few years of this research, there has been a flurry of merger and acquisition activity in this market, especially for bike and scooter share. Uber and Lyft have each purchased micromobility outfits with the goal of diversifying their mobility offerings. The pressures all point towards consolidation, with every company wanting to become the go-to platform for any trip. Lyft has described this strategy as a way to become "the ultimate transportation middleman," and wants users to

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[2] One blogger estimated that, in Louisville, scooter company Bird was losing approximately $300 over the lifetime of each of its scooters (Griswold, 2019). The steep per-trip loses for Uber and Lyft are well known to investors.

open their app "at the moment you've decided where you're going—and before you know how you'll get there" (Davies, 2018). Corporate imperatives have sometimes meant that mobility providers rapidly leave a city, or change their prices, or require a different app after a merger. This churning and the financial incentives of these companies have caused some anxiety among the city agencies trying to ensure the availability of reliable transportation options.

As for the providers of mobility services, namely ridehailing and micromobility, their current relations with cities have been strongly influenced by the cities' experience with Uber and Lyft a decade ago. In the story told at conference panels and in reports, cities were caught off guard in the early 2010s by the rapid expansion of Uber and Lyft, and are now determined not to repeat the same mistakes. Ridehailing initially worked its way through legal gray areas, with Uber and Lyft claiming that they provide software but do not employ drivers or operate vehicles, and drivers claiming that they were not taxis, and so did not need to be licensed, because they did not pick up fares on the street. By the time complaints from incumbent taxi drivers mounted, and others complained of increased congestion, Uber and Lyft had built constituencies of drivers who counted on ridehailing for income and riders who evangelized about the safety and convenience of the services. Cities eventually created regulatory regimes with various requirements for driver registration, but, in their telling, the ridehailing companies had the upper hand. Cities still feel at a disadvantage.

This history was fresh when, as NACTO tells it,

> a new breed of Shared Active Transportation [i.e., bikeshare and scooter share] companies began operating on North American public streets and rights-of-way. Many of these companies initially launched absent contracts, permits, or business licenses, often completely independent of municipal knowledge, policy making, or existing partnerships and community programs. (NACTO, 2018, p. 3)

For several reasons, regulatory agencies were in a stronger position with micromobility than they were with ridehailing. For one thing, it is much easier for cities to haul away unlicensed bikes from the sidewalk than to chase down and remove unlicensed taxi drivers. "I could go rent a U-Haul and pick them all up. So the vendors know that cities have a lot more leverage," SDOT's micromobility manager told me. Given municipalities' legal authority over the public right of way, the providers would need the explicit or implied permission of local governments to continue operating. Perhaps for this reason, many providers, though not all, were more proactive than Uber and Lyft in cooperating with local DOTs. They hired former transportation planners as government liaisons and began speaking the language of active mobility and connections to transit, as examples in this chapter will show. Where Uber and Lyft began with user approval and then only later sought legal permission, micromobility companies like Lime, Jump, and Bird made their moves on two fronts simultaneously: building a user base and securing the blessings of regulators. Uber and Lyft too have recognized that government buy-in is essential for their business. This position helps explain why, at the historical moment of this study at least, so much of the corporate promise of new mobility seems to align with planners' visions.

Planners and allied professionals are well aware of the financial incentives of these corporate players, and remain wary of their long-term goals. The work of regulation, some of which is examined in chapter 6, is where conflicts between the goals of corporations and city governments are sorted out. When dealing with the promise of new mobility rather than its practice, however, these planners tend not to focus so much on the business particulars. They squint a bit to try to see beyond the companies and models actually involved today to envision instead what the underlying technologies *could* do some time in the future. For the most part, my study operates at that level as well, focusing on the mobility practices promised by these technologies themselves, regardless of business feasibility.

Pitches: Envisioning what new mobility will do

While the illustrations above are actually existing cases of what new mobility currently *is*, this section shifts to the visions for what *could be* if and when such practices expand or improve. Here the specifics of the new mobility vision come into focus. Using reports, conference presentations, and other material from transportation professionals, I describe the explicit promises of new mobility—how they are imagined to work, and what is hoped they will achieve. The ultimate vision—of people moving easily across the city without driving a car—is familiar to urban transportation planning. What is new, however, are the digital technologies themselves, and the ways that the promises attach these new tools to the old desires. In these pitches, access to better information is the agent of change. Two other agents of change in the city are conspicuously absent: the built environment, and people. These pitches do not imagine substantial changes to infrastructure or, especially, land use. Furthermore, they do not engage with the unpredictable and conflicting desires and agency of people, as would be necessary to lead changes in travel behavior or engage in the political conflicts over the allocation of right-of-way space, transportation funding, or other scarce resources. Achieving the kinds of mobility transformation envisioned will certainly require infrastructural and political interventions, not just informational, but these pitches distract us from those challenges with the lure of a simpler, digital terrain.

To illustrate the pitches, I build on the five above examples of the digitization of mobility—Metro's public API for real-time bus locations, the couple planning their morning commute, the Eastgate Ride2Transit program, Seattle's free-floating bike share, and

Seattle's new bike data. These are grouped into three pitches. First, the production and consumption of travel information, represented by Metro's GTFS feed and the trip-planning vignette, work together to support the promise of real-time trip planning across multiple modes. These practices help illustrate the promise of "Mobility as a Service." Second, both microtransit and micromobility, illustrated with the examples of the Ride 2 Transit program and Seattle's free-floating bike share, are examples of the promise of new mobility business models offering more effective and cost-efficient services to a broader area. Finally, Seattle's monitoring of bikeshare through MDS is an example of a larger push for cities to use data for monitoring and managing current conditions as well as making longer-term decisions about policies and capital investments. There are two points to keep in mind throughout this discussion. The first is that the promised outcomes of new mobility are consistently articulated in the language of transportation planners. New mobility rarely asks planners to accept new goals, but rather invites them to imagine new ways those goals might be achieved. Second, new mobility promises not just specific tools, but the purposes to which those tools will be put. For example, the promise of systems for collecting and sharing data on where shared bikes are parked is not just about the nature of the data that will be available. The promise is about how cities will *use* such data in interventions to make the public right-of-way safer and more efficient. This neatly conflates a technical change with an organizational or behavioral change.

Information for integrating modes: Mobility as a Service

In this pitch, the availability of integrated, real-time transportation information will make traveling with a combination of shared or human-powered mobility services—transit, shared rides, cycling, walking—as convenient as driving your own car, leading to significant travel behavior changes away from driving. Mobility as a Service is described as "the widespread availability of integrated modes of transportation, which can be easily accessed and planned together" (Shared-Use Mobility Center, 2020). The vision of Mobility as a Service, abbreviated as MaaS ("moss"), is a framework for practices of transit agencies publishing up-to-the-minute location information and of travelers using trip-planning apps. Conceptually, mobility as a service derives from Silicon Valley's popular "software as a service" business model, under which software companies stopped selling software applications as a product that the end user owns and installs and began offering access to a centrally hosted program on a subscription basis. The parallel vision for MaaS is that travelers will not own the means of their mobility, e.g., a car, but will instead access mobility services from another provider, such as a transit agency, ridehailing platform, or scooter share company. Travelers pay not for a product but for the service, either on a per-trip basis or through a flat subscription model. In the strongest MaaS vision, all mobility service providers are integrated into a single app that travelers can use to plan, book, access, and pay for travel.

The MaaS vision assumes the existence of multiple transportation modes and proposes the integration of information that will allow travelers to easily use these modes to suit their personal needs. City transportation planning documents illustrate versions of this vision of using digital information to integrate separate mobility services:

> This emerging, technology-enabled, seamless, nearly door-to-door transportation system is what we call the new mobility. It allows Seattleites to treat urban transportation as a customizable, on-demand service. They can book and pay for different transportation services as they go, based on what they need. (SDOT, 2017)

> People are moving between public and private modes of transportation. Agencies and private partners need to help support this by providing seamless information and payment systems to bridge the gaps between services and remove friction in the system. People...want a system that makes their trip easy no matter how many modes or providers it may involve. (Denver Metro Chamber et al., 2019)

> Mobility as a Service can significantly improve access to jobs, education, healthcare, and other services by making it easier for Angelenos to find and utilize an increasingly complex suite of services through a single interface. This affords Angelenos more choice when determining what mode best accommodates their schedule – a key element in rider satisfaction. (LADOT, 2016)

Note the emphasis on the experience of the individual traveler ("customizable, on-demand," "makes their trip easy," "rider satisfaction") and the role of data integration in improving that experience ("seamless," "bridge the gaps," "complex suite of services through a single interface"). Public transit has long suffered a reputation as being inconvenient and impersonal, first in comparison to driving your own car wherever and whenever you want, and then in comparison to accessing that same level of convenience in Uber or Lyft through an intuitive and informative interface. In this context, MaaS can be seen as transportation planners' new hope for providing a competitive level of convenience.[3]

Digital data are central to these visions in two ways: integration and communication. The MaaS vision recognizes that its replacement of the door-to-door convenience of the private car usually requires transfers and mode changes. SDOT envisions that "someone could share a ride to a transit station, then take rapid transit, then get off at another station where they could use bike share, ride share, or car share to get to their destination" (SDOT, 2017). When heading to the train station, a traveler might want to know the bus route that will take her there, or the best time to request the Lyft, or a flat bike route without too much traffic, or the location of the nearest scooter. Making such connections without real-time information is often possible, but risky. Checking information

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[3] The mobility service providers, including especially Uber, Lyft, and Lime, have also envisioned themselves as contenders to be the single MaaS interface for all modes. Travel info apps like Google Maps, Transit, and Citymapper also offer degrees of data integration, and some have begun integrating abilities to book or pay for certain services. The focuses and intentions of these commercial apps are obviously different than those of the transit agencies, but this tension between corporate and public interests remains beneath the surface in most visions of MaaS, as it does in the promise of new mobility generally. The focus of this analysis is on the planners' vision.

in two or three different apps is cumbersome. Integrating the data into a single interface, where travelers can see their steps and options together, is the way MaaS promises to piece together existing travel options into what travelers can navigate as a unified network.[4] As one keynote speaker said at the SUMC conference, bringing modes and information together will enable "that magical experience in your multi-modal commute when you feel like you didn't waste a single minute." New tools for making real-time travel information available are seen as the means for making non-car, multi-modal transportation attractive.

Communication of travel information is seen as particularly helpful for transit agencies, who struggle to make complex networks and schedules visible to riders. Transit planners have an expectation that many would-be riders are simply not aware of the bus route that would take them where they want to go, but if such information were easily accessible, they might choose transit over driving. Bibiana McHugh, one of the GTFS pioneers, said that she "made it [her] mission to make it just as easy to get transit directions as it is to get driving directions" (McHugh, 2013, p. 125). Transit directions have been a feature of the standard Google Maps interface for many years. More recently, Lyft has used the same transit data APIs to offer transit directions in its app alongside many ride requests, suggesting that this will encourage some to take the bus instead of hailing a Lyft. Real-time schedule updates are also seen as important for helping riders to tolerate longer waits for the bus. In one study, conducted by the Seattle-based creators of early transit app OneBusAway and cited often by advocates for real-time transit data, bus riders say their wait for the bus feels shorter when they have real-time arrival information

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[4] Payment integration is also a goal of MaaS, although this work has proven more difficult than integrating information about service availability.

(Watkins et al., 2011). For transit agencies, such data promises to attract or retain riders without investments in new service.

With MaaS, modal options and their possibilities for connections become more complex, while the experience of navigating the system becomes simpler. Digital technologies promise to make these diverging goals possible to achieve simultaneously. As SUMC puts it:

> Just as the availability of more modes makes it easier for people to get around without driving alone, better information about how to use these options together seamlessly can yield a transportation network greater than the sum of its parts. (Shared-Use Mobility Center, 2020, p. 3)

Metro's GTFS feed and the app-checking of ordinary commute planning have existed now for many years, but the hope for what these technologies will do in the future is much greater. Through the expansion of data sharing and consumption practices like these, planners envision digital technologies enabling and encouraging people to use modes other than a privately owned car.

Of course, the existence of viable options for non-car travel is a prerequisite for integrating those options into MaaS.[5] There is also the question of who should do the integration—a software company (e.g., Transit app), a private mobility service provider (e.g., Lyft), or a government agency (e.g., a transit authority). For these reasons, the more promising examples of MaaS are in European cities with good transit service and centralized control of transportation. North American planners working towards MaaS take note of these requirements, and look with envy on transit systems elsewhere. "No matter how slick the app is for your multi-modal trip, no one wants to wait 23 minutes for the bus,"

[5] The availability of "multiple transportation options" is a given in "Level 0" of a MaaS typology used in the industry. (Shared-Use Mobility Center, 2020).

one transportation consultant remarked at a conference session on MaaS. Planners like these are actively calling for greater investment in transportation infrastructure to support modes other than driving. Still, much of their effort is focused on data sharing agreements, data integration protocols, and user interfaces that simply take existing mobility services as a given. Better transit and more bike lanes would be nice, and those interventions have their dedicated advocates. In the meantime, the pitch of MaaS is that travelers will forgo a trip by car to instead piece together a trip by bus and bikeshare, as long as the right information is available to them. Focusing on the apps and data does little to acknowledge the difficulty of changing individual travel behaviors, or the stubborn attractiveness of driving your own car in a city built for just that.

Information for expanding mobility: Last-mile services

The last-mile pitches claim that digital technologies allow new, more efficient travel services that can expand the reach of transit without requiring more transit infrastructure. Transit agencies in the United States constantly struggle to fund their services. Most agencies recover a small portion of operating expenses from fares, with the remainder coming from a mix of state, local and federal subsidies. With limited resources, agencies face difficult decisions about the services they provide. Many such choices revolve around what is known as the ridership/coverage tradeoff. A transit agency wants to maximize the number of people who ride transit while also maximizing the number of people who have access to the transit system. A ridership focus tends to concentrate resources into improving service on a few high-demand routes, while systems with a coverage focus have routes that might be less frequent or less direct, but are accessible to more people by reaching farther into low-density neighborhoods. The tradeoffs are rarely clear-cut, but in general terms, a system focused ridership increases revenue from fares and attracts people who might otherwise drive, but greater coverage serves equity goals by avoiding scenarios in which only people in certain neighborhoods with certain kinds of commutes have access to transit. Transit planners are often frustrated that their routes can get close to a population, but not close enough for riders to comfortably walk between the transit station and their destination. This is known as the last-mile problem, fundamentally a spatial mismatch between the geometries of transit operations and of low-density land use patterns, and it is what ridehailing and micromobility promise to solve. Each claims it can reach more people at lower cost than transit, and can do so while working with the existing routes and resources of transit agencies. Planners are encouraged to imagine new services for getting a ride with a car, bike, or scooter as links integrated into existing mobility networks to make them more effective as a whole.

In the opening Ride2Transit case, ridehailing expanded the reach of Metro's bus network by taking some passengers of a high-ridership commuter bus a few miles from the transit center to their dispersed final destinations. Those trips operated in dedicated vans, but ridehailing companies Uber and Lyft have made similar promises about what their platform-based contract drivers can offer to transit systems. In its 2021 report on how it is "offering public transportation agencies new tools to operate more efficient, connected and equitable mobility networks," Uber explains its vision:

> The mainstays of bus and rail will remain at the core of public transportation, moving large numbers of people along dense urban corridors. These modes will be complemented by the addition of microtransit, ridesharing, and micromobility modes which will gain an increasing share of the public transportation supply mix. The addition of new modes with a variable cost structure like ridesharing and the proliferation of on-demand services will unlock new optimums of efficiency and lower cost structures for public transportation agencies. This transformation will also offer agencies more opportunities to improve the equity, accessibility, resilience, and flexibility of their networks. (Uber, 2021, p. 5)

In Uber's view, trends including "new supply modes in the public transport mix" and "more options for riders with increasing on-demand trips" will lead to "improved equity and access," among other goals (p. 7). The company's specific offerings include software products for agency operations as well as tools for agencies "to use Uber's ride-sharing platform as one of their core modes" (p. 33), with flexible subsidy and integration options to coordinate with existing transit services and goals. Uber points to the capabilities of its proprietary routing and ride-matching software as well as the familiarity and usability of its interface. However, much of the promise of expanded reach and reduced cost is not about a technological change, but an economic one. Uber explains its cost savings are achieved by replacing the fixed cost structure of a bus—which has hourly operating expenses that change little whether that bus is full or empty—with ridehailing's variable cost structure. In the variable cost structure that is the core business model for Uber (and Lyft), drivers are responsible for their own vehicle costs and are paid only when transporting a passenger, so Uber does not pay drivers when they are not generating revenue. In proposing this model to transit agencies, Uber imagines that agencies might still subsidize trips (and may choose to collect a fare as well), but lower ridership will directly lower costs (p. 17).

For its part, SDOT (2017) shares at least some of this promise, noting that up to 5% of the city's transit trips are on low-ridership routes that "could be served by new mobility" more cheaply than by buses, which would allow Metro to "reallocate resources to provide even more frequent service in corridors in need of more service." A Metro transportation planner said in an interview that Metro is "fully embracing" many of the options in "an ocean of possibilities" offered by new mobility, pointing out that more buses are not the only way to reduce single-occupancy vehicles. Denver, too, projects cost savings by changing some of its feeder bus routes to the flexible routing and costs of app-based on-demand services. It also expands beyond this specific use case to envision how the region will "integrate new options of vehicle sharing and ridesharing into the existing multimodal transportation system network" (Denver Metro Chamber et al., 2019, p. 51). Unsurprisingly, the role of regulators is stronger here than in Uber's vision, but many of the specifics are the same: ridehailing should prioritize connecting to transit, it should be incentivized to serve the passengers who need it the most, and it should favor pooled rides instead of single passengers (pp. 51–56).

Shared bikes and scooters make much the same promise to expand mobility where transit does not reach. Lyft claims that "shared micromobility systems enhance local transportation networks by filling gaps, provide connections to transit, and offer a green alternative to driving" and that 79% of its "shared micromobility riders have used shared micromobility to connect to public transit" (Lyft, 2021b, p. 3). In pitching New York City to allow it to operate citywide, Lime argues that such an expansion "would put an additional 1.5 million New Yorkers within a 10-minute walk, bike, or scoot of a subway line." (Lime, 2019). Planning and delivering a new bus line is time-consuming and expensive, and subway expansions much more so. Micromobility offers an alternative, at least in some scenarios, at low or no cost to the city. Even absent transit connections, shared bikes and scooters are promised to replace cars for the frequent trips that are too far to walk. Seattle cites a consultant's study projecting that a fleet of 7,500 scooters in the city can "replace up to 175,000 car trips" each month, with a corresponding reduction in CO2 emissions (SDOT, 2020). As with ridehailing, equity has been a focus of the pitch for micromobility. Lime (2019), which says it is "founded on the simple idea that all communities deserve access to smart, affordable mobility" (p. 19), emphasizes that the places in New York where transit does not reach are typically poorer neighborhoods of color, then claims that its bikes and scooters offer "new, reliable, affordable transportation options" to "these underserved communities" (p. 2). Lime's position is easy to dismiss as mere marketing pitch aimed at securing a larger service area from regulators, but these promises appear in city documents as well. Seattle is typical of many cities in asking its bikeshare permit applicants help meet city goal to "ensure affordable and equitable service—particularly for cost-burdened communities of color—while expanding access to opportunities" (SDOT, 2018, p. 8).

Digital technologies, specifically location-based information networks connecting people and vehicles in real time, are necessary to the operations of micromobility. This is true with ridehailing as well, and in these cases, it is the novelty of the service model—shared vehicles that can be used for point-to-point trips nearly anywhere—rather than the supporting technology that fuels the promise of transforming mobility. The promise is that such flexible systems can integrate with fixed transit systems to provide a more comprehensive and more equitable network for people to get around the city without their own car. The financial viability of these last-mile solutions is questionable, and transportation planners repeatedly remind us that public transportation has never been a profitable business. Accordingly, they have been reluctant to go all-in with any plan counting on Uber or Lime providing long-term transit services. Ridership in pilot programs, including Ride2 Eastgate, has been mostly underwhelming, and the data on micromobility-to-transit replacing car trips is inconclusive at best (McQueen et al., 2020). I also heard a belief among some planners that the entire last-mile pitch is little more than a cover for ridehailing and bikeshare providers to win the favor of regulators.

The promise, however, lives on, as planners continue to envision that some version of these systems offering point-to-point travel in a shared vehicle will expand the reach of transit without major changes to transit infrastructure or existing land use. (The vision also assumes many of the same changes in travel behavior imagined in the MaaS pitch.) Even if these interventions might not work in all situations, they promise to make some measurable impact. This might be true; research on that impact is ongoing. What is important to point out, however, is that this vision locates answers in apps and real-time data, which now allow us to coordinate on-demand rides or find a shared bike parked nearby, but does nothing to engage with the more difficult work of reimagining a built environment that is not designed to support transit. Popular transit consultant Jarrett Walker observes that technology companies believe they can transform spatial problems of mobility into the communications problems that they are able to solve (Walker, 2018a), and warns that this pitch "can encourage denial about the real issues facing a transit agency," such as labor costs and funding existing services (Walker, 2018b, n.p.). Any win for transit with these last-mile interventions is likely to be modest in comparison to their impact in distracting us from the underlying infrastructure and land use conditions that produced the situation in the first place.

Information for city monitoring and control

The monitoring and control pitch envisions that better data will allow agencies to make more efficient decisions, and, implicitly, to bypass the messy politics expected to get in the way of such decisions. It stays with the workings of transportation agencies, but returns focus to the role of data and analytics. The city agency is central here, and is positioned as the means for achieving the goals of transportation, given the right data. This pitch is broader than the other two, and its general sense that "more data will give us the right answer" speaks directly to the desires for certainty and solvability that I argue are central to digitality's promise. It illustrates how pushing for more certainty and more solvability typically calls for a withdrawal from political engagements.

In the MDS example at the opening of this chapter, new data has provided Seattle with a higher resolution image of bike travel in the city than it had before. The expectations for how this data, and mobility data like it, could be used in the future are among the most common and most appealing of new mobility's promises. Seattle's vision is typical:

> Our streets flow with a rich stream of data generated by traffic sensors, on-vehicle sensors, and mobile data from ridehailing, car share, and other services. This flow of data could give us more insights into emerging travel patterns and the effects of new mobility services on the way people use transportation. (SDOT, 2017)

Cities claim that increasingly, "access to new sources of data...is essential for transportation planners to plan and manage the future of mobility" (Populus, 2020a, p. 8). Jascha Franklin-Hodge, then the leader of development of MDS, put it even more strongly to attendees at a conference workshop: "Managing the public right of way is your responsibility. Access to the data you need to do it is your right." A conference workshop on new mobility data offered three "levers" for planners solving mobility problems: design of the right-of-way, policy for managing what happens in it, and data "to confidently prioritize and evaluate design and policy interventions." In other words, the data lever is the prerequisite for the design and policy interventions. The digital representations of vehicles and travelers are a core mechanism of new mobility, and these representations typically include both trip data and system data. Trip data, produced by GPS-equipped vehicles and smartphones, describes times, origins, destinations, and routes of individual journeys. (The detail available varies with the mode, the service provider, and the data sharing agreement.) System data includes the current or historical locations and statuses (e.g., available, reserved, out of service) of shared vehicles, whether on a trip or not.

Today, the comparatively new modes of bikeshare and scooter share are the sources of most of this data. But for many transportation officials, this is merely the first step towards a future in which far more of urban mobility is represented in data available to transportation officials. "Micromobility has served as a testing ground for a new model of API-enabled right of way management," the Open Mobility Foundation (2020, p. 9) reports in its summary of MDS. The organization is actively exploring future applications of MDS to existing mobility practices like ridehailing and deliveries as well as more speculative applications to AV fleets and "urban aerial vehicles." Transportation planners have long sought high-resolution data of all kinds of travel, and have fought mostly unsuccessfully to get such data from Uber and Lyft. Micromobility, however, has given them a taste of this information. The actual emerging practices with bike and scooter data are of interest not just in themselves, then, but as glimpses of a broader vision of data-based mobility management. (Such data practices are examined in greater detail in chapter 6.)

Along these lines, new mobility envisions an expansion of data on infrastructure in addition to travel. Cities currently have GIS datasets describing road and transit networks with enough detail to route trips. However, most lack the spatial resolution to represent things like individual parking spots, street signs, or bike racks. In response, cities like Los Angeles have called for "a digital infrastructure that mirrors the current hardscape and that gives transportation assets like curbs, streets, sidewalks, airspace, and subterranean space a digital identity" (LADOT, 2019), while Regina Clewlow, head of data analytics firm Populus, has said that the lack of quality infrastructure data is one of the "big data problems." Curbs are a clear example of this data gap. Especially in dense cities, curbs are contested sites of parking, travel, and access uses, but representation of their physical properties and their assigned policies are mostly missing from the datasets. "Key to improving curb management and updating regulations more efficiently," Populus says, "is access to better data." Envisioned data includes representations of the curbs themselves, regulations, and actual use, all of which must be communicated among agencies and operators (Populus, 2020). Shared Streets, a non-profit devoted to open-source transportation software, has made a step in this direction with the development of CurbLR, a data specification for curb regulations intended "to help government agencies effectively manage and regulate the curbside, and to support public and private users of city streets," according to its website. Whether describing physical assets or trips, existing mobility data is seen as just the beginning of what could be available for the monitoring and management of mobility policies and infrastructure.

The pitch for how cities can use mobility data in support of their goals takes two related forms: data for managing current operations, and data for planning future mobility. First, cities argue that data is needed to monitor vendor compliance and observe current usage. In Seattle, the city uses trip and vehicle data reported by bike and scooter share vendors to determine whether they are complying with terms of their permits, such as limits on the number of vehicles and their geographic locations as well as the length of time an out-of-service vehicle is in the right-of-way before being removed. Once set up, such monitoring is fairly straightforward. But cities also imagine more complex uses, as in this example of data supporting equity goals:

> The data that these services generate will help us understand the unseen biases in the transportation system so we can correct them. We can then create incentives and regulation to make sure the system serves everyone. We could also better target subsidies to those who need them most. (SDOT, 2017)

With micromobility especially, data is considered essential not just for monitoring compliance with existing policy, but for guiding new policies. Given the uncertainty around how emerging micromobility modes actually work, a rapid cycle of evaluation and adjustment is seen as necessary to "create more precise policy solutions," as one industry representative put it at a conference, for managing these unfamiliar modes in ways that serve the city's existing goals. LADOT (2016) imagines that digital technologies "can help improve infrastructure, services and user experience by providing a real-time view of system demand, information for decision making, analysis for deploying better alternatives in the future and guiding more effective responses."

The case of micromobility—where data is plentiful, policies are not yet settled, and cities are regulating aggressively—has also become a center for a vision of a mode of data-driven management that is more dynamic with a more active role for city regulators. This is imagined to extend well beyond bikes and scooters to all forms of urban transportation. The vision is not new; the active monitoring and real-time management of the transportation system has precedent in transportation centers that can monitor vehicular traffic and respond to incidents by, for example, dispatching a response team or adjusting signal timing. Described as "active management," this vision, for LADOT, is an

> approach to using real-time digital communications to express mobility policies and regulation and govern the City's right of way: our streets, sidewalks, curbs, and airspaces. LADOT is using digital tools (including MDS) that allow us to communicate anonymously with fleet vehicles that operater [sic] on the public right-of-way. Active Management can provide a variety of digital infrastructure services, such as digital parking, dynamic speed limits, curb access, digital notifications for street closures, and directed public notifications. Today, LADOT is using Active Management to govern dockless shared scooters, bikes, taxis, and buses in accordance with policies and regulations set by City Council. Tomorrow, the same tools will assist in communicating with autonomous cars, drones, and whatever else the future holds. (LADOT, 2019, p. 9)

To return to the example of curb management, data-enabled active management envisions protocols allowing cities to monitor real-time curb usage and to communicate dynamic adjustments to parking rates. With such tools, Populus (2020a) argues, cities could target restrictions, prices, and enforcement for curb use at finer temporal and spatial scales than existing signs, paint, and enforcement officers allow. They propose such dynamic regulations might adjust fees and fines for different times of the week, or for different categories of users. A digital protocol could even prohibit ridehailing or micromobility vehicles from ending a trip in certain zones at a given time. Emerging tools like these promise "dynamic and granular opportunities to coordinate and manage the public realm on behalf of citizens" (LADOT, 2019). Note, however, that such visions have little to say about the politics of curb restrictions, parking rates, or the automatic enforcement of speed limits, all the kinds of interventions that will surely have opponents. Instead, the emphasis is on the technical potential of real-time data exchanges between the DOT and vehicles or infrastructure.

In addition to real-time management, data also promises to support longer-term infrastructural planning, a more established function for the transportation field. Most of the infrastructural levers here focus on the design of the public right-of-way. One common example is bike corrals, the low-cost designation of a portion of roadway as reserved for the parking of shared bikes and scooters using paint and bollards. Cities have used trip data from MDS to identify locations where bike parking is in demand, then prioritized investments accordingly. Additionally, Populus promises that trip data "can provide rich information about where vulnerable road users, such as cyclists and scooter riders, are making trips so that transportation planners can expand safe micromobility infrastructure" (Populus, 2020a, p. 9). SDOT, for example, has said that bikeshare data helped it decide between two streets for installing a new bike lane.

Data can inform, but data does not create policy or infrastructure. This pitch, however, pushes data into a stronger instrumental role, where it does not just *identify* the best decision, but also becomes the political means to *implement* it. Mobility data is expected to "present evidence that can shape the political will required to accept changes...that are often politically challenging" (Populus, 2020a, p. 10). In 2020, Spin, a bikeshare company, piloted a program in which community groups advocating for transportation interventions were given access to a suite of data platforms and analytics tools. In recounting the success of the program, Spin emphasized stories of groups able to "harness mobility data in service of garnering community support" (Spin, 2020, p. 10) for projects like street redesigns in often overlooked neighborhoods. The transformation of data into narratives with political purchase is sometimes explicit, as, for example, with studies on the traffic impacts of Uber used to argue for stricter regulation of ridehailing. At other times, though, the step between data analysis and policy change—the step in which various stakeholders weigh in with their own interpretations, concerns, and visions—is overlooked. Most of the new mobility reports and conference discussions make little mention of the contentious issues at stake in their pitches for technologically driven mobility improvements, even though (or perhaps because) transportation planners know well that bike lanes, bus lanes, parking removal, road pricing, and other interventions favored in the field are often unpopular.

The point is not just that these visions for urban mobility were *developed* without robust public debate, but that the visions themselves are for a city in which politics are absent. In this view, data, not people, provide the answers to what an equitable bikeshare system looks like or how to allocate scarce curb space. The fantasy of the escape from politics is by no means unique to new mobility; it is central to a long history of technocratic management. We also know from a great deal of experience that this rule by experts can never fully eradicate politics. The danger of this promise, then, is not that it will succeed in avoiding political conflict, but that it teaches us that we should. Similarly, the singular focus on data and analysis fails to teach us how to engage in that work of sorting through collectively what we want the city's mobility to look like.

Desires: The drivers of the promise

A promise attaches an object to an existing desire, claiming that this is the thing that will bring about that state you long for. I have described how new mobility introduces digital technologies into existing practices of urban mobility, pitching that expanded access to information is the basis for integrating transportation modes, expanding the reach of transportation systems, and allowing cities to monitor and control mobility throughout the city. This section draws out the desires within transportation planning that these practices are speaking to. There are two kinds of visions here. First is transportation system built around transit, biking, and walking, rather than cars, in order to support the broad goals of access, equity, sustainability, and safety. This is a well established vision within transportation planning, and new mobility has attached its digital tools to this familiar desire. The second kind of vision is less explicit, but is an important frame for understanding what drives the promise of new mobility. This is the desire for certainty and solvability. These broader desires, which take shape in the specific visions for digitally mediated urban mobility, are dangerous, since in their idealism they teach planners to avoid the mess in which the city is always uncertain, and solutions are complex.

Envisioning cities for people, not cars

Certain goals appear repeatedly in transportation planning, and appear to be broadly shared. They have transferred directly into the new technical and corporate contexts of new mobility. "What kind of city do we want to create?" asked Dorval Carter, president of the Chicago Transit Authority, at the 2019 SUMC conference. "I think we can all agree," he continued, and named three main components of the vision: to "move large amounts of people without increasing congestion and traffic," to reduce emissions and ensure a "green future," and to "get people where they want to go affordably and efficiently." At the same conference, Kyle Rowe, who left a position at SDOT to work for micromobility provider Spin, remarked that cities and operators have the same mission: "to provide sustainable, safe, and enjoyable forms of transportation to people." Together, this vision for urban mobility that is accessible, equitable, sustainable, and safe is guiding the work of countless transportation professionals and untold billions of dollars in investment. As broad targets, these values are rarely questioned, and nearly any transportation proposal is justified by appeal to one or more of these goals. Accordingly, the tech companies of new mobility have situated their products and services as the means to achieve these ends. Without giving a full summary here, I will briefly identify four of these goals: access, equity, sustainability, and safety. I then describe the somewhat more specific vision for a city with fewer cars and more transit, walking, and biking that is largely accepted as the best way to achieve those goals. This established vision has shaped transportation planning for many years, and have now been adopted into the promise of new mobility.

Access represents an evolution of transportation engineering's longstanding concern with congestion and traffic delays. It recognizes the goal of transportation planning is not to reduce traffic delays per se, but to ensure that travelers can get to where they want to go with ease. Transportation is seen as a means to something else of value—such as social relationships, availability of goods, and economic exchange—not an end in itself (Sclar et al., 2014). Access can be impeded by traffic jams, but also land use patterns that separate uses, the monetary costs of trips, and the basic availability of the means of transportation to the person who wants to go somewhere. This view, now familiar to a generation of transportation planners, has tried to reframe the field as a social endeavor, not just technical.

Equity also has a long history in transportation planning, but has become an inescapable buzzword in recent years. The transportation field's vision for equity appears primarily in concerns about the availability and affordability of transportation options, and to a lesser degree in transportation as a key means of socioeconomic opportunity. LADOT's typical vision is of a city in which "all people have access to safe and affordable transportation choices that treat everyone with dignity and support vibrant, inclusive communities," and it supports "treating movement as a fundamental human right" (LADOT, 2016). Within transportation planning, equity concerns appear regularly in considerations of the societal distribution of transportation benefits and harms. In many ways, equity is the new carrier of the modern infrastructural ideal (S. Graham & Marvin, 2001) discussed in chapter 3.

Sustainability concerns (focusing on the environmental impacts of transportation, rather than the broader equity and economy dimensions of sustainability) revolve around the energy efficiency and emissions of vehicles. This appears in a few different ways. One is in the shift to electric vehicles, and the accompanying technical and social changes necessary to facilitate this shift. The other is in a broader effort to reduce total vehicle-miles traveled, whether by facilitating travel by alternate modes, or by reducing trip distances. Transportation's contribution to greenhouse gas emissions is frequently cited, and issues of air quality have been a concern of metropolitan transportation planning for decades. Zero-missions transportation powered by renewable energy is a broadly shared goal driving sustainability efforts in this area.

Finally, safety is another old issue for transportation planning that has both continued and taken on a different tone. Reducing deaths and injuries from car collisions remains a primary concern for transportation planners, especially in the Vision Zero campaign to eliminate traffic fatalities that has become popular among American city transportation planners. Safety appears as a special concern for cyclists and pedestrians, described as "vulnerable road users," and now the riders of electric scooters, whose novelty has generated a flurry of safety concerns. Health concerns not related to injuries include visions for improving air quality and for fighting diseases of sedentarism by promoting walking and cycling.

Those general goals for access, equity, sustainability, and safety take shape in a particular solution that can be envisioned in more specific terms. This approach, dominant for many years now in urban transportation planning, is characterized by efforts to reduce policies and investments that favor private car usage and to increase policies and investments favoring transit, walking, and biking. In the multi-modal, anti-car vision, cars are seen to be dangerous, inefficient uses of scarce road space, generators of pollution, the causes of affordability and congestion barriers to travelers with low incomes. In a typical statement, LADOT, the agency responsible for managing thousands of miles of roadway used by millions of cars every day, claims that "[t]he use of one vehicle per person to get around this vast metropolitan region is no longer viable." Having identified cars as the problem and a combination of transit and human-powered mobility as the solution, however, planners are then faced with the work of realizing this vision. This is, to put it mildly, an enormous undertaking, requiring the undoing of land use patterns, transportation infrastructures, economies, and travel behaviors that have been built around car-based mobility for more than a century. And, notwithstanding some small successes here and there, transportation planners in American cities have achieved no meaningful reductions in car use, and continue to struggle to move the needle on measures of access, equity, sustainability, or safety.

This is the context in which the promise of new mobility takes hold. The new information technologies promise to bring about the transformations that cities have stubbornly resisted for so long. Since smartphones, sensors, location data, and other underlying technologies of new mobility have developed so quickly in recent years, they suggest a current of change that might sweep up the slower-moving elements of transportation—infrastructure and travel behaviors—along with them. After all, internet-based technologies really did transform domains like shopping, entertainment, and journalism, so why not urban mobility too? The promise attaches the newness of digital technologies, with their aura of disruption and progress, to the longstanding vision of a multi-modal, minimal-car city that has proven so difficult to achieve. Despite some novel elements of this pitch—electric scooters have not been part of the urban mobility vision for long—the envisioned mobility system is in essence the same one that planners have been promoting for decades.

The attachment of new technologies to familiar desires can be seen clearly in the ways that the corporate players in new mobility have positioned their offerings as the means to reach planners' stated goals, being careful not to challenge any of the accepted tenets of urban transportation. Consider that Lyft, which operates a marketplace for the drivers of some two million cars, has consistently positioned itself as a champion of "people, not cars." In the opening of its 2020 annual report to investors, it states:

> We believe that cities should be built for people, not cars. Mass car ownership in the twentieth century brought unprecedented freedom to individuals and spurred significant economic growth. However, in the process, city infrastructure became overwhelmingly devoted to cars. Roads and parking lots have replaced too much green space. Mass car ownership strains our cities and reduces the very freedom that cars once provided. Car ownership has also economically burdened consumers and can equate to a substantial portion of a household's transportation spend despite the average car being parked and unused a majority of the time. (Lyft, 2021a, p. 7)

Despite Lyft's slight of hand in describing the problem not as cars but as "car ownership," the statement is remarkable in that it could be inserted verbatim into any city DOT or transit agency document without attracting notice. Here is the comparable text from an SDOT report:

> The car and related technologies and innovations delivered on the promise of economic growth, middle-class jobs, and mobility on demand. At the same time, they contributed to massive economic, social justice, and environmental inequalities. In reshaping our existing cities and planning new cities optimized for privately owned cars, we took down mass transit systems, disconnected and razed whole

> communities (usually communities of color), and created new ways to exclude people by race and income. As we narrowed sidewalks to widen roads, our cities became uncomfortable to people walking. As we re-engineered our streets to prioritize speed over safety, our roads became hostile to anyone not traveling in a car. (SDOT, 2017, p. 13)

The report goes on to say, as Lyft does, that we need "cities for people," not "cities for cars." The apparent consensus among the players in urban mobility is summarized by one of the "Shared Mobility Principles," signed by dozens of government, non-profit, and corporate entities, which says:

> We prioritize people over vehicles. The mobility of people and not vehicles shall be in the center of transportation planning and decision-making. Cities shall prioritize walking, cycling, public transport and other efficient shared mobility, as well as their interconnectivity. Cities shall discourage the use of cars, single-passenger taxis, and other oversized vehicles transporting one person. (C40 Cities et al., n.d.)

In the new mobility pitches described above, information technologies are the key to integrating, expanding, monitoring, and controlling multi-modal mobility. Silicon Valley's platform paradigm, in which independent actors' disparate activities are networked through a centralized protocol, has been especially productive for making this link. At the SUMC conference, Gabriel Scheer of Lime described his company's vision for "a future of mobility that's a stack of different options." The same day, Ryan Rzepecki, of Jump, said of his bikeshare company's acquisition by Uber that the two companies shared the same goal of "reducing personal car ownership," and that meeting this goal requires "a suite of services" on "a multi-modal platform." The "stack" and "platform" language come from Silicon Valley, but the call for choice among multiple modes for getting around town is an echo of contemporary city transportation discourse. It is in these kinds of encounters between tech companies and transportation planners that the new tools of the former are promised to realize the visions of the latter.

The pursuit of certainty and solvability

My goal here is not to predict whether new mobility really can or will do what it promises, with new digital technologies finally achieving the established goals of transportation planning. Neither do I attempt to evaluate whether these transportation goals *should* be pursued. Instead, I want to widen the view beyond the specifics of urban transportation to bring a different set of desires into focus: certainty and solvability. The promise of new mobility is not just a more efficient bus network, or expanded bike ridership, or new data sources. Rather, the promise is that with the right technologies, planners and travelers can know these systems with certainty, and can use technologies to solve any problem that arises. Further, the appeal of this promise is its transcendence of the messiness of material and political constraints. In showing that new mobility promises this certainty and solvability, then, I also want to show how it hides from us the messiness of these constraints that we need to deal with in order to achieve any vision of a better city.

Digital technologies deliver information, and so are often associated with delivering certainty. Planning, like many other professions, has a desire for certainty that it turns to digital data to fulfill. "You can't set policy without data" is a common refrain among transportation planners, coming in this instance from Regina Clewlow, head of the mobility data analytics firm Populus, speaking at the SUMC conference. In story after story at these events and in industry publications, planners and vendors collect or wish for data on trip origins and destinations, travel times, socioeconomic characteristics of travelers, the use of rights-of-way and parking infrastructures, and more. In the "information for monitoring and control" pitch described above, these data and their analysis are expected to answer some question and guide officials to an optimal decision. As Seattle's New Mobility Playbook puts it:

> We cannot effectively manage our streets without the right data. ... Data allows us to understand and assess the impacts of new mobility services and technologies. Without proper access to data ...we risk being unable to protect our communities and residents. (SDOT, 2017, p. 31)

One concern here is that "proper access to data" is never guaranteed, and so we might fairly expect that local DOTs will find a way to manage our streets in their absence. What SDOT and others really want is to know the *right* course of action, the best choice with a known outcome, and data is appealing when it offers such assurance. For example, the agency had been pushing for bike lanes on certain downtown streets, and was able to use a vendor's bikeshare trip data to support their argument that cyclists were in fact riding these routes. Although the planners had already envisioned the intervention, the data offered more certainty that the investment would be worthwhile.

The desire for certainty sometimes attaches to a specific issue like this, but in many cases, planners seek whatever data might be available to collection without a specified purpose. Smartphone apps, ridehailing vehicles, and shared bikes and scooters collect tremendous amounts of data on individual trips and travelers, and planners have imagined what such data might reveal to them. Tensions and lawsuits have emerged when cities have tried to require mobility providers to share data that providers consider their intellectual property. Partly as a result of these skirmishes, some voices within transportation planning have urged cities to refrain from demanding all of the data, but to instead begin with a specific question and then identify the minimum data needed to provide a satisfactory answer. At a SUMC session, transportation researcher Anne Brown made this point with several examples. If the question is whether ridehailing impacts parking demand in a restaurant district, she said, then the data you need is aggregate trips to and from the neighborhood at different times of day, not the specific origins, destinations, and times of each trip. Still, the appeal of more data is hard to shake. SDOT, for example, has wondered how they might "obtain frequently updated data (even up-to-the-minute data) on how new mobility services are impacting the transportation system and furthering racial and social justice" (SDOT, 2017). The nature of this data is not specified in the report, but it is difficult to imagine how progress against systemic racism can be meaningfully monitored on a minute-by-minute basis. In any event, we surely ought to invest our energies into addressing social justice based on whatever we know already, but the allure of certainty risks diverting this energy towards more data collection.

The danger here is that the quest for certainty, promised by digital data, becomes the goal in itself for planners, regardless of what it actually achieves. We can see this in the link between certainty and solvability, where digital tools are expected to deliver not just new information, but new modes of intervention. For example, in new mobility's data analytics discourse, discussed above, the step between new capacities for analyzing mobility and new techniques for controlling it is so short as to be often imperceptible. Recall the example of the conference workshop on data tools for ridehailing and micromobility, in which participants were introduced to an imagined problem and given three "levers" to solve it: data, policy, and design. The data tools at the center of the exercise were new and attractive, with high-resolution trip records and dynamic visualizations, but the policy and design levers were unspecified, assumed to be whatever planners had available to them already. An executive of the workshop sponsor Remix, a mobility analytics company, said that emerging mobility data streams would allow agency officials to "choreograph all the activities you want to happen in the city" and "allow cities to achieve their holistic goals," but did not dwell on the mechanisms besides data analysis this might require. As one report claims, mobility data "can provide rich information [about bike and scooter trips] so that transportation planners can expand safe micromobility infrastructure" (Populus, 2020a, p. 9). Similarly, Seattle's New Mobility Playbook (SDOT, 2017) says that "all that data" will provide "understanding of how people are getting around Seattle—and how we can improve the experience of getting around" without expansion of the political, financial, infrastructural, or behavioral steps that might be necessary for such improvement. It later lists the hopes for what digital mobility tools will allow SDOT to do:

> The data generated by new mobility could also revolutionize the way we plan the transportation system and direct resources. We could operate more nimbly while also making better-informed policy decisions and investments. We could have more responsive transportation management and may even be able to forecast and correct for problems before they occur. ... The data that these services generate will help us understand the unseen biases in the transportation system so we can correct them. We can then create incentives and regulation to make sure the system serves everyone. We could also better target subsidies to those who need them most. (SDOT, 2017, p. 25)

In this scene, new data is imagined to provide not just new visibility, but new control. With hardly any distinction between the ability to "see" biases or "forecast" problems on the one hand and the capacity to "correct" them on the other, desires for solvability are deeply entangled with those for certainty. The incentives, regulations, subsidies, policy decisions, and investments mentioned above can indeed be informed by data, but they also require funds and political will that no amount of data can provide. Claims like these contain within them a quiet assumption that better information is not just necessary for solving problems, but is sufficient. In the discussion of new mobility's use of digital information for monitoring and control, we saw a suggestion that the right data could be used to help interventions that might be unpopular, such as bike infrastructure, become politically palatable. We often see a conflation of digitality's capabilities for seeing and shaping the city, and much of new mobility's promise happens in this equivocation.

Since the promise is an anticipation, always oriented to the future, it is effective even when solutions are nowhere apparent in the present. This delayed delivery can be seen when new mobility promises to solve not just the longstanding problems of urban mobility, but also the new problems that they themselves have created. Shared bikes and scooters, for example, have become a nuisance on many city sidewalks when they are improperly parked. In solving the apparent problem of shared bikes constrained to designated docks, free-floating bikes have introduced new conflicts in the public right of way. For dockless providers, this is a problem that its technologies can solve. At a conference session, an executive from Bird confidently assured the audience that they are "constantly innovating around these things" and have "put in place between eight and 10 different solutions" to deal with clutter. The solutions she named were all digital, including better in-app instructions, more accurate location tracking, a reporting mode for "community members" to notify the city of violations, and automatic image-based enforcement. In its 2018 Seattle permit application, Lime told the city it plans on "implementing machine learning techniques to create an automated system that can verify riders' parking jobs" (Lime, 2018b, p. 15). In a different example, Uber and Lyft have come under heavy criticism for their contributions to urban congestion. In response, they say that their advanced route-matching algorithms will enable maximally efficient carpooling, ultimately reducing city traffic. That responses like these have not yet proven to be adequate solutions is not the point. Rather, the point is that the promise of these companies, service models, or digital tools endures even as their clean ideals are sullied by the mess of actual implementation. Additionally, the familiar tools for solving the problems—building bike racks or taking the bus, say—are not necessarily dismissed as irrelevant, but are at least deemphasized in favor of the newer digital tools that the providers themselves can offer.

The desire for solvability then has both technical and political dimensions. Technically, the desire is that new or soon-to-arrive tools will fix any problem, even those that they themselves have created. Politically, the desire for solvability is a hope that more comprehensive information will provide the singular correct answer, the implementation of which can be fast-tracked without political opposition. In its hope to escape the messiness of problems—technical, urban, infrastructural, or political—solvability risks avoiding messy solutions that might ultimately be more effective.

Conclusion: The dream of transcendence

In introducing the current practices of new mobility and the pitches for what it could do in the future, this chapter has shown how we can see these digital technologies as not just tools for intervening in the city, but as vehicles for promises that endorse certain visions while ignoring others. New mobility promises that urban mobility can be known with certainty, and that its problems can be solved with better data and tools built on them. In doing so, it dodges any reckoning with how we might act in conditions of uncertainty, and it floats above the infrastructural and political dimensions of how we get around the city. A disengagement with messiness like this is characteristic of any promise, which is a kind of idealism built around transcending the mundane world as we know it now. Urban transportation as we know it now comprises land use patterns and infrastructure built for cars, travel time and cost burdens falling again and again on those least able to pay, chronic underfunding of public transit, limited right-of-way space, the physical vulnerability of bike riders and pedestrians, and continual disputes about interventions aimed at addressing any of these. The newness of various smartphone and GPS technologies tempt us into thinking that they can circumvent this entrenched reality. Such a narrative is inherent in the popular notion of technological "disruption." Silicon Valley's imperative to disrupt means to fundamentally transform the rules of the game, sidestepping the old challenges of a given technology's development in a way radically expands access to a new object that just displaced the old one. Disruption is in this way an escape, a kind of do-over that can, like a myth, “offer an entrance to another reality,” one with “the promise of the sublime” (Mosco, 2004, p. 3).

New mobility promises to transcend politics by turning problems of competing values and the distribution of scarce resources into technical problems, and to transcend infrastructure by turning spatial problems into communications problems. Transportation planning has long focused on building the right infrastructure and, in parallel, promoting the kinds of land use and travel behavior that generate the right kind of use of this infrastructure. New digital technologies shift this focus. When ridehailing and bikeshare promise to expand the reach of the transit network by providing last-mile mobility from transit centers, they are telling transportation officials that they no longer need to worry about funding new bus routes or acquiring property to build new rail. The carpooling algorithms from Uber and Lyft promise that our existing roads are enough, we just need smarter information tools for using them. Dockless bikesharing replaces the infrastructure of docks with GPS and smartphones to locate bikes. Real-time transit information, which everyone knows does not make the bus come any faster, is hoped to make the existing network more useful. Although the connection between land use and transportation is fundamental knowledge for anyone in the profession, mentions of land use were surprisingly rare in the new mobility material I reviewed. Changing land use is slow and politically difficult, but underlying land use arrangements are inescapable as the drivers of travel patterns. The absence of this topic contributes to the sense that fundamental demand for mobility and its basic structures will not change, and so the aim of new mobility is to redirect efforts away from the hard work of building things in the city and towards the more straightforward manipulation of data.

To be sure, most of the more exaggerated claims of radical disruption come from mobility vendors, especially those more closely aligned with tech startup culture, rather than the battle-weary transportation planners who have first-hand knowledge of the challenges they face. Horace Dediu, a tech industry veteran who is credited with coining the term "micromobility," said at a 2021 roundtable event that in the context of the climate crisis, bikes' and scooters' far lower emissions and energy consumption compared to a car mean that micromobility "actually can save us all," and that "if micromobility were a pill, it would be considered a miracle pill." Planners are on the whole more skeptical, and they consistently and continually remind audiences that, for example, transit remains the most spatially efficient way to move people around dense urban areas, bikers and walkers need safe infrastructure to lure them out of cars, and certain transportation modes work better with certain land use patterns. They are also well aware of the financial incentives of the tech companies and mobility service providers entering the field, pointing out that there is little profit to be made in transportation and that corporations do not share the public missions of governments. Planners' visions have been foiled by misaligned land use, inadequate infrastructure, political opposition, and uncooperative travelers many times before, and they are not expecting to abandon these fronts in their battles to improve urban mobility. Nevertheless, the examples in this chapter have shown a persistent sense that some degree of technology-driven transformation really is taking place. Transportation officials saw Uber transform the taxi business in short order, and many cities were blanketed with new shared electric scooters seemingly overnight. Travelers now have access to real-time information, and transportation is generating massive amounts of new data. Given all this, no one in this study said "things are going to pretty much stay the same." Nor, for that matter, did anyone say that things *should* stay the same. Even skeptical planners are not rejecting the private companies' promises of transcendence outright so much as they are reappropriating them, folding data tools and new services into their own agendas for equitable and sustainable mobility.

This chapter has shown how the familiar agendas of transportation planning are driving the promise of new mobility, in which the mechanisms of certain information technologies are envisioned to bring about a long-desired vision of urban mobility. It has also argued that that this promise is driven by desires for certainty and solvability. Returning to the theoretical foundations in chapter 2, Ahmed (2010) and Berlant (2011) caution that our orientations to better futures can become obstacles to our living will in the present. In this pessimistic light, what the promise of new mobility does is allow a disengagement from the here-and-now. It seeks to neutralize political disagreement and takes existing infrastructural arrangements for granted, reaching towards the digital tools that are more readily available regardless of whether they will or ought to work. At the same time, dreams of transcendence can only last so long in the thoroughly immanent domain of urban transportation. People are moving through the city at all times, and masses of pavement are impossible to ignore. The future of mobility is always checked by its present. That present—the actually existing software, vehicles, infrastructures, and travel behaviors—is the subject of the empirical work that follows in the next two chapters. In the messiness of the artifacts and people who constitute mobility everyday, we will see where promises are both realized and threatened.

CHAPTER 6

Datafication

The promise of new mobility is an anticipated future, but it is also a present experience. This chapter examines actually existing practices of datafication as a link between the visions articulated in the previous chapter and the complications of their realization. I understand datafication as the rendering of qualitative phenomena as discrete manipulable digital representations (Amoore & Piotukh, 2015; Franklin, 2015a; Mayer-Schönberger & Cukier, 2013). Digital data begins with the mess of reality it sets out to represent, and is later put to use guiding some action within the mess. But in between, the data is a *vision* for how that mess ought to be understood more simply. In these passages between vision and practice, datafication both reveals someone's ideals and tests their realization. This chapter shows where digitality's promises of certainty and solvability appear in practices of datafication, focusing on examples from city agencies' efforts to monitor and control mobility. It illustrates how the kinds of digitally enabled visions introduced in the previous chapter encounter certain obstacles in the messiness of the city, and how this messiness also provides the ground from which new promises emerge. Seeing this cycle in motion shows how datafication perpetually presents itself as the means of ordering messiness. Datafication is often effective at meeting its own goals, but I will also argue that in inviting us to see the world digitally, datafication asks us to overlook the agency of human actors, the messy people who introduce conflict and ambiguity into these systems. One goal of the chapter, then, is to humanize these data systems by showing the people who create them according to certain visions as well as the people in the city that are invisible to the data once deployed.

The chapter's two parts, visibility and regulation, roughly correspond digitality's promises of certainty and solvability. Datafication promises new kinds of visibility, and various organizations within new mobility have pursued data tools that will allow more of mobility to be seen. This persistent drive to see more leads to more complex data structures that nevertheless fail to provide the complete picture that city agencies often hope for. This is a function of technical limitations in the translation of mobility phenomena into defined categories, but also of complications and contradictions in the visions behind them. Conflicts become apparent when these tools need to clarify what, exactly, should be visible to whom. Regulation through datafication is built on this foundation of being able to see mobility digitally, but introduces the promise that such data can be used to intervene in some aspect of mobility in pursuit of some mobility goal. This section focuses on the digital regulation of shared bikes and scooters, which some cities hope is a pilot for systems that can automatically manage a much wider array of mobility activity. Micromobility regulation shows that digital control's requirement for quantified and unambiguous rules obscures the human-scaled relations that define mobility problems and solutions. Throughout, I want to show not just that the messiness of digital development is an impediment to a preexistent promise, but that these concrete practices are where promises are actually articulated. This offers a way to repoliticize technical objects and actors. The examples in this chapter show how digitality risks, first, perpetuating planners' intolerance for being uncertain and lacking control, and second, idealizing a view of the city lacking ambiguity and difference in both people and environments.

Visibility

This section examines digital visibility—ways of representing the messy phenomena of the world to a specific audience through digital data—as a key site of the promise of certainty. It uses examples from the development three systems of visibility. OneBusAway, and its supporting General Transit Feed Specification data, makes buses visible to travelers. The General Bikeshare Feed Specification makes shared bikes and scooters visible to travelers, and the Mobility Data Specification makes them visible to city officials. Each of these promises a kind of certainty, and speaks to someone's general desire to have more comprehensive and more accurate information. In their development, however, we will see how this broad push to know more encounters a need to specify what certainty exactly is desired, how technically to deliver it, and for whom it should be provided. These cases show two sources of messiness that recur in this process. One is the tension between wanting to see more and wanting some things to remain hidden. Concerns for individual privacy emerge as the primary resistance to the expansion of certainty, and reveal diverging visions among the creators of these tools. This latent tension that could retain its ambivalence in the simpler narrative of the promise must be resolved in actual development decisions. The development of OneBusAway and of GBFS each wrestles with visibility and invisibility to different audiences. The second is the technical challenge of seeing the complexity of mobility in a standard format, which requires deciding what difference and detail should be maintained and what can be discarded in a digital representation that must be legible and transferrable. The drive for more visibility leads to more complex data structures, but these nevertheless fail to capture the full certainty that creators envision. When faced with ambiguity or uncertainty, transportation officials respond with more digital interventions, rather than with a strategy for acting with incomplete information. The MDS case, an exemplar of new mobility's promise of city monitoring and control, illustrates this effort of perpetual datafication. Throughout these examples, we see both how certain actors' visions direct the choices shaping the development of data tools in specific ways that work to bring the promise down to earth, and how practices and experiences with the mess are the grounds in which those idealistic visions emerge.

OneBusAway: Making transit visible

OneBusAway was developed with a specific purpose: making buses visible to riders. It assumes that if riders are more certain of the time their bus will arrive, they will be more likely to choose to use transit, and more satisfied when they do. Its development has also been guided by a specific set of commitments. Its code is open source, so that reviewing or contributing to the code is not limited to a certain group. An API is available for developers, meaning that other transit agencies can quickly implement it without developing their own tool. For riders, it has always been free to use, and use is not tracked. These commitments are typical of software projects aimed at furthering an identified public interest, but differ from those of a for-profit software company. Collectively, these visions for the development and use of the tool have shaped what it has become.

The story of OneBusAway's development begins in 2006, when Brian Ferris was a doctoral student in computer science at the University of Washington who had no car and took the bus everywhere. He learned of a website, made at UW, called MyBus.org, which used a system of radio transmitters and bus odometry to report the estimated locations of King County Metro buses. It had been developed to settle bus driver contract disputes related to on-time performance. The system was clunky and not meant for public consumption, but Ferris wanted to know when his bus was coming. Over the summer, he met someone who gave him access to the API for the bus location data. He then set up a free local phone number, and connected it to the data feed through his desktop on campus. Now, when he was at a bus stop, he could call this number on his cell phone, enter an ID for the bus stop, and find out if his bus was on time.

Over the next few years, Ferris and his collaborator, Kari Watkins, a UW civil engineering doctoral student, developed this system into OneBusAway, a tool that eventually offered more user-friendly smartphone apps and web interfaces for riders to answer the same question: when is my bus coming? The app became increasingly popular with the riders in the region, and both Metro and Sound Transit began coordinating with Ferris and Watkins on the data and development. After they both graduated, the system continued to operate from UW servers for many years. OneBusAway is now maintained by a handful of volunteer developers as an open-source project and has since 2019 been managed by the newly incorporated Open Transit Software Foundation. Transit agencies in roughly a dozen regions have deployed it. The largest, New York City's MTA, handles as many as 30,000 requests per minute (Open Transit Software Foundation, 2022).

Today, OneBusAway uses GTFS and GTFS-realtime, the open-source standards for transit schedule and real-time location data. GTFS itself was developed between 2005 and 2007 in a partnership between Portland's TriMet and Google. At TriMet, an IT manager named Bibiana McHugh was frustrated that travelers had easy options for getting driving directions, but planning a route by transit was more difficult. Unlike many other governments and transit agencies at the time, TriMet was a champion of "open data," a movement rooted in ideals of government transparency and civic resourcefulness that imagined governments making their data freely available for community members to develop tools to improve their communities. McHugh and her collaborators envisioned a standard format for transit data that agencies would publish and third-party developers would use to deliver transit directions to travelers. Google, which had been pursuing a similar vision for showing bus trips in Google Maps, partnered with TriMet and other agencies to develop the data specification.[1] To facilitate use in agencies that might not have sophisticated tech capabilities, GTFS data is stored in a simple and adaptable CSV format rather than in XML or JSON formats that demand more technical expertise (McHugh, 2013). As developers began using GTFS for new applications, transit agencies' adoption of the specification quickly spread, and it has become the de facto standard for representing transit schedule data.

The visions motivating the development of OneBusAway and GTFS are similar: use better information to make riding transit more convenient. Ferris's account of OneBusAway begins with the premise that public transit is good, and that we ought to "encourage new riders" and improve the system's "usability." In his dissertation documenting the project, he is attentive to the user experience and behavioral impact of the app, not just the technical achievement of creating it. His core argument is that "a real-time transit traveler information system can improve the usability of public transit, ultimately positively changing a rider's use of and satisfaction with their transit system" (Ferris, 2011, p. 5). Over the course of the project he and Watkins did a number of surveys, interviews, and focus groups to find out what prevented people from riding buses, and how OneBusAway might make them more likely to take it (e.g., Watkins et al., 2011). In the same way, McHugh's efforts on GTFS originated in TriMet's mission to serve the public with reliable transit.

In the decade or so since then, transit data has become integral to services extending far beyond the "make life easier for bus riders" mission of transit agencies and scrappy

[1] Despite Google's heavy involvement and interests in the project, the spec has always been open source. The initial name "Google Transit Feed Specification" was later changed to "General Transit Feed Specification."

civic-minded development projects. GTFS has made it easy for apps focused on their own ridehailing or bikeshare products to include transit information as well. Beginning in 2018, Lyft began showing "nearby transit" options in its app, part of its vision of "becoming the ultimate transportation middleman" (Davies, 2018). Taking this integration a step further, "Uber Transit" launched in 2020 to give travelers options to book an Uber ride in advance that will take them to a station just in time a specific train, rather than "bouncing between multiple apps" to plan departure times based on the coordination of real-time train arrivals, Uber availability, and traffic conditions (Uber, 2020). Even if the traveler opts to take transit only and does not book a ride on an Uber or Lyft, these companies presumably win in keeping users on their apps, where they can collect use data and promote their own expanding suites of travel services. Meanwhile, for-profit navigation apps like Transit (a Canadian startup with some $26M in investment), Citymapper (British, $59M investment) and Moovit (Israeli, acquired by Intel for $900M in 2020), which integrate travel information for many different services but do not offer any mobility service of their own, build proprietary trip planning programs with open-source data and tools. The revenue models for these companies, existing or proposed, are undisclosed and uncertain, but are likely to involve user fees (Transit launched a fee-based premium service in 2021), partnerships with transit agencies and mobility service providers, or some version the standard internet business model of selling user data. The privacy policies of all three of these companies allow collection of location and other personal data, the use of this data for an expansive range of internal purposes, and the sharing of the data with third parties, including linked social media accounts.

"We don't need to track people," said Alan Borning, a UW computer science professor involved with the OneBusAway project, in an interview. Without a profit motive, he said, they can focus on delivering data to the user, rather than collecting data from them.

Referencing the idea of "surveillance capitalism" popularized by Shoshana Zuboff (2019), he pointed out that monetizing user data is very likely the core business model for the commercial apps. In a post on the Seattle Transit Blog, he argued that OneBusAway provides an alternative for users to avoid surveillance, a "public option" for transit data (Borning, 2019). At the same time, OneBusAway's user interface is much more basic, and it lacks the trip planning capability that features on the commercial apps. Borning described "people like Brian Ferris" as the initial imagined user for the app, meaning frequent transit users who are already familiar with the routes want more information to make the trip easier. (Ferris agreed with this characterization.) The commercial apps use public GTFS data, but also supplement it with proprietary statistical models for predicting bus times based on historical arrival data and real-time data collected from users. OneBusAway lacks both the user data and the programming resources to develop such models, which means their arrival estimates are often less accurate.

Although its use has expanded enormously since launching in 2008, OneBusAway remains a small homegrown operation. At the time of my interviews with Borning and Ferris in the summer of 2019, OneBusAway was being transitioned to its first dedicated institutional home with the newly incorporated Open Transit Software Foundation after years of having no legal identity and precarious access to servers. Although volunteer developers have for many years fixed bugs and added features, much of the app's operations were unsustainable. Integrating with individual transit agencies and fielding customer emails is time-consuming work. Operating reliable servers is expensive. Borning said he wished he had spoken up earlier to challenge the idea that agencies could just publish the data and let third party apps do all the work, saying that the organizational structure is important. He is now asking transit agencies to pay a modest licensing fee of $2,000 per year to support development and operations costs.

OneBusAway and GTFS were founded with similar visions of using information to encourage transit ridership. They also share technical structures designed to deliver information about transit vehicles to riders, but without any mechanism for collecting information about the riders themselves. Their development reflects the values of open data in which information available to government agencies—real-time bus locations—ought to be visible to the public, and the values of open-source development in which efforts to develop software ought to be shared widely. They seek to make public transit visible while keeping travelers invisible. OneBusAway's protection of user privacy and its non-commercial, non-proprietary structure have limited the data and financial resources that the for-profit apps use to develop more accessible user interfaces and more accurate arrival predictions. Arguably, this limits the effectiveness of the app for its identified purpose of using real-time information to influence travel behavior (although the record of success on this count for the commercial apps is hardly any clearer). OneBusAway and the commercial apps all ostensibly share the goal of giving travelers greater certainty about their trips, but their different approaches to user privacy have developed in parallel through different tools. In the next example, tensions about the visibility of travelers emerge within a single data tool.

General Bikeshare Feed Specification: Limits of public visibility

When bikeshare systems began launching in North America around 2010, many system operators began publishing real-time data on stations, showing number of bikes and empty docks available, on their own apps. In 2014, a bikeshare system IT manager named Mitch Vars began working on a standard data format for bikeshare called the General Bikeshare Feed Specification. The newly formed North American Bikeshare Association quickly endorsed the project and formed a working group of bikeshare operators to develop the specification. The vision was that bikeshare options from any system could easily appear on any navigation app, "making bikeshare ever more convenient and accessible to the public," Vars said. Echoing OneBusAway, it was hoped that such visibility would increase use of this emerging transportation mode. GTFS, which was by then well established, was the model for a tool that allowed multiple transportation operators make their services visible on third-party applications. More than with GTFS, however, an established bikeshare standard was expected to make data management easier for operators, not just travelers. GBFS launched at the end of 2015, and all of the major operators quickly committed to implementing the standard on their systems (Gray, 2016; MobilityData, 2021; North American Bikeshare Association, 2015).

Although its primary use case was showing bikes at docks in station-based systems, GBFS from its first version could accommodate free-floating bikeshare systems in an optional `free_bike_status.json` file. If used, this file would include an array of objects representing bikes not at a station or on a trip. Each object comprised a unique bike identifier, a latitude and longitude, and indications of whether the bike is reserved or disabled. With the 2017 introduction and rapid expansion of free-floating bikeshare systems in North America, this functionality became increasingly important for riders to find available bikes, which were no longer limited to stations but could be nearly anywhere in the city's public rights-of-way. By January 2019, however, project contributors noted a problem. The data, all publicly available in real time, could be used not only to see where bikes are now, but to track where they go. A contributor named Morgan Herlocker demonstrated that by scraping data from a public GBFS feed, a set of snapshots of bikes available at a given time can be used to reconstruct the history of bikes' origins and destinations. The key to this analysis is the stable `bike_id` field, which links a bike's location at one moment to the same bike's location at a different time. Even though no data about the rider is published, the location data of the bike over time is seen as a privacy vulnerability.[2] Knowing that a trip ended in front of someone's house is a strong clue about who is riding the bike. Although `bike_id` could also be used to reconstruct trips in station-based systems, the fixed locations of station meant that knowing a given trip's origin and destination was not an obvious way to identify the rider.

Questions of what threat a stable `bike_id` posed and what ought to be done about it were the subject of discussion for several months on GitHub and at the September 2019 NABSA conference. The issue that quickly became apparent was that for certain users and uses, the stable `bike_id` was a feature, not a bug. Producers and consumers of this data had built their own systems and processes around the GBFS format, and in some of those the consistent bike identifier was necessary for integration. For example, a Google Maps representative said that they needed a stable `bike_id` to verify that the bike information they displayed on their app, using data hosted on their own servers updated periodically from the bikeshare provider's data, agreed with the most recent data from the provider. On the traveler side, one contributor pointed out the usefulness of tracking a specific bike's movements for his friend who "forgot a personal item in the bike basket and was able to locate the bike and retrieve the item." The discussions also raised some skepticism that the possibility of identifying origins and destinations was really such a threat to personal privacy.

[2] Locational privacy research has shown that just four spatio-temporal points are usually enough to uniquely identify an individual (de Montjoye et al., 2013), even though for legal purposes location data is typically not considered personally identifiable information.

Most of the resistance to changing the stable `bike_id`, however, came from cities, many of whom were using GBFS data to monitor bikes and bikeshare providers. As one contributor put it,

> GBFS is an excellent dataset for municipalities to monitor and control micromobility operators (and this time municipalities are early in the game compared with the earlier disruptions started by Uber and AirBnB for example). I am a bit worried that privacy is used as an easy argument to not share the data, even if the risks are relatively small (the operators themselves have much more privacy sensitive data).

This agency monitor-and-control use was not the originally intended purpose of GBFS data, but it had become common. In particular, the expansion of dockless systems operated by private vendors had made bikeshare operations both messier—with more bikes in more places across the city—and more independent of municipal control than the legacy dock-based, municipally managed systems. Removing bikes from docks had given cities new reason to monitor them and, because of the greater spatial resolution of dockless trips, had increased the threat of this monitoring to personal privacy. Cities were using GBFS data to map bikeshare trips, precisely the use that Herlocker and others were concerned would be available to nefarious actors, in order to analyze system use and inform bike infrastructure planning. They were using data to identify "stale" bikes, those that had been in the same location for a long period of time, and ask operators to move them. Cities could identify a bike repeatedly ridden for a very short distance and report it to the operator as likely broken. Basic counts of the number of bikes on the street, a key metric in virtually all bikeshare permits, could be done easily through the IDs available in the provider's public GBFS feed. Without discounting privacy concerns, analytics professionals like Regina Clewlow cautioned that "removing vehicle IDs entirely also makes the data feed far less usable for cities that are holding mobility operators accountable with dockless mobility policies that may involve vehicle counts or parking durations." Or as another said in defending the publishing of more data, "our main goal is to help individuals and govs make efficient decisions about bike sharing and help save the planet."

For other contributors, none of this outweighed the privacy risks. These arguments often returned to the traveler's point of view, at times appealing to the common goal of increasing ridership:

> If you said to an average citizen: "the origin and destinations of every bike share trip is being published, in real-time", do you think that would match their expectations? GBFS feeds are often public, which means we should have a *very* high design standard for privacy. We should be concerned with both real and imaginable attacks ... [This will] prevent a situation where people don't want to use bikeshare due to a perceived privacy problem.

Meanwhile, some bikeshare and scootershare providers had already been changing a given vehicle's `bike_id` after every trip, a use that was technically out of spec and that frustrated cities trying to supervise compliance. Some had recognized the privacy vulnerability and chosen to address it on their own, and at least one city had even required ID rotation already. But privacy was not the only concern. At a conference workshop on GBFS, vendors claimed that a stable `bike_id` can reveal sensitive operational details, especially rebalancing locations, to competitors. Scooter provider Bird had a different issue related to its program that pays independent contractors for redistributing scooters and charging batteries. The company was worried that stable IDs created a vulnerability that would allow scammers to claim to have completed a task without being physically present, and so they began rotating IDs as a precaution.

In short, GBFS had encountered a situation where a single method of handling data could not serve the multiple purposes to which that data was being put. Data integration, like that at Google Maps, is facilitated by consistent IDs, but Bird's efforts to prevent abuse called for obscuring IDs. A stable `bike_id` gives cities views of bikeshare systems useful for their regulatory efforts, but risks rider privacy. Most fundamentally, given the personal nature of the location of dockless trip ends, there is no straightforward way to protect the privacy of individual trips while also making available bikes visible to the public. By December of 2019, a project contributor wrote that "there is a shared understanding about the risks of publicly publishing stable `bike_id`, and that we just need to come up with the right solutions for how to address it and still meet industry needs."

Addressing privacy vulnerability and meeting industry needs was a question both of technical capabilities and of the broader intention of the spec. In the originally proposed technical solution, `bike_id` could be required to rotate at the end of every trip, or more frequently, to prevent its use in reconstituting trips, but this approach would deprive cities of their views of trips and bikes. Alternatively, the `bike_id` field could be split into a public rotating `bike_id` and a stable `immutable_bike_id` available only to cities with authentication, or a separate authenticated `monitoring_bike_status.json` feed could be set up with trip and bike data not visible to the public. Or, `bike_id` might be dropped entirely, since the usefulness of a constantly changing ID is questionable. Without this ID, functions like trip tracking, bike booking, or system monitoring that used the ID would need to be built differently. Some contributors pointed out that even a rotating ID can be used to estimate origins and destinations with some frequent data scraping and probability-based analyses. Making bikes visible seems to inevitably risk making riders visible.

In these discussions, the disagreement was not just about how to fix the problem, but what the problem actually was. Put differently, GBFS's implementation had outrun its vision. Evaluations of proposed fixes quickly turned to simple question: What is GBFS for? When the `bike_id` issue was on the table in autumn of 2019, the spec's "guiding principles" read, in part:

> GBFS is a specification for real-time or semi-real-time, read-only data. ... The spec is about public information intended for bikeshare users. GBFS is targeted at

> providing transit information to the bikeshare end user. It's [sic] primary purpose is to power tools for riders that will make bikesharing more accessible to users. GBFS is about public information. Producers and owners of GBFS data should take licensing and discoverability into account when publishing GBFS feeds.

In September, 2019, the "What is GBFS?" section of the GitHub repository was edited to include the final sentence below:

> The General Bikeshare Feed Specification, known as GBFS, is the open data standard for bikeshare. GBFS makes real-time data feeds in a uniform format publicly available online, with an emphasis on findability. Because GBFS is intended to make information publicly available online, information that is potentially personally identifiable is not currently and will not become part of the core specification.

These texts make clear that GBFS data is meant to be visible to the public and that the data's end user is the traveler. (The language is broadly the same today.) These principles were cited in dismissals of cities' use of the data for monitoring as unsupported and in arguments against the creation of authenticated private feeds. By the time of the developers' workshop at the end of September, the focus was on traveler use cases. When regulatory uses were suggested on GitHub, a typical response was this one: "GBFS is intended to be used for traveler-facing information… going forward privacy concerns outweigh alternate use cases like this for GBFS that fall outside its primary purpose."

In January 2020, a vote was held among GBFS contributors on GitHub to approve a proposed change to the specification requiring vendors to change each bike's `bike_id` to a new, random ID at the end of each trip. Seven contributors, representing both producers and consumers of GBFS data, voted in favor, and none against. In GBFS version 2.0, released March 16, 2020, `bike_id` remains a required field in the free_bike_status.json feed, but with the following definition:

> Identifier of a bike, rotated to a random string, at minimum, after each trip to protect privacy *(as of v2.0)*. Note: Persistent `bike_id`, published publicly, could pose a threat to individual traveler privacy.

Feeds that publish a persistent `bike_id` will still function technically, but will be considered out of spec, which would be considered a violation in cities whose permits require providers to publish a GBFS-conformant data feed.

What then becomes of the city monitoring capabilities? Almost no one in the `bike_id` debates questioned the need for cities to have fine-grained visibility into micromobility trips and shared vehicles in the right-of-way, but without a persistent identifier, cities' view would be limited. The solution to the distinct data needs of city agencies and mobility service providers, as opposed to those of travelers, is a distinct data specification. The Mobility Data Specification was developed by LADOT in 2018 specifically to give the city standardized tools for receiving data from its rapidly expanding network of bike and scooter providers. Visions for the spec always included expansion beyond LA, and in 2019 MDS gained a roster of municipal adopters, a new home at the freshly established nonprofit Open Mobility Foundation, and the attention of a full-time executive director (Bliss, 2019; Carey, 2020). MDS is for private APIs, available only with authentication. As such, it can carry far more sensitive location data than anything published through GBFS. At the time of the GBFS `bike_id` discussions, MDS had deployed a stable release and development was continuing rapidly with a push for wider adoption. The evolving maturity of the MDS standard helped firm up the identification of GBFS as public and traveler-facing, with private MDS feeds ready to take on the incidental monitoring functionality that GBFS had served.

At the time, however, MDS was not fully suited to answering the question of "what is the current status of all of the micromobility vehicles in the right-of-way?" MDS was designed as a historical record of the movements of vehicles and their statuses, not a real-time monitoring tool like GBFS or GTFS-realtime. Cities query MDS data to analyze how weekday and weekend travel differs, or to check how many bikes are available in certain neighborhoods each morning, for example. An API endpoint called `/status_changes` reported the *changes* to a vehicle status during a given time period, but did not return any information about vehicles whose status did not change in that period. In theory cities could use historical `/status_changes` data to "replay" all of the changes over a time period and construct a picture of the current state, but data on some bikes could still be missing and the processing is cumbersome. Instead, cities were using the real-time GBFS feed as their picture of the system. As the changes to GBFS pushed out these uses, MDS developers worked to fill the gap with a new endpoint called `/vehicles`. As OMF's executive director Jascha Franklin-Hodge explained on the GBFS GitHub,

> We created `/vehicles` in part because we knew GBFS was considering removing stable device IDs for privacy reasons. Our goal was to offer an authenticated alternative that could meet the needs of regulators who want stable IDs and/or additional information.

The new `/vehicles` endpoint, released in May, 2020, is described as "a near-realtime endpoint and returns the current status of vehicles in an agency's Jurisdiction and/or area of agency responsibility... As with other MDS APIs, `/vehicles` is intended for use by regulators, not by the general public" (Open Mobility Foundation, 2018/2022c). It uses an authenticated feed and a stable identifier for every vehicle, and includes the state of each vehicle (e.g., `reserved` or `non_operational`) as well as its most recent "event" (e.g., `reservation_start` or `battery_low`), giving new visibility of vehicles to cities.

This case of bike visibility in GBFS and the transfer of certain functionality to MDS is an illustration of the promise of certainty encountering the messiness of conflicting visions and technical limitations. Developers and providers initially wanted to use public data to make the locations of available bikes visible to riders, but the availability of this data led to regulators seeking greater visibility of bikes and trips for themselves. This visibility of bikes then risks creating an unwanted visibility of riders to the public. Cities want to preserve rider privacy, but do not want to manage without the certainty that rider data offers. GBFS contributors differed in their evaluation of this tradeoff, and struggled to find a technical solution that would satisfy competing desires for visibility or invisibility to different groups. The resolution requires two separate data tools, with different data for different audiences. Besides showing the promise of certainty encountering the messiness of implementation, this case also illustrates, in the other direction, how promises emerged from and were reinforced by the mess. The technical limitations of the data and conflicting behaviors of various users forced an engagement with the question of what these actors want, and how they expected to achieve it. The diverging practices of data use made the inherent contractions of the vaguer "data will make bikes visible" promise untenable, and so two newly sharpened promises take its place, one for GBFS and one for MDS.

Once personally identifiable trip and vehicle data is no longer visible to the public, however, it invites cities to imagine even more possibilities for data-based monitoring and control, as the next example details.

Mobility Data Specification: Showing cities more

The practice of datafication serves as a bridge between the messy particularities of the world on one side and the vision for ordering that world on the other. As such, the two-part test of any component of the data specification is its fit to the world and its fit to its purpose. The expansion of MDS is a response to complications of both. Over the past five years, micromobility vehicles, services, payments, and policies have become significantly more complex. At the same time, the hopes for what data about these systems can do for cities have also expanded. This section illustrates the general expansion of MDS with a focus on the expansion of options for representing bike statuses in MDS data. It shows an ongoing effort on the part of city agencies to see more of mobility digitally. Many of these efforts are no doubt successful, offering greater visibility and certainty. But the MDS example also shows that as data try to capture more and more of the mess, they become messy themselves, shedding some of their alluring promise of tidy certainty.

The purpose of MDS is to enable standardized communication of data between mobility service "providers," such as Spin or Lime, and government "agencies," typically a municipal DOT. (Third-party data analytics companies also use MDS in partnership with providers or agencies.) As discussed above, MDS data is not publicly available. MDS is built as a modular system, with consumers able to choose among the various specifications to suit their needs. The system comprises separate APIs which are themselves made up of endpoints. An endpoint is simply the digital location where data in a specified format is exchanged; different types of data, such as those representing bike trips and those representing bikes being put into service, require different endpoints. Local permits will usually require providers to use specified MDS endpoints. The entire specification uses generally consistent definitions and data structures throughout, and many endpoints are intended to be used in coordination with one another.[3]

Since its launch in 2018, the number of MDS APIs and the number of endpoints has increased. This expansion represents increases in both the scope and the resolution of mobility data captured by MDS. In the Policy API, for example, MDS expands its scope by developing tools for the transformation of previously unstructured local regulations, which would be communicated to providers in incommensurable formats like permit

[3]In the case of MDS at least, the decision of whether different data should be delivered in a separate endpoint within the same API or in separate APIs entirely is mostly a question of organization and makes little technical difference.

documentation or web pages, into a standardized format. The resolution increases when, for example, the number of options for representing vehicle status changes are increased.

MDS expanded from a single API to six in its first three years, as shown in table 5. The core of MDS is the Provider API, which allows providers to communicate data on their operations to regulatory agencies. The first release also included an early version of the Agency API, a more complex interface that allows two-way communication between providers and agencies. The Agency API lays the groundwork for "adaptive regulation," and requires more technical sophistication on the part of the regulating agency. It has remained less commonly implemented, but development continues. The October 2019 release introduced the Policy API, which allows agencies to communicate their micromobility policies—rules like speed limits and no parking zones—to providers in a standard format. The Policy API included a `/geographies` endpoint for representing various territories for applying policies or tracking operations; this became the separate Geography API in the March, 2021 release. The same release introduced a new Jurisdiction API, for communication among neighboring agencies, and a Metrics API, which standardizes some of the common data analytics used for monitoring mobility operations (Open Mobility Foundation, 2018/2022a).

Table 5: MDS APIs

Version 0.2.0 June 2018	**Version 0.3.1 April 2019**	**Version 0.4.0 October 2019**	**Version 1.1.0 March 2021**
Provider	Provider	Provider	Provider
	Agency	Agency	Agency
		Policy	Policy
			Geography*
			Jurisdiction
			Metrics

**Before becoming a separate API, Geography was an endpoint of Policy in version 0.4.0.*

The number of endpoints has also expanded. This is clear in the Provider API (table 6), which is the most used and receives consistent development attention. It was launched with two endpoints. Data in `/trips` describes the specific beginning, end, and routes of individual trips, which cities can query over specific time periods. This endpoint is central to the MDS promise, with its detailed view of origins and destinations forming the basis for visions of use-based infrastructure planning. Other endpoints support this planning vision and also offer capabilities for regulatory monitoring. A new record in `/status_changes` is created each time a vehicle changes status. These endpoints were designed to support querying of historical data, as cities might analyze, say, trips in the last month, or create a report of status changes last week. To more efficiently represent data on thousands of vehicles over weeks and months and years, the `/status_changes` endpoint does not store the state of every vehicle at every time. Instead, it creates a record only when something changes. Creating a picture of the vehicle states in a given moment, then, requires looking back to its most recent change. The `/events` endpoint introduced in October 2019 uses the same schema as `/status_changes`, but is designed to support real-time monitoring. The `/vehicles` endpoint, introduced in May 2020 and mentioned in the GBFS discussion above, further complicates this picture. Like `/events`, it also shows real-time data, but rather than representing vehicles only when they change status, it provides the current picture of all vehicles.[4]

Because MDS was first developed to represent the free-floating bikes and scooters that were proliferating across Los Angeles and other cities in 2018, it did not initially include any data representing docks or other parking infrastructure. Data described

[4] A discussion in summer 2021 suggested that `/events` might be redundant given the capabilities of `/vehicles` and `/status_changes`, but enough consumers said they had use of it that there are no current plans to discontinue it.

vehicles, their locations, and their changes. Eventually, however, the need to represent stops became apparent. Some systems were hybrids, with bikes that could be parked either at a permanent dock or left elsewhere on the sidewalk. Many cities had begun installing various parking corrals, ranging from a patch of painted pavement to permanent bike racks with battery charging facilities. Proposals for a `/stops` endpoint to represent these began in 2019, and was modeled after the schema in use in GBFS, but intended for city monitoring and historical analysis rather than public consumption. The new endpoint was released in the September 2020, which also included options to include stop information in data in other endpoints as well. Much of the development focused on aligning with GBFS, which was simultaneously trying to represent different types of bike parking, and keeping options open for expansion to different parking types.

Table 6: Endpoints in the MDS Provider API

Version 0.2.0 June 2018	**Version 0.4.0 October 2019**	**Version 0.4.1 May 2020**	**Version 1.0.0 September 2020**	**Version 1.1.0 March 2021**
`/trips`	`/trips`	`/trips`	`/trips`	`/trips`
`/status_changes`	`/status_changes`	`/status_changes`	`/status_changes`	`/status_changes`
	`/events` (beta)	`/events` (beta)	`/events`	`/events`
		`/vehicles` (beta)	`/vehicles` (beta)	`/vehicles`
			`/stops` (beta)	`/stops` (beta)
				`/reports` (beta)

The newest endpoint in the Provider API, `/reports`, was introduced in March 2021 and is still in beta. It allows providers to share static, pre-generated monthly ride reports. Unlike anywhere else in MDS, Reports delivers data on the riders themselves, not just trips or vehicles. Providers know who their riders are and can link them to specific trips on their vehicles, but this individual data is not shared with cities. Reports counts the number of unique riders, not just the number of trips, in a given month. It also offers a separate classification for "low income" riders, as determined by use of income-based pricing discount programs, and has options for adding details on other "special groups." The endpoint includes no data on times or locations of trips, and also offers guidance for redacting data below certain thresholds in order to protect anonymity.

Put together, these endpoints represent a desire for agencies to see more. They present information on trips, vehicles, and riders in different formats so that agencies can see micromobility operations currently and historically. This same interest in more accurate and fine-grained visibility has driven an expansion of the options for representing a real-world activity within any given data exchange. As data projects develop, they often add new fields. (Invalidating a previously valid value is problematic for backwards compatibility, so adding options is easier than removing them.) For example, when MDS launched, GBFS had no field to differentiate traditional pedal bicycles from e-bikes, but MDS from the beginning included a separate `propulsion_type` field. Allowable values for this field are `human`, `electric_assist`, `electric`, or `combustion`. (GBFS includes this beginning in March 2021.) These allowable values for a given field, called an enumeration, have similarly expanded. For example, the enumeration of `vehicle_types` has expanded from `bicycle` and `scooter` to also include `cargo_bicycle`, `moped`, `car`, and `other`.

To understand how cities' desires to see more shape this data specification, we can look more closely at the evolution of MDS data representing vehicles in the `/status_changes` endpoint. Recall that this endpoint is for mobility service providers, who are already tracking activity on their vehicles, to share this data with regulatory agencies. Vehicle data describes their states (e.g., available for rent or broken) and transitions between them (e.g., a rider beginning a trip, a provider removing the vehicle). In the first version of `/status_changes`, a reported vehicle state, called `event_type`, could be available, removed, reserved, or unavailable. An event_type_reason was also required. Each of the set of 10 options corresponded to a single event_type, so that, for example, using the event_type_reason of maintenance_pick_up requires reporting the event_type as removed.

After a year or so of use, this setup was proving inadequate. For one thing, many scenarios were not mapping neatly onto the schema. Sometimes the city removed a scooter, maybe for blocking a right-of-way, but the options described only providers removing vehicles. Providers occasionally shut down their systems temporarily, for inclement weather perhaps, but there was no event_type_reason to accurately described this transition to unavailable. Some real-world distinctions considered to be important were being lost in the data. maintenance could mean a bike requires repair, or just a battery charge. user_drop_off could mean a user finishes a trip, or had a reservation and cancelled it without touching the scooter. And cities began asking about representing new practices: Could we represent stopovers, where a rider parks the vehicle temporarily without ending their trip? How do we show that a vehicle in the right-of-way is charging? The issue, however, was not necessarily that micromobility was getting more complex (although it was), it was also that regulators wanted more detailed data about what was happening. MDS's initial concept came from GBFS, whose user-facing purpose means that distinctions other than "Can I rent it now?" are unimportant. As MDS came into vision as a tool for a different kind of mobility and compliance monitoring, the corresponding data needs began to emerge.[5]

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[5] Another important issue driving changes to these schema was an effort to make terminology consistent and coherent. Similar phenomena were sometimes referred to differently across MDS, and there was much discussion about whether terms like, say unavailable or out_of_service better communicated the ideas to users. A program within SAE International, a standards organization,

Table 7: Comparison of vehicle states in MDS versions.

Options for event_type (MDS 0.2.0)		**Options for vehicle_state (MDS 1.2.1)**	
removed	A device is removed from the street and unavailable for customer use	removed	Examples include: at the Provider's warehouse, in a Provider's truck, or destroyed and in a landfill.
available	A device becomes available for customer use	available	Available for rental via the Provider's app. In PROW.
unavailable	A device is on the street but becomes unavailable for customer use	non_operational	Not available for rent. Examples include vehicle has low battery, or currently outside legal operating hours.
		on_trip	In possession of renter. May or may not be in motion.
reserved	A customer reserves a device (even if trip has not started yet)	reserved	Reserved via Provider's app, waiting to be picked up by a rider.
		elsewhere	Outside of regulator's jurisdiction, and thus not subject to cap-counts or other regulations. Example: a vehicle that started a trip in L.A. has transitioned to Santa Monica.
		unknown	Provider has lost contact with the vehicle and its disposition is unknown. Examples include: taken into a private residence, thrown in river.

(Source: MDS GitHub documentation. My approximate mapping.)

A long redesign effort, most of it for the 1.0.0 release in September 2020, created new schema for what are now called `vehicle_state` (formerly `event_type`) and `event_type` (formerly `event_type_reason`). (See tables 7 and 8 for comparisons of the old and new schema for vehicle states and for event types, respectively.) From launch to the current release (1.2.1), the number of vehicle states has increased from four to seven, and the number of events has increased from 10 to 26. As before, not all events can be applied to all states, and the mapping of permissible transitions has become rather complex. For

had been working at this time to define some core micromobility terminology (Mobility Data Collaborative, 2020), an effort that influenced decisions within MDS.

example, the trip_start event can be applied to a vehicle in the available or reserved states, but not non_operational, since you can't begin a trip with a scooter that doesn't work. Additionally, transitions between some states are not permitted. A status change cannot report a bike changing from the non_operational state directly to the reserved state without being reported as available first. The data scheme allows 79 valid combinations of prior state, event, and new state, represented in figure 1.[6]

Table 8: Comparison of event types in MDS versions

Options for event_type_reason (MDS 0.2.0)		**Options for event_type (MDS 1.2.1)**	
		agency_drop_off	Drop off by the agency
		agency_pick_up	Pick up by the agency
		battery_charged	Battery charged
low_battery	A device is no longer available due to insufficient battery	battery_low	Battery low
		comms_lost	Communications lost
		comms_restored	Communications restored
		compliance_pick_up	Pick up for compliance
		decommissioned	Decommissioned
		located	Located
maintenance	A device is no longer available due to equipment issues	maintenance	General maintenance
maintenance_pick_up	Device removed from street so it can be worked on	maintenance_pick_up	Pick up for maintenance
		missing	Missing
service_end	Device removed from street because service has ended for the day (if program does not operate 24/7)	off_hours	Off hours - end of service

[6] The situation is actually a bit more complicated than this, since MDS allows ordered events to be reported together in a single status_change. For example, if scooter trip ends with a low battery, the vehicle can transition from on_trip directly to non_operational, skipping the intermediate available state.

Options for event_type_reason (MDS 0.2.0)		**Options for event_type (MDS 1.2.1)**	
service_start	Device introduced into service at the beginning of the day (if program does not operate 24/7)	on_hours	On hours - start of service
maintenance_drop_off	Device introduced into service after being removed for maintenance		
rebalance_drop_off	Device moved for rebalancing	provider_drop_off	Drop off by the provider
rebalance_pick_up	Device removed from street and will be placed at another location to rebalance service	rebalance_pick_up	Pick up for rebalancing
		reservation_cancel	Reservation cancelled
		reservation_start	Reservation started
		system_resume	Resume system operations
		system_suspend	Suspend system operations
		trip_cancel	Cancel trip
user_drop_off	User ends reservation	trip_end	End trip
		trip_enter_jurisdiction	Trip enters a jurisdiction
		trip_leave_jurisdiction	Trip leaves a jurisdiction
user_pick_up	Customer reserves device	trip_start	Start trip
		unspecified	Unspecified

(Source: MDS GitHub documentation. My approximate mapping.)

This illustration shows that cities continue to want higher resolution representations of mobility, and that these data schema become increasingly complex in response. The structure itself becomes messier as it accommodates the messiness of micromobility operations and the expanding desires of regulators. A data schema, however, remains an ideal as much as a practice. Defining the terms within MDS reflects an aspiration for how the world will look when seen through data, but it cannot guarantee that it will be used as directed.

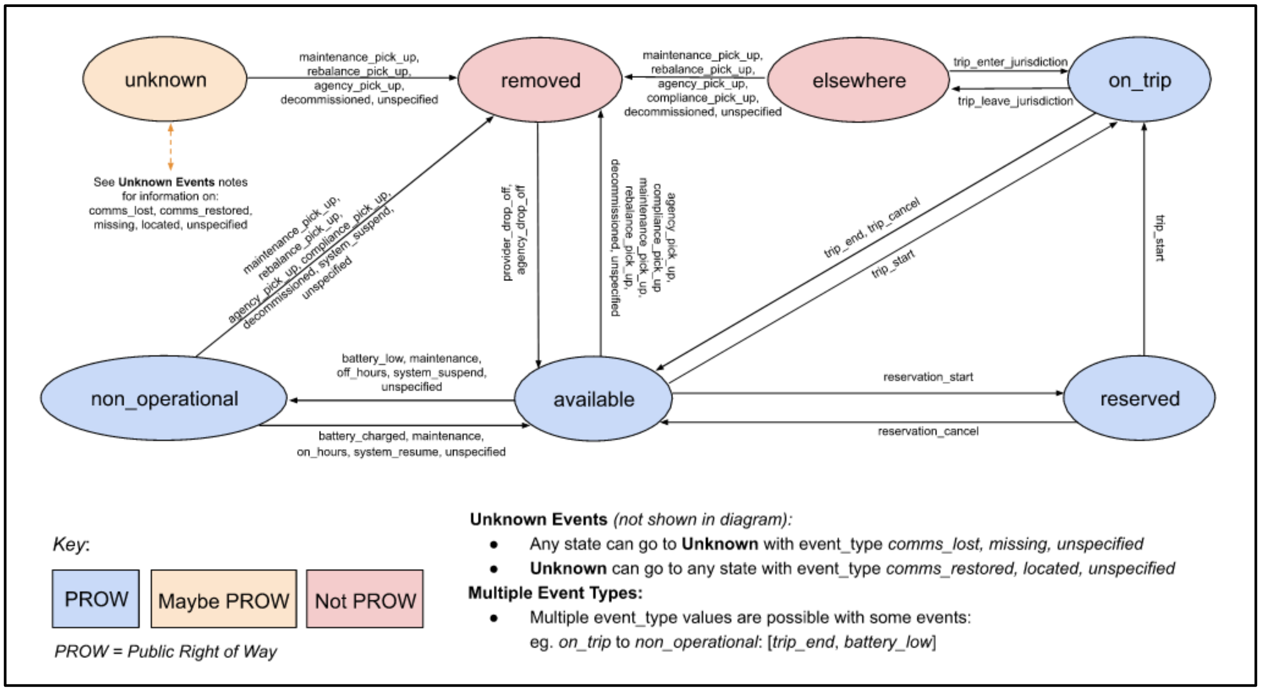

Figure 1: MDS State Machine Diagram

The diagram describes the how a vehicle can transition from one `vehicle_state` *to another via a specified* `event_type`. *(Source: GitHub, last updated August 28, 2020.)*

For example, in its 2019 e-scooter pilot program with 10 providers, the Chicago Department of Transportation observed that "companies have different standards for determining when and whether a certain status change event should be triggered," and "companies often did not all use the same names for status changes" (City of Chicago, 2020, p. 77). The report also noted that

> the status changes often did not follow a logical flow; an event would be reported, but it should have been impossible for that event to happen after the most recent event. For example, an e-scooter might first be reported as taken off the street for maintenance, but then is next reported as starting a passenger trip without being reported as back on the street, an impossible sequence of events. Finally, a e-scooter would often report being on the street and then was never heard from again, even though it was no longer on the street. In such a case, an event that the e-scooter was removed or was shut off due to a low battery should have been received. Without that second event, the data seemed to indicate the e-scooter was on the street indefinitely, even though other evidence conflicted with that assumption. (City of Chicago, 2020, p. 77)

Clearly it remains quite possible technically for scooter share providers to operate their systems in ways that do not align with the MDS specification. Some practices are invisible to data because there is no suitable category. Developers can respond by expanding and redefining the spec. However, the Chicago experience shows that some practices are invisible to data because the mechanisms linking a phenomenon on the street to its digital representation are indirect and imperfect. When it works as envisioned, MDS data can reveal previously hidden phenomena and patterns to agencies. In promising more, however, it overstates the possibilities of standardizing differences into simple stories. When agencies encounter uncertainty, they respond by developing in the data specification an ideal of greater visibility, described by more categories and more narrowly defined relations between them, that promises to deliver better answers. One observation from MDS is that the ideal itself become messier as it is asked to do more work. The broad promise of "giving cities the data they need to understand current and historic use patterns" (Open Mobility Foundation, 2020) becomes nitty questions about, say, how to account for a bike that is reserved with a low battery, questions that demand a choice among different possible resolutions. A different lesson is that much of the work of certainty happens not in the data specification, but on the street. Building better models is useful only insofar as reality is ready to conform to them, but the focus on data specifications does little to reckon with the persistence of uncertainty outside of them. A final observation, a preview of the traveler experience in the next chapter, is that as city officials get more data, they want more data, and become frustrated when asked to act without it. They then turn to digital solutions while overlooking other kinds of interventions.

Regulation

Unlike many tech companies built on the monetization of data, city transportation officials for the most part have little to gain from visibility in itself. Instead, they are interested in providing equitable transportation services, promoting safety in the public right-of-way, and other objectives of the public interest. Datafication is seen a means to these ends, both because it can show the degree to which they are being met and because it can offer tools for achieving them. This section examines how tools of datafication are used not just to see mobility, but to control it. Where *visibility* through data involves efforts to turn the messiness of the city into a more legible digital representation, *regulation* through data helps us to see the effort in the other direction, as a digital ideal is applied to shape that messiness. Urban mobility in general is characterized by a jumble of infrastructures and individual travelers acting unpredictably on their own desires. This is particularly true of dockless bikeshare, in comparison to legacy docked systems. In free-floating systems, cities cede operational control to private vendors, and those vendors in turn cede control to riders who, no longer confined to a few dozen stations, now have far more options for where to ride the bikes. Officials have always sought to control the messiness of transportation through various forms of regulation, but micromobility provides both a new need for and new means of control.

In this study, “regulators” refers to the municipal transportation officials who have jurisdiction over the public right-of-way, and who permit micromobility operators and travelers to operate shared bikes and scooters within it according to certain rules. By examining datafication as an emerging tool of regulation—an example of digitality’s promise of solvability—I show how digital control demands an unambiguous quantification that suits some activities but not others. Datafication leads transportation planners to see both problems and solutions in a certain way, and so we risk missing other ways to respond to identified challenges as well as opportunities to be more thoughtful in identifying problems in the first place. New mobility positions digitality as the way to achieve various planning visions, but I argue that trying to expand datafication to fill these tools' inevitable gaps leads to a troubling retreat from non-digital relations, namely those at a human scale.

Before presenting examples of how this regulation by datafication works, I will briefly put these regulatory efforts in their historical context.

A test case for the active digital management of mobility

This chapter's examples of datafication for regulation come from micromobility. The recent history of shared bikes and scooters helps explain why there has been so much activity around data and regulation in this arena. After their slow response to ridehailing, cities like Seattle approached the regulation of micromobility vendors more aggressively (SDOT, 2018). After its 2017 pilot, SDOT's 2018 permit application cycle (SDOT, 2018) included caps on the number of allowed bikes and, most controversially, an annual fee of $50 per vehicle. These funds would support SDOT's program management, rider education, and capital investments in parking infrastructure. SDOT specified requirements for the safety and mechanics of the bikes themselves and for vendors' customer communication and support. It required vendors to submit an "equity plan" describing their efforts to reach underserved communities, and detailed geographic distribution targets and parking restrictions, goals discussed further below. Finally, SDOT listed detailed requirements for data sharing. Since vendors were already generating and collecting data on these digitally based systems as part of their regular operations, regulators found it natural to ask them to share it. The approach was similar in other cities. As a Populus report says:

> In part because ridehailing (e.g. Uber, Lyft) and delivery services grew rapidly with relatively few regulations in the prior decade frustrating policymakers, cities

> established more extensive policy frameworks to regulate and manage micromobility services over the past two years. In many ways, micromobility is one of the most regulated shared mobility services in terms of datasharing requirements, insurance requirements, and restrictions on the number of vehicles allowed to operate, as well as where they are allowed to park and ride. (Populus, 2020b, p. 4)

Requirements like these generated some pushback from providers. In Seattle, two of the three vendors from the pilot balked at the fees and did not apply for new permits. At the 2019 SUMC conference, providers and cities alike noted the lack of parity between the fees and data demanded of bikeshare providers and the far less required of drivers. A representative of Lime said that cities coming out of difficult experiences with Uber tend to overreact by either “putting up a wall” or “demanding everything.” A city representative pointed to a study (Cortright, 2019) showing that bike fees per mile amount to 20 times what cars pay, creating incentives in direct opposition to transportation planners’ goals.

Although a push from some corners seeks to reduce this imbalance by loosening restrictions on new bikeshare modes, the stronger drive-in transportation planning goes in the opposite direction: expanding the reach of the kind of regulations applied to bikeshare to ridehailing and even to ordinary driving. Data, which has been comparably accessible in micromobility, is central to this vision. LADOT’s Tech Action Plan, for example, imagines collecting roadway usage fees from ridehailing providers based on trip data (LADOT, 2019, p. 16). A frequent vision described at conferences was using vehicle data collection as the basis for dynamic tolls charged to motorists that might vary by distance, geography, and time of day.

Transportation planners’ engagements with micromobility in recent years reveal a situation in which the goals of forceful regulation and the tool of enhanced digital visibility have emerged at the same time and come into alignment. In the novelty and inherent digitality of these modes, cities have seen opportunities for new forms of data-centered regulation to achieve their goals of equity, safety, and others. The micromobility case is relevant in itself insofar as we want to evaluate how likely dockless bikes and scooters are to deliver on their promise of expanding mobility options and reducing car use. However, the case should also be understood as a sort of proving ground, in which cities hope to demonstrate that these new types of active, automated, fine-grained monitoring and control of mobility can be the basis for managing other travelers, vehicles, and infrastructures.

Quantifying rules

I introduced MDS as a tool for monitoring, but it is also envisioned as a means of digital control. Examining the quantification required for these automated interventions helps to reveal the gaps of digital solvability. MDS's Policy API, launched in 2019, aims "to enable agencies to create, revise, and publish machine-readable policies, as sets of rules for individual and collective device behavior exhibited by both *mobility as a service* providers and riders / users" (Open Mobility Foundation, 2018/2022b). The use of a standardized format for machine-readable policies is meant in part to ease the scaling process for providers entering many markets, each of which will have their own sets of regulations requiring localized adjustments. At the same time, it gives agencies new possibilities for their visions of dynamic regulations. For example, a city might create a temporary prohibition against parking in a certain zone during a crowded event.

The API's structure permits many custom variations of regulations, but they must be quantified and unambiguous. This requirement is apparent in two required fields: `rule_type` and `rule_units`. Rule types include `count`, `time`, `rate`, and `speed`. Each of these is associated with a specified unit. For example, rules with the type `count` use the unit `devices`. These rules reflect common regulations regarding total fleet caps for the city, prohibited zones allowing zero devices, or minimum device counts required in an equity zones. `Speed` rules communicate local speed limits and are measured in `mph` or `kph`. A `time` rule could be used to communicate the maximum amount of time an out-of-service bike may be left in the right-of-way before the vendor is required to remove it, for example. The `rate` rule, which has units of time and cost associated with it, can be used to communicated subsidies or fees for specified vehicles. These rules are specified to apply to certain geographies, so a city can, for example, set a lower speed limit on a popular beach than elsewhere in the city. Additionally, rules can apply only to vehicles in a specified `vehicle_state`, e.g. `non_operational` or `available`. MDS contributors offer a number of examples of how policies can be translated into JSON objects exchanged over a Policy API. For example, a Los Angeles policy specifying a 15 mph speed limit in the city, but a 10 mph speed limit in Venice Beach on weekend afternoons uses two different rules, each with a `rule_type` of `speed`, a `rule_units` of `mph`, a maximum value, and, in the case of the beach rule, `start_time`, `end_time`, and `days`. The object describing the more restrictive beach rule is applied first, then the broader city rule with the higher speed limit. Other examples include a 25-cent fee for trips that begin in a certain zone, or a per-hour fee for parking in certain areas at certain times. Examples like these emerged from actually existing policies that MDS developers sought to digitize and from speculation about the types of regulatory control that might be useful to agencies. The use of different maximum and minimum values for different units, applied to various combinations of geographies, vehicle states, and times offers countless permutations of policies to be expressed in a standard format.

Even within this flexible structure, however, there are gaps. Seattle's new scooter share permits, launched in 2021, are typical in setting a 15 mph speed limit for scooters in the city. They are unusual, however, in setting a separate 8 mph speed limit for first-time riders. Providers must ensure that on their first trip with that vendor, a rider cannot go faster than 8 mph, but on subsequent trips they are permitted to go faster. Such a policy is not difficult to represent and enforce digitally, and the providers themselves can apply these limits automatically with the user data available to them. However, MDS, which describes the activity of vehicles but has no data on their riders, cannot identify first-time trips. Seattle's policy cannot be represented through the Policy API as currently specified. Other gaps appear in a `rule_type` called `user`, which is not quantified, but instead delivers text describing policies that cannot be monitored or enforced digitally, such as helmet laws.

The Policy API can express rules, but providers and regulators must establish separate procedures for identifying infractions or enforcing compliance. There are two broad types of policies, those that providers must follow and those that riders must follow. To control riders, providers have several automatic mechanisms available. E-scooters can be physically restricted from traveling faster than a certain speed. Vehicles can be prevented from locking when they are in designated no-parking zones. Riders' accounts can be automatically credited a bonus for trips into priority areas. In other cases, as we will see below with the parking example, automatic enforcement proves more difficult. Rules for providers are enforced by city agencies. Some rules, such as geographic distribution requirements, can be monitored through MDS data, but they cannot typically enforced automatically. Digital monitoring can lead to warnings and fines, but agencies have no direct control over provider vehicles, short of physically removing them from the right-of-way. Even with these APIs, agencies still perform some amount of extra-digital analysis and enforcement.

We can begin to see two different limits to the vision of using datafication for regulation. One is that some rules do not easily align with the data and structures available for representing them. The other is that using digital tools to *express* rules is not the same as digitally *enforcing* them.

Equity zones

Sometimes digital regulation works more or less as promised. This is true of equity zones, which would in fact be quite difficult to implement without automatic digital monitoring. Like many other cities, Seattle has created what it calls “equity focus areas” in support of its goal of providing mobility, in this case bikeshare, to everyone in the city. The regulations are an acknowledgement that, as with any public-private partnership, the goals of the players are often not aligned. For example, vendors will tend to strategically set the numbers and locations of devices that can generate the most revenue at the lowest cost, maximizing usage per device. Cities, however, might prefer to focus on the coverage of devices, putting more devices in more places even if they are rarely used. By the same token, cities want transportation to be affordable to all, including those with less ability to pay. Seattle has required bikeshare providers to offer reduced fares for low-income riders, an approach modeled on transit agencies’ comparable programs, against the complaints of many providers who say that such subsidies are not financially sustainable for them. SDOT’s program director, Joel Miller, describes the relationship between SDOT and vendors as a “partnership” with a built-in tension between roles: “The private sector is going to innovate and going to push the envelope, and so it’s up to the city to kind of set the guardrails, to steer that towards hey, let’s allow things to happen, let’s pilot, but let’s make sure it’s meeting city goals.”

Equity, the broad target introduced in chapter 4, is a classic example of a city goal that might not be served by the unregulated market. In many city bikeshare policies, “equity” appears geographically. Agencies fear that, left on their own, providers will concentrate their vehicles only in the most lucrative neighborhoods, leaving many without access to a transportation mode that is meant to serve all. In response, they designate neighborhoods believed to be most vulnerable to being underserved by providers, usually those with lower income residents and lower densities. Seattle's permit requires that "the vendor shall distribute 10% or more of its deployed fleet in designated equity focus areas" (SDOT, 2018, p. 50). (See figure 2.) The hope is that this will support goals of a more equitable transportation system by ensuring greater access to this mode of transportation for the people who would not otherwise enjoy it. Still, SDOT's Joel Miller acknowledges that these policies "are a very blunt tool, let's say." He went on, saying that SDOT would really like to

> learn about, what are the real barriers for these communities? And how can these kind of blunt equity distribution requirements become more focused? … Instead of saying, 'Hey, you need to put X amount of devices here every day,' [I'd like to] say, 'Hey, this is exactly where we want them, in this corral that we built here next to transit, and this other one next to the public housing. We want you to put them here.' And so [we could] take whatever very specific learnings we get from these communities, of how to make it easier and better, and use our leverage to apply those specifically to the equity areas where I think the city needs to have a larger role. Because it's not going to be driven just by market. (Joel Miller, interview)

This vision represents the same quest for more certainty through more precise data that we have seen elsewhere. It also reflects a view of equity as more nuanced than defined neighborhood boundaries, a view that is echoed elsewhere in transportation planning. Generally speaking, transportation planners know that simply providing transportation resources to communities is both necessary and insufficient for achieving their vision of equitable access to mobility. Barriers to transportation also appear in right-of-way infrastructures and transportation services, in languages and cultures, in prices and payments, and in access to information.

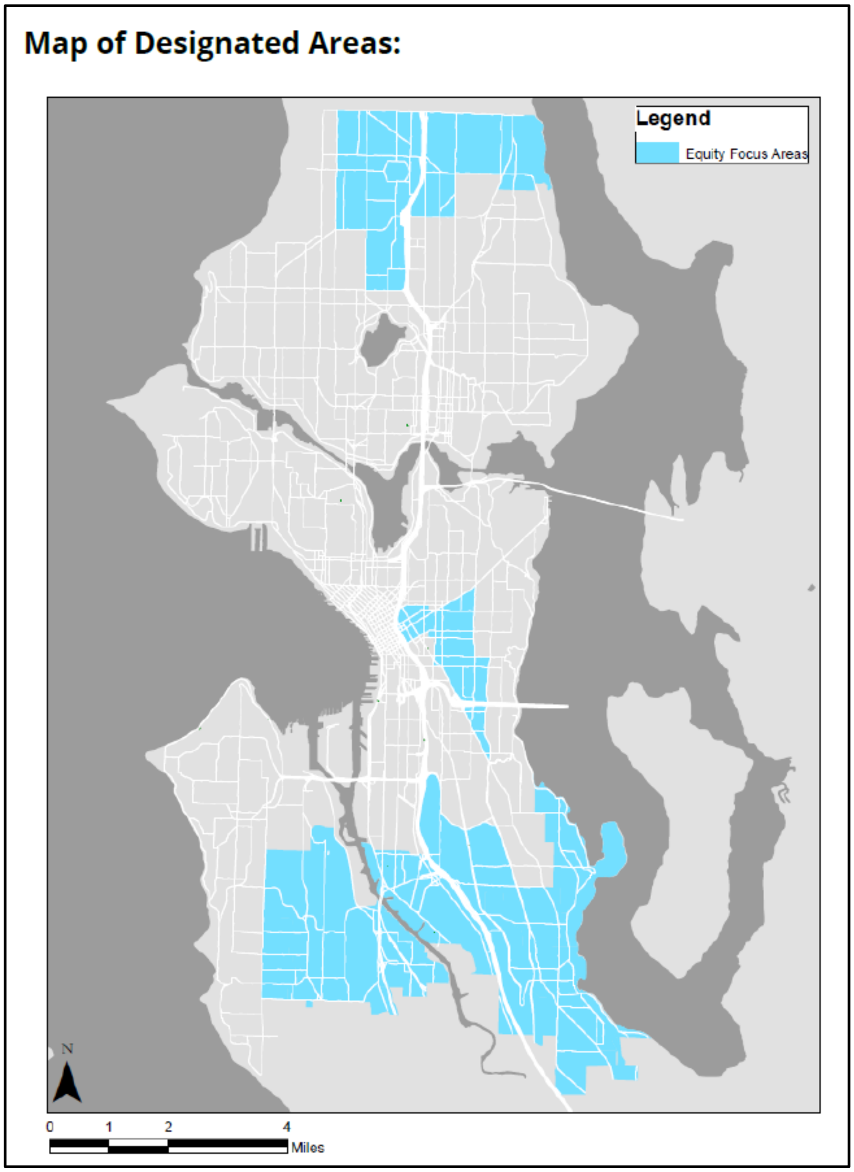

Figure 2: Map of SDOT's Equity Focus Areas

(Source: SDOT, 2018, p. 50)

At the same time, this "blunt tool" of equity zones appears regularly in city bikeshare policy as a simple way to mitigate inequitable outcomes.[7] Additionally, trip data

[7] Similar concerns have driven analyses of ridehailing, which use origin/destination matrices aggregated to census tracts or similar geographies to determine, for example, whether poorer neighborhoods have longer wait times or more cancellations when using Uber and Lyft than richer neighborhoods (e.g., Brown, 2019).

appears again and again as a means for new insight into mobility barriers and solutions. The goal of "equity," which no one denies is multifaceted with no easy solutions, attaches to an intervention that corresponds to the tools available: data for counting bikes in locations. Equity zone requirements are simple to represent and monitor digitally. SDOT requires vendors to share "deployed device data," which includes including "the status and location of each device that is deployed in the City of Seattle or within 1000 feet of city boundaries and is not being rented" at least once every 30 minutes and also at any time the vendor moves the device (SDOT, 2018, p. 28). Location data is required to be reported in decimal degrees to four decimal places, or approximately 10 meters. This data makes for a straightforward GIS analysis to determine compliance with the equity zone requirements. The analysis simply counts the number of bikes that are located within the designated equity zones over the course of a day and divides this number it into the total number of available bikes in the city. If it is at least 10%, then the vendor is in compliance. Accommodations for this kind of calculation, which has become part of many cities' regulations, are built into MDS, which shares data describing vehicles, including their location and status, to agencies.

Even seemingly simple calculations are quickly complicated, however. Cities have identified discrepancies among themselves and vendors in what counts towards the total fleet for the denominator: all bikes in the right-of-way, or only those in good working order and available to rent? Is the calculation made from a snapshot of a given time of the day, or an average over the full day, or does it simply count any bike that enters an equity zone at any time during the day? The industry has made efforts to standardize these terms and calculations across cities and vendors (Mobility Data Collaborative, 2020). Of course, the policies as defined might not align with the actual goals of providing equitable mobility, and vendors might find loopholes undermining the effort.

Evaluated on its own terms, however, datafication for equity zone regulation basically works. Without automatically reported location data, agencies would have no reasonable way to know, on a daily basis, how many bikes were in certain neighborhoods. GPS-equipped bikes and data sharing protocols have enabled this new type of rule and provided an effective means of monitoring compliance. It works because the vision is easily quantified (10% of bikes within these areas) and the technical means for monitoring it are available (frequent, automatically reported location data). However, not all targets of digital solutions meet these criteria.

Dockless parking: Street relations

A good example of the friction between digital solutions and the messiness of the street is dockless bikeshare parking. On a map, countless streets stretching across the city suggest abundant available parking, far more than a handful of designated docks. This vision runs up against a messier reality: sidewalks filled with signs, trees, grass, railings, restaurant seating, building entrances, or bus stops. Some streets have no sidewalk, while on others the sidewalk is too narrow to park a bike. Providers tell their users they can take their bikes "anywhere," but riders expect to find parking very near their destination. When suitable parking is not readily available, riders begin locking bikes wherever they can, which is often in someone else's way. The flexibility dockless providers grant to their users has been enabled by the digital tools that allow bikes to be found and unlocked outside of docks, but this flexibility hits limits in built environments that do not always support bike parking. One solution to this would be to build more designated bike parking infrastructure, versions of the docks that the new bikeshare systems had sought to avoid. City DOTs are indeed doing this, but the digitality of the systems promise solutions that can avoid being constrained to these racks and corrals, which require unappealing financial and political investments.

"Parking is the greatest challenge for a free-floating program," Seattle's permit application claims (SDOT, 2018, p. 4). As with most cities, Seattle's primary parking concern is maintaining safe passage on sidewalks for pedestrians, especially those with disabilities. Wheelchair users and people with limited vision have been vocal opponents of dockless systems, which have presented new obstacles on sidewalks. An additional concern is residents' complaints about the unsightliness of bikes and scooters scattered across sidewalks. In response to this challenge, SDOT details parking requirements that both vendors and riders are expected to follow. Descriptions of allowed and disallowed parking run across four pages of the application (pp. 17-20). Some of these rules are fairly explicit: parking is not allowed "less than eight feet inward from the curb" where there is a bus stop or taxi stand, "in or blocking access to crosswalks, travelways, driveways, alleys, bicycle lanes, or paths," or "on vegetation," for example. Other rules are open to interpretation. Parked devices must not create "an obstruction hazard" that, for example, "obstructs pedestrian circulation and navigation for people with low vision or mobility difficulties" or "otherwise creates a safety hazard."

Such policies are difficult to enforce digitize, for two reasons. The explicit rules could, in theory, be mostly translated into a detailed city-wide map of where parking is and is not permitted. This, however, would be a lot of work. The city does not have a base map describing all sidewalk furniture, building entrances, vegetation, and other details at the resolution of less than one foot that would be needed to map out the listed restrictions. Moreover, sidewalks are dynamic; as construction sites and cafe tables come and go, they change where parking is or is not allowed. Even with a suitable digital representation of parking zones, digital enforcement of parking would require GPS accuracy much greater than what is actually available. Although these GPS devices are often quite accurate within a foot, they are also susceptible to signal bounce, especially close to large buildings, as well as other technical phenomena that can cause large errors in reported locations. These inconsistencies make it impossible to determine with certainty whether the parked bike has left, say, five feet of clearance or six. Chicago even reported difficulty using GPS to locate prohibited riding within an entire 20-foot-wide corridor (City of Chicago, 2020). To add to the challenge, GPS does not report whether the bike is parallel or perpendicular to the sidewalk, nor if it has fallen over.

The less explicit rules, on the other hand, raise a different challenge for digitization, a challenge that attends any policy open to interpretation. To represent a general rule like "do not create a safety hazard" in digital form would require a series of explicit quantifications that would both fail to capture differences among various environments and would be the subject of disagreements. What one person sees as an obstacle might look to another as a manageable inconvenience. Getting in and out of other people's way is a part of negotiating a city that is at best only vaguely regulated by laws and ordinances. This is the territory of social norms, and disagreements about them.

The unambiguity of digital rules poses a problem for rules that are not actually meant to be enforced. For example, Seattle's permit technically forbids vehicles from being parked on property controlled by the Seattle Department of Parks and Recreation. In practice, of course, parks are among the most popular locations for bike trips. Vendors makes no visible effort to communicate this restriction, and SDOT makes no effort to enforce it. Bikes' locations inside or outside parks can be determined digitally as easy as their locations in equity zones, but they are not. The prohibition is an artifact of the distinct jurisdictions of SDOT and the parks department, and one SDOT representative described the popularity of parks for bikeshare as an "open secret." The rule has a legal function, but is apparently not intended to direct everyday practice of bike parking, at least not consistently. In this gap between the ideal—a story about what is allowed that serves a purpose but is essentially fictional—and the actual acceptable practice is an ambivalence that does not translate well to a digital system for automatic enforcement.

Despite these difficulties, the promise of datafication solving the parking challenge is tempting. Recognizing that complaints about sidewalk parking are one of the main obstacles to the public acceptance of their businesses, bike and scooter share providers have sought various approaches ensuring compliance. Two approaches that are largely unappealing to providers are cleaning up parking themselves and fining users. Seattle's permit generally requires providers to field complaints about improperly parked scooters and to respond within a set period of time, as little as two hours for obstruction hazards (SDOT, 2018). This requirement is consistent with industry guidance and is found in many other city permits (NACTO, 2018). Staffing a round-the-clock ground crew is expensive, however, and providers want to avoid investment in this kind of presence. Fining users is also detrimental to providers' business models. If Seattle issues a fine for an improperly parked vehicle to a provider, it requires the provider to pass that fine along to the rider who was responsible for that parking. Providers, however, do not want to get involved in the labor-intensive process of adjudicating responsibility. (Bikes can be moved by someone else after they were parked, so the most recent renter is not always to blame.) More importantly, they do not want riders to be penalized for using their services. In Silicon Valley's prioritization of user satisfaction over short-term profits, it makes more sense for providers to absorb the cost of the fine themselves rather than risk alienating a customer. Joel Miller of SDOT suspects that vendors are often not fining riders for violations.

The providers would much rather have a scalable digital approach to preventing parking obstructions in the first place, and cities too would like to avoid the work of performing street audits and fielding citizen complaints. Providers use in-app instructions to remind riders of local parking rules, but these are usually just one or two screens, capturing only the basics of Seattle's four pages of regulations. And they still rely on riders choosing to do the right thing. Some providers have experimented with community-based policing through their apps. Many have begun requiring riders to take photos of the vehicle after parking. This can serve as a reminder to riders to think about their parking, but it is also the basis for a software tool to automatically identify parking compliance based on images. As mentioned in chapter 4, Lime has promoted its work developing an AI-based image recognition engine that can automatically identify incorrect parking, based on training data generated by unpaid users labeling photos (Lime, 2018a, 2018b). However, to my knowledge no automatic image-based parking enforcement system is currently operational. Any of the digital solutions still require some degree of user cooperation.

For the foreseeable future, then, it appears that the ways shared bikes and scooters are left in the right-of-way will be invisible to data-centered regulatory efforts, and that riders will continue to have the freedom to park incorrectly. Rather than datafication, some combination of behavior change and infrastructure are more likely to achieve some degree of success in ordering of parking's messiness, as Seattle and other cities seem to recognize. Overlooking these approaches, and failing to recognize that some problems will never be completely solved, is the danger of focusing on digital interventions.

I have noted the current technical difficulties of managing parking through datafication, and in certain cases future technologies might indeed serve these purposes better. But I also want to emphasize how the location of bikes within the right-of-way is a different kind of problem than the location of bikes across various neighborhoods of the city, and this difference points to different kind of obstacle to digital solutions. The neighborhood locations are framed as a question of distribution, making sure that a given resource is available to a certain group of people, with that availability measured by a simple geographic proximity. Parking within the right-of-way, on the other hand, deals with conflicts between legs, canes, and wheels. It is a problem of how people relate to one another at a human scale, and how they ought to. Seeing the sidewalk means seeing its dynamic and interpersonal performances of bodies, needs, and behavior—much more than shows up in the data. People see and evaluate these relations everyday, but for digital data they remain mostly illegible. It is not coincidental that the arena in which datafication works well for regulation is the one in which people have disappeared, since people are messy. People have different needs, and they disagree in their evaluations of the various benefits and inconveniences of transportation. Most of the built environment, too, is invisible at the scale of the equity zones. Once we zoom in, we see the differences in spaces for riding and parking bikes that the apps' maps had hidden. The danger of trying to apply the digital logic that works at one scale to problems at another scale is that it asks us not to see the human and environmental relations that comprise the city in the first place.

Conclusion: What datafication is useful for

In the popular aphorism from statistics, "all models are wrong, but some models are useful." I want to avoid simply pointing out where new mobility's digital models are wrong—where they fail to correspond with the reality they set out to see. Rather, I am interested in what wrongness is tolerated, and what is not. This is a way to foreground the *usefulness* of datafication, which is not a technical question about the technical artifact, but a matter of inquiring about the particular user, purpose, and circumstances that define a judgment of utility. If all models are wrong, then of course digitality's vaguer promises of complete certainty cannot be realized. Indeed, the usefulness of the model depends on ignoring much of the underlying complexity it models; "certain forms of knowledge and control require a narrowing of vision" (Scott, 1998, p. 11). The development of tools of knowledge and control is where the concrete choices about what should be seen are revealed and resolved. Examining these practices with OneBusAway, GBFS, and MDS has shown where software and transportation professionals have been willing to narrow their vision, and what it is they want to see.

In these examples, a concern for traveler privacy has been the most prominent force asking agencies to deal with less certainty. In the development of OneBusAway, the goal was to make buses visible to riders, but to keep riders invisible. Its decisions have produced a system that delivers less certain transit information and is less commercially valuable than some comparable apps, but aligns with its commitments to openness to both transit agencies and riders. The tension between making vehicles visible but not travelers became more difficult to maintain in GBFS, since the locations of free-floating bikes can be more easily linked to individuals. Developers wanted a different visibility for regulatory agencies than for the general public. Rather than asking agencies to find a way to work with the incomplete picture of specific bike histories that was available to the public, a separate tool, MDS, stepped up to deliver expanded visibility to a restricted audience. MDS, as an authenticated feed, theoretically avoids concerns about violating individual privacy, and has been a site for agencies to imagine greater and greater certainty through data. In this expansion, the ideal represented by the spec has become far messier, and has become reluctant to identify the limits of what it needs to know. In its focus on the data categories themselves, this expansion also risks becoming detached from the messier practices on the street—hardware, riders, support staff—that are needed to support this visibility through data.

The application of datafication for regulatory purposes is where the gaps between data and the street become apparent. Examining these gaps shows where datafication is not just a matter of seeing more or seeing less, but seeing in a certain way. Regulation is a familiar way for authorities to bound the messiness of mobility and direct it towards certain goals. Micromobility has produced both new messiness and new data tools for controlling it. These data, however, do not see well at the scale of the human body, the scale at which conflicts over sidewalk parking, among others, play out. Instead, data-based regulation works best with quantified and unambiguous policies that do not need to see people. The danger is trying to use data as a tool of control in other circumstances requires a narrowing of vision that sees people as recipients of transportation services rather than participants in the city. Not only will such tools inevitably fail in those situations where actors are free to act outside of digital structures, they teach us that such agency is a problem for the usefulness of the model, rather than a desirable condition of life with technologies. The next chapter will look more closely at the agency of people.

For now, we can see that datafication is both an ideal and practice. Its structures contain within them promises of knowing more and solving problems, ideals spelled out by the many contributors who build these tools. In its practices of aligning the messy phenomena of mobility to these structures, however, we can see the inevitable shortcomings of datafication models—categories that don't allow certain values, kinds of information sharing that don't align with certain actors' commitments, or people who don't behave as they are imagined to. Only by sorting through this transit between datafication's promise and mess can we see what exactly it is useful for. Or, perhaps more importantly, we can see what they are not useful for—seeing or responding to the ambiguity of human relations—and can remember to look elsewhere for the means of dealing with that.

CHAPTER 7

Travelers

Chapters 5 and 6 have focused on new mobility primarily from the points of view of planners, developers, vendors, and other professionals. Now, we turn to the traveler. The promise of new mobility works in parallel here; these information technologies and transportation services still promise certainty and solvability, but at a different scale. This chapter presents research from my interviews and focus groups with Seattle-area travelers about their experiences using apps to get around the city. The focus is on smartphone apps that either provide trip information (Google Maps, OneBusAway) or enable access to a mobility service (Lyft, Lime); I pay less attention to the travel modes themselves and the system data that featured in the previous chapters. From one perspective, this study is an examination of the degree to which the promises of new mobility plans and products coming from city and tech professionals are actually realized in everyday practices. In this light, empirical accounts can answer whether travelers use the apps as envisioned, or why they choose one mode over another. More than this, however, I am interested in beginning with the travelers themselves to ask how their experience of the city, and of themselves as actors within it, is shaped by their engagements with mobility apps. Put differently, I am tracing the relation between promise and mess at the scale of the individual's mobility, rather than that of the city's mobility. Doing so allows me to show how apps engage with desires for certainty and solvability within a subject. This personal dimension of travel is relevant in itself. I argue that apps perpetuate a state of dissatisfaction among travelers as they set expectations for ever more certainty that is never fully satisfied, and simultaneously erode travelers' trust in themselves and their abilities to cope with uncertainty. Further, I show that the solutions the apps promise to travelers are most appealing when they erase the messiness of people and infrastructures in which they must inevitably be implemented, thus reducing travelers' capacities for working through that mess. However, the personal dimension of travel is also relevant as a way to understand analogous processes happening among planners working with new mobility's promises at the city scale, as examined in the previous two chapters.

In chapter 3, I introduced the idea of autonomy as having two components, desire and agency, and the idea that each of these is situated in social and material affordances and constraints. There are familiar stories of technologies expanding our agency, giving us new means to do what we want to do, or alternatively, restricting it, controlling what we do to suit its own agenda. In this chapter, I want to show also how technologies shape our desires. The apps create and intensify desires that they are not always able to fill. Autonomy, like datafication, points at once to both the promise and the mess. Datafication connected the ideal vision represented by ordered data and data structures to the messy practices of their antecedent phenomena and of their subsequent uses. Autonomy's linking of an ideal vision and a messy reality happens in the relation between a desire and the efforts to act on it. Certain desires appear frequently among the travelers in this chapter: desires to avoid mistakes, surprises, and entanglements with other people. In various ways, apps promise to satisfy these. I also show how efforts to enact these visions require engagements with various forms of the messiness: the built environment, personal abilities, and social relations. In drawing out how apps engage with both desires and agencies, the framing of autonomy allows us to see that the trouble with apps comes not just when they fail to give us what we want, but when they lead us to want something that imperils our ability to live well in the messiness of the city.

In this chapter, the apps themselves, rather than plans or data structures, make promises. They promise that a bus will arrive in 6 minutes, or that an Uber will come take you home, or that a detour off the freeway will be two minutes faster. Travelers usually encounter these promises while already sitting in the mess of a trip, and they learn quickly if the app's prediction is accurate. The short temporality of this promise, with its frequent cycling between vision and reality, is an asset to this investigation. Travelers are always anticipating their futures—the next turn or the arrival of the bus—but have little opportunity to dwell in the imagined ideal of the promise. They allow us to see the cycling back and forth of promise and mess, and of desire and agency, in a way that we cannot with the planners, who might wait years for an evaluation of a plan's success in practice. Foregrounding this cycle allows us to see how visions drive action and how experiences shape desires.

The chapter begins with an introduction to travelers' concerns—the desires for certain kinds of travel experiences that they described as motivating their travel decisions. I then devote one section to information-seeking practices and the corresponding desire for certainty and another section to actual mobility and the desire for solvability.

Travel concerns

An initial grounding in traveler concerns will help us to understand the subsequent discussion of travelers' interactions with apps for travel. Without exception, each subject provided some indication not only of *what* they did when using mobility apps or traveling around the city, but of the concerns, values, or drives that explain *why* they did these things. Their reasons are not surprising, but their thoughtfulness about them sometimes was. Very often, interview subjects were quick to describe the nuanced internal states—of anxiety or enjoyment, say—guiding their travels rather than focusing on simple utilitarian motivations. Their motivations for travel practices range from the straightforward and obvious (such as getting somewhere on time) to more personal and complex (such as seeking a sense of safety or managing their stress). In various ways and to varying degrees, these are the desires that new mobility technologies promise to satisfy. This section not only illustrates that such multifaceted drivers exist, it emphasizes that they are experienced and evaluated differently by different travelers.

When analyzing interview data, I settled on the word "concern" to describe a broad range of interview statements that expressed a subject's desire to experience or avoid something. The word did not come from subjects themselves, but I find it useful in its flexibility. A concern can refer to a mild preference or a deeply held value. Subjects expressed concerns for their ability to get to work on time, for their own safety, for their phone's battery life, for their emotional wellbeing, for the labor conditions of Uber drivers, for following social norms, for avoiding walking in the rain, for not becoming dependent on Google Maps, or for the ease of entering destinations in Waze, among many others. Measures of certain quantifiable concerns are usually apparent in app interfaces, but interviews surfaced concerns about more than the mechanics of when to leave, how to get there, and how much it would cost. My summary of concerns begins with simpler measures of time and money, but goes on to show that these are insufficient for explaining why people travel as they do. Some of the more personal concerns that motivate action but are less easily quantified or represented in apps include feelings of anxiety or desires for independence. These are introduced here and will appear throughout the rest of the chapter. Following the framing of autonomy, I want to show that travelers are motivated by some desire within them, and they seek to make choices based on them. Later, we will see how apps influence not just the ability to act according to these concerns, but the development of the concerns themselves.

Time and cost: Trip characteristics

Subjects were fairly consistent in describing time, money, and a general sense of "convenience" or "comfort" as primary factors to consider. These are often balanced against one another. "It's time, price, and comfort, in that order," said Armin.[1] Jennifer says she is "always balancing what is easiest versus what is cheapest." Subjects might decide to take the longer drive across the free bridge instead of the faster drive across the tolled bridge, for example. Time and money can be quantified fairly easily, and feature prominently in app interfaces. They were almost always the starting point for travelers planning a trip.

Time concerns appeared in two distinct but related ways. A concern with the *time duration* drove travelers to seek the fastest trips, minimizing the number of minutes spend moving or waiting. A concern with *schedule time* referred to travelers' ability to leave or arrive a given place at a certain time of day. Both schedule and duration times appear prominently in many mobility app interfaces: Google Maps, for example, describes a trip as "35 minutes" and says you will "arrive by 5:40," depending on the request. While there were stories of leisurely walks or deliberately indirect scenic drives, many subjects presented their preference for minimizing travel time as self-evident. Some mentioned an overall concern for efficiency, and being deliberate in how they spend time during their busy days. Although the seniors sometimes raised concerns with travel schedules, and their ability to

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[1] Traveler names are pseudonyms.

make medical appointments social engagements on time, they rarely raised concerns with travel time per se. “Because I’m retired, I can allow plenty of time to get there,” one said. Regardless of how long it takes to get somewhere, knowing with some certainty *when* you will get there was important for many travelers. This concern for punctuality drives many of the app engagements we will see.

These concerns for time are often balanced against money; in Darcy’s words, “it all comes down to money and time.” When she was younger, she says, “I wouldn’t spend five dollars to save ten minutes. Now I don’t even think about it.” Subjects described awareness of several costs associated with specific trips, including parking and tolls for driving; Uber, Lyft, and taxi fares; transit fares; and rental fees for shared cars, bikes, and scooters. (They did not mention gas expenses or other marginal and largely hidden costs associated with driving.) Price concerns came up most often when evaluating ridehailing options, which was often considered an optional luxury that was occasionally worthwhile to avoid some inconvenience: a particularly slow bus trip, difficulty parking, hauling luggage, or avoiding alcohol on a night out. Interview subjects varied in price sensitivity; summer interns had less money than established professionals, and the residents of income-restricted Council House were more budget-conscious than other seniors. Some described Uber and Lyft as infrequent splurges, while others praised their affordable convenience and used them often. Regardless of willingness to pay, most subjects were aware of travel costs. The variability of many costs, especially for ridehailing and parking, means that learning and evaluating them often requires a new effort for each trip. High current Uber or Lyft fares would lead some travelers to opt for the bus, wait for surge prices to go down, or ask a friend for a ride.

The travel time and cost of a given trip are features that are basically consistent regardless of who is taking the trip; they are characteristics of the trip rather than the traveler. This is also true of the route and the mode itself. Together, these are the features of the trip that are most easily dealt with through an app interface: a time and a cost for a certain vehicle traveling a specific way. The accuracy of this information will of course vary, but an app can state clearly enough how they expect a given trip will go according to these dimensions. The concerns that are more subjective, by contrast, are harder to see in the app.

Travelers' non-representational desires

The more interesting concerns that travelers raised were those that must be understood not just as features of the trip itself, but as a relationship between a specific person and their travel experience. These include concerns related to stress, ease, safety, joy, and independence. While most travelers in most circumstances will want to minimize the time and cost of their trip, other concerns reveal greater differences in what exactly people want and in how they weigh competing desires. This difference is immediately apparent in mode choices—some people are happy to ride a bike while others would never consider it, for example. But interviews also revealed concerns that were more complex than a superficial mode preference. After introducing them here, I will return to these in examples throughout the chapter. Apps are clearly promising to help travelers find faster and cheaper trips, but I argue that it is just as important to recognize the less obvious ways that digitality and mobility promise to satisfy desires for avoiding anxiety, making travel convenient and easy, maintaining a sense of safety, providing pleasure, or promoting independence.

Concerns about stress and anxiety can be found in some way behind nearly any travel behavior. Subjects often describe it as an explicit motivation. Most could readily describe the situations they expected that would cause them stress: running late, missing a bus, waiting a long time for a bus, navigating complicated routes, getting lost, being stranded somewhere without transportation, or spending a lot of effort making travel decisions. Simply not knowing what will happen next on the journey was a source of stress that will appear often in the examples. Stress was discussed most often in relation to issues of time, such as arriving to a destination late or waiting impatiently at a bus stop. Delays are part of the stresses of traffic and parking, but they also cause stress because they are unpleasant in themselves. Others were anxious about depending on a shared bike or a Lyft that might not be available for their return. We will see frequent examples of travelers seeking more information in order to plan a less stressful trip, or to manage the anxiety of uncertainty in the moment.

Closely related to the sense of anxiety, and in many ways its opposite, is the notion of ease. Getting around should be simple, convenient, and hassle-free, travelers said. Easy travel is not about laziness or a lack of ability. Instead, travel for most subjects was simply not an area of life where they wanted to invest a lot of effort or attention. "I like not having to think about it," one said. Many appreciated easy app interfaces. Kyle, for example, noted how much he likes that his navigation app knows where he is and also, based on the time of day, makes a good guess about where he is going. Jason recalled downloading an app for bikeshare and being pleased with how simple it was: "It gave me a three-panel instruction, it was super-quick. I was like, 'got it, got it, got it, OK.'" The same is true of easy travel modes, especially ridehailing, which travelers say makes it "easy to get around." The general "less effort is better than more" rule was also obvious when travelers discussed driving their own cars, which was considered to be easier than the alternatives.

Safety concerns were made explicit only occasionally in interviews, even though people always have at least some background level of concern for their own safety, and transportation is an inherently dangerous activity. Expressed safety concerns related to avoiding two distinct types of hazards: vehicular collisions and dangerous people. In various situations, subjects worried that they lacked the ability to handle the car, bike, scooter, or other mode safely. This includes seniors with worsening eyesight and travelers planning an evening involving alcohol. Some were concerned about the safety of their ridehailing drivers. Cyclists in general showed a heightened awareness of their own safety as a product of road conditions, traffic, and their own abilities. In a separate category, travelers expressed concerns for their personal safety when travel brought them into contact with other people. No one told stories of an actual conflict, but rather discussed feelings of discomfort or fear in certain situations. For some senior women, such situations were riding a Lyft or Uber alone late at night, while others remarked on how ridehailing made them feel safer when out at night, allowing them to be more confident travelers. Travelers mentioned sometimes avoiding bus rides or shared Uber and Lyft trips because they feared the passengers they might be riding with. Some travelers also perceived walking at certain times in certain places, especially unfamiliar ones, to be dangerous.

Interviews included plenty of discussion of utilitarian concerns like punctuality and safety or negative emotions like anxiety. But many travelers were also eager to speak about transportation as pleasurable or enjoyable. Transportation could be playful, as when Jay does bunny hops on shared scooters or when Brian takes the bus because his toddler thinks it's fun. Several spoke of how they enjoyed car travel; "I love driving," more than one said. George talked about riding his moped through the city and making a turn whenever traffic was stopped. Even if his trip would be longer, it was more fun to keep moving. Walking too had an inherent joy for many travelers, often as a time to enjoy exercising in fresh air or being alone. Several walkers and drivers described looking for more scenic routes, even if they might take longer. Wandering without a set route, discovering new places, or learning your way around is also rewarding for some. "I'll go to places because I've never been there before. And I have no idea where I am. And it's more fun! I love to explore," Linda said.

Finally, a few travelers mentioned the pleasures they sought in travel specifically as a product of relations with other people. Several enjoy chatting with Uber and Lyft drivers, and some like meeting strangers on shared rides.

Lastly, a general concern for independence appeared in two different ways. The first relates to dependence on apps for information, and the other deals with dependence on others for transportation. In both cases, there was great variation among subjects in their level of concern for feeling independent or not, and in the situations when they noticed it. Several travelers described a general sense of unease about how much they needed their smartphones, saying they disliked "feeling dependent" or "feeling reliant" on them. "I'm embarrassed I use it as much as I do," said Luke. "I feel like I should be more self-sufficient." Darcy gave an example of trying to drive to her friend's house without using GPS, because "I just feel like I should know." Age explained some difference in attitudes towards technology. "I don't rely on my phone," George, an older professional, said. "If wifi dies, I'll survive. I've lived life as an adult without a smartphone, and that's just not true for a lot of people now." Jason is one of those people. He says that "I've never had to travel a city as an adult without a phone, and so this is the only way I know how to," and this dependence does not bother him. Several others were similarly unconcerned. I asked Chris if his phone was "like a crutch," and he answered that yes, like a crutch, "it's there and it helps, so what's the harm?" Tech dependence was generally more tolerable than social dependence. Among the younger subjects, Armin was unique in his preference for asking strangers for directions rather than using his phone. Seniors were generally more accustomed to asking for help when they needed it. Betty, for example, was adamant that the best way to learn the status of the buses is not by checking an app, but by calling Metro or talking to a bus driver. More generally, seniors' changing abilities made them aware of their needs for assistance from others. The seniors in my study all lived in formal communities, where they were often travelling together and exchanging information with each other. They discussed needing assistance from others to learn how to use certain apps or meet a Lyft, or to get in and out of cars, or to find the right bus stop as a part of life. But they did not necessarily embrace this dependence. Several appreciated the mobility services that allowed them to travel independently. "It's great not to have to be dependent on other people for rides," one remarked. A general trend I found among all of the travelers is a willingness to trade social dependence for tech dependence.

There are other concerns in travel—the labor conditions of ridehailing drivers, contributions to traffic, or environmental impacts, for example—but they appeared in interviews either not at all or inconsistently in comparison with to those introduced here. When examining, in the remainder of the chapter, how travelers seek information on apps, how they make choices about how to travel, and how they *feel* about these behaviors, I will point back to these concerns as the initial desires that various actions are hoped to satisfy. At the same time, apps feed back into those desires, creating, intensifying, or undermining them. By paying attention to travelers' experience and awareness of what it is that they want, we can understand the work of apps' promises in everyday mobility.

Information: The promise of apps that know everything

Travel apps are information tools. Some, like Uber or Lime, are also the means of accessing a form of transportation, but in this section I focus on their functions in delivering information. These are numerous, and expanding. Apps tell travelers the fastest route and the time it will take in current traffic, the delay of the bus, the locations of rides and bikes available nearby, and much more. This section takes app-based travel information as illustrations of new mobility's promise of certainty and examines how travelers relate to this promise. Travelers want certainty. More accurate knowledge about more things can support travelers' decisions for seeking or avoiding costs, conveniences, pleasures, or any of the travel concerns identified above. Most often, though, certainty is seen simply as the means of avoiding the unease that comes with not knowing. Apps, with their extraordinary capabilities for providing a wealth of knowledge on demand, promise to prevent anxiety by satisfying this need for certainty. But travelers' accounts often show them to be unsatisfied. The availability of this certainty creates expanded expectations for what can be known about any given trip, and generates new possibilities for disappointment when those expectations are not met. Meanwhile, travelers have learned from their encounters with app information to trust their own capabilities less, and so lean more heavily on those apps. This section begins with illustrations of travelers' desires for certainty before then examining the relation between personal knowledge and digital information as sources of that certainty. It concludes with examples of the kinds of additional information that travelers say they wish their apps could give them, as they continue to turn to digital technologies to deliver on their promises of certainty. Collectively, travelers' accounts depict a perpetual cycle of wanting and receiving certainty that leaves them both doubting themselves and disappointed with apps.

The desire for certainty

The certainty desired in these examples takes two forms. One is finding the right answer, by whatever metric—typically speed, cost, or some kind of convenience. Only by evaluating all possibilities, with complete consideration of current delays and availability, can the best travel decision be identified. The other is avoiding surprises. Even when there is no real decision to be made, travelers simply want to know in advance what will happen on their trip—when the bus will come, whether there will be a construction detour, and what time exactly they will arrive. The following examples show practices of seeking certainty through apps to support a decision when planning in advance and to tell you what to do right now, with apps and travelers shifting towards the latter. They also show how often information is not meant to guide a decision at all, but just to alleviate a discomfort of not knowing.

Seniors in the study were especially enthusiastic about planning in advance in order to avoid surprises. "I'm planning a trip tomorrow on the bus, and I investigated the prospects about a week ago," one said. "I'm enough of a little old lady now, I do it three days ahead of time, so I can process it," said another. For many of these travelers, an outing is not an event to be taken lightly. When traveling to appointments or social events, they worry about their physical or mental capacity to simply make it up as they go. "The truth is, time is different for us. Time is much different for us," Betty explained, since for her and many of her neighbors, getting somewhere quickly is far less important than factors related to comfort or ability, like avoiding crowds or hills. That requires planning ahead. Several mentioned tools for investigating hills and possible ways around them, for example. Some of the professionals, too, planned in order to try to foresee any obstacles en route. Jing, for example, investigates the parking situation before her trip:

> Maps doesn't tell you where the parking spot is, it will only tell you the location of that spot [the destination]. So I will tend not to rely on it too much, when I need to look for...the parking lot. It might be behind the building, so usually I will check the street view, or the satellite to see where the parking lot is. (Jing)

I asked what would happen if she just drove to the place and looked around for parking, instead of checking the street or satellite view online. She said that maybe in a lot of places, "it's not that hard to find the parking lot," but anywhere close to downtown, she would find it "necessary" to find out in advance. In cases like these, getting information in advance is not just about planning a schedule, but about avoiding unpleasant surprises.

Careful planning was also a way to find the best trip, by whatever criteria, through proper research. Kyle is among the travelers who carefully weigh travel options in advance, considering time, cost, and other factors before deciding how and when to travel somewhere. “Before I go, I’ll plug it into to Google Maps, use the time of arrival options, maybe the day before, I’ll plug it in, look at the routes to see if it makes sense,” he says. This process involves “a risk analysis” taking into account highway merges and difficult turns. For people like Kyle, this process is a joy in itself, a puzzle to be solved. For travelers who regularly get around using several different modes, apps provide the information needed to decide between, say, a bus or a Lyft, or taking a walk or riding a shared bike. Some, like Armin, say they choose “purely on time,” while others evaluate other criteria. For nights out or trips to events, Jennifer says “there are no usual options. It’s a decision every time. It’s kind of annoying.” Indeed, while such planning was satisfying for some, for many, the effort of seeking certainty was not necessarily a pleasant experience. Chris, who is comfortable with the full suite of apps and transportation options at his disposal, also sometimes finds himself wishing that he could not spend time “overanalyzing” so many choices for a ten-minute trip.

Those who preferred to plan in advance sometimes found themselves at odds with the interfaces of Google Maps and other apps, which assume that the traveler is planning a trip right now. Its default recommended routes will be based on existing traffic conditions or transit arrivals. A few participants noted a frustration with this mismatch:

> My problem is that I usually do it several days or weeks in advance, and so they keep wanting to give me directions for the time I’m currently experiencing. I have found finally ways to get to where I want to be on the day I want to go, but it’s not easy. (Heidi)

Depending on the specific situation, changing the time of planned departure or arrival could result in either a different route, a different travel duration, or both. The Google

Maps interface allows a user to specify an arrival time in advance, but this requires some extra steps and know-how. Many of the apps seem to be designed for on-the-fly use, rather than advanced planning. They default to your current location, and the current time. They also ask for the origin and destination of a specific trip, rather than supporting a user's broader exploration-based learning of transportation options. A developer at Google Maps told me in an interview that these defaults simply align with how most people use the app—to tell them how to get to their destination right now. Of course, the app can also be more accurate relaying current conditions than trying to forecast traffic in the future. For current trips, navigation apps estimate travel times to the minute. When planning in advance, however, Jennifer was frustrated with Google Maps' lack of precision: "Google said '1 hour 20 minutes to 1 hour 40 minutes.' Well, which is it?" For travelers seeking certainty, then, it's usually easier to simply wait until closer to the moment of travel.

Research about how to get somewhere, including not just the route but the mode itself, often happens very close to the time of departure. Several travelers agreed with Ian about the ease of using Google Maps to review these options in a single app, comparing price and time:

> You open Google Maps, type in place you want to go. I love that bar at the top, telling you the minutes using different modes. It's an instant dashboard. You can filter options, it's all right there. (Ian)

Others complained about the difficulty of checking prices in the Lyft app, then traffic on Google Maps, then seeing if a bus was nearby on OneBusAway before finally making a decision. "It's just a lot of choices," Chris says. Darcy and Armin both mentioned a habit of checking both Lyft and Uber prices before requesting a ride, which involves some extra effort on the phone. The number of apps travelers often switched through in planning their trips was a recurring complaint. "To see bikes and Lyft and the buses and all in one app would be amazing," one subject said, though he, like others, admitted that he's fairly comfortable switching between several apps on his phone. Many accounts of comparing travel options at the moment of travel involved being in a hurry, and such instances often favored Uber and Lyft. Some travelers would avoid ridehailing to save money when planning in advance, but these became the best or only choice when they found themselves needing to get somewhere quickly. Others mentioned shared bikes as a helpful resource when running late on a trip originally planned to be by foot or by bus. In such scenarios, they would check the app to see if a bike is available nearby, and reserve it if so. In cases like these, the apps' information, including up-to-the-minute availability, time, and pricing for nearby travel options, enables a kind of improvisation; the expectation of certainty on demand obviates the need for advance planning. This flexibility appears later in the chapter as an example of digitality's promise of solvability.

Even if they weren't using the app to decide how they would begin a trip, subjects described consistently checking apps to decide when to leave. "I'll usually check a half hour, 20 minutes before, so I can see if the buses are running on time," Carol says. George says he just asks his smart speaker, connected to OneBusAway, when the bus is coming as he is getting ready in the morning. Travelers know that the predictions might not be right, but some still say they check these apps to "get a sense" of current conditions, or to know that they do not need to be "quite so urgent" in getting out the door. Jing says that when she is studying at the library at the end of the day, she will check traffic for her drive home. If it looks bad, she will stay at the library for another hour or two. "I don't like wasting my time on the road," she says. Sometimes, the time the app gives until the bus or the Uber arrives becomes a hard deadline structuring travelers' schedules. "It's the countdown for [my girlfriend] when we're getting ready," Luke said. "'Honey, I called the Uber, you have four minutes left to get ready.'" Several described booking an Uber or Lyft and then watching the car's movement towards them on the map.

Similarly, many travelers keep an eye on current traffic before and during their trips. This might not change their chosen departure time, but would give them information about their arrival time, which is less in their control. Chris checks traffic while riding in a Lyft to know if he'll be late. Armin says he uses Google Maps or another app for every trip because it provides "a good estimate of the time, when you're going to reach the place. So that is always necessary, whenever you're traveling, right, because you want to know when you're going to be there." Jason agrees that an ETA is necessary:

> I like to know ETAs. I like to know when I will be there, so that when someone asks me 'When will you be there?', I can tell them exactly when I'll be there. I don't know if I'm just really, like, super anal retentive about knowing what time I'm going to be at things, but ... That gives me comfort, knowing that. Knowing that I'll be there to make that workout class, or ... I mean most of the time if I'm going somewhere, it's to be there at a certain time. (Jason)

These cases might not involve the possibility of making a different travel decision, but they simply provide greater certainty about what will happen. Other travelers echoed Jason's point about feeling an obligation to tell someone at their destination when exactly they would arrive. Because the information is available to the traveler, there is a social expectation that others will share this certainty too.

In many cases, however, travelers can make a different decision, and many suggested an expectation that they should always be seeking the information needed to make the best one. Driving a different route to avoid traffic is the most common example. This practice that was long informed by traffic reports on the radio is now fine-tuned to account for minute-scale comparisons of every street. Even on routine drives, travelers said they are not comfortable departing without knowing the best route at the current moment:

> This morning I needed to take my granddaughter to school in Shoreline, which, I know how to get there, but I needed to see where the traffic was. And that's what I use Waze or Google Maps for, more than anything. (Martha)

> The only time I won't check Google Maps before going somewhere is if I've been there a hundred times, but even then I'll check in case there's some traffic issue or a road closure. (Jennifer)

> Sometimes I keep it open in the car, but I'm not using it for directions, I just want to see if it changes mid-route. There might be an accident or it might change the route or something, there might be something faster. (Brandon)

In at least one case, this practice of checking current conditions before leaving applied to walking too:

> Even when going someplace familiar, I use it. I don't want to walk past the place, or end up going the wrong way, or maybe there's a parade or a marathon or something. (Chris)

In this kind of behavior is a shift from something that might be explained as a process of making an informed decision to something that is simply seeking info to avoid the anxiety of not knowing what is going to happen. In some conversations, travelers made this observation explicitly. Real-time transit arrival apps are sometimes imagined to allow people to choose to stop to get a coffee without worrying about missing the bus, or to choose to walk to a different bus stop where another route will come sooner. In practice, people simply check it while standing at the bus stop when they have no ability to take any different action if the bus comes sooner or later. When Judy described this behavior, I asked her what she did when the app told her when the bus was coming. She laughed and said, "I stand there, for the number of minutes, and I know *exactly* how many minutes it's going to be." With some sarcasm, she added "It's really great," and later explained that she "can't imagine not knowing. Even though it's completely ridiculous, I realize." Jason, who said above that ETAs are very important to him, has a similar account:

> I rely on my phone a lot, so when I'm planning my trip to get to the bus stop, when I'm on my way there, when I'm at the bus stop, waiting, and checking, and

> refreshing to see how long that delay time is, I'm always checking to see: Is it coming? When is it coming? I just like to be in the know. And if I'm closing my app, then I'm like looking up the street to see if it's coming still. [Even though the bus will not come any faster,] it makes me feel like I know that it'll be here eventually, and, if I can count the minutes, that I know when it'll be here, it gives me reassurance that, I don't know, I know I'll get to my destination on time, or like I'll get there when I'm expecting I'll get there. ... It's just the expectation. (Jason)

Here, the specific arrival time is important, but just as important is that the arrival time aligns with expectations. Travelers want to know what to expect, and not be surprised.

Alex runs with his smartphone and uses an app to track his route. Would he ever run without his phone? "No. I could, but I'd feel very, like, unguided I guess." Is "unguided" how he would feel without using Google Maps or OneBusAway on his commute, a route he is very familiar with?

> I could do it without those things, but it would be very unnatural, and probably kind of stressful. So, when I'm taking the bus in the morning, even though I know where my bus stop is and everything, I just check OneBusAway as just peace of mild almost. Just, because I don't get there at the same time every morning, so I'm just constantly checking, 'oh it'll be here in three minutes,' or 'it'll be here in one minute.' (Alex)

Reflecting on this later in the conversation, he said "I think it makes it worse, to be honest, because I want it to come faster, but it isn't coming faster, so I'm just frustrated." But he still checks, and other travelers too said that it was traveling without current information, not getting unwanted news, that made them uncomfortable.

Knowing your current location, the blue dot on the map, was especially comforting, and several travelers sought out this real-time guidance rather than rely on their own geographic awareness. During a drive to a hike on which she had shut her phone off, Helen said it was "unnerving" to not know her location, even though she had written out directions to the trailhead. "It was hard because I'm used to the blue dot," she said, "telling me where I am, where the exit is, when I need to go." Jennifer too said that she prefers to keep her navigation app on. "It's like my little co-pilot," she said. "Even if I'm driving 30 miles on I-90, I like that it says I still have 10 miles to go. It's often just confirming what I already know."

This desire for confirmation comes with a sense that a traveler's own knowledge is not to be trusted, an issue I will return to shortly. For example, Li, who said that she generally considers herself to have a good sense of direction, described the process of coming to our interview, which was at a coffee shop she already knew about a mile from her home in a neighborhood she often visits. She said she had a "rough idea" of where she was going, but wanted to check to make sure she was thinking of the right place. She searched the directions, just two turns, and estimated travel time before leaving. "It confirmed what I thought," she said. While stopped at a red light on the drive, she checked Google Maps again "to make sure I was going the right way." Of course, travelers described how navigation apps also serve their purpose of directing them to their destination in the many situations when they don't already know how to get there, but checking constantly when you do know seems to reveal something different, a need for reassurance and an intolerance for making a misstep.

Seniors were more likely to want to internalize routes rather than rely on an app, but for many of the professionals, the sense was that if the best answer is always at hand, why bother learning it yourself? Accordingly, some checked their apps constantly, not for reassurance about what they already know, but because they've learned only the current step of the journey. Jing, for example, uses a notification on an app to tell her when to pull the cord on the bus. Jennifer will follow walking directions "exactly" through her own neighborhood, a grid with many possible equivalent routes. And Armin knows that when walking, he needs to check the map again after every intersection. Some travelers have a harder time with directions than others, and they welcome tools that make it easier for them to get around.

The many examples of this section have shown different kinds of searches for certainty. Travel information sometimes identifies the best travel choice, either in advance or in the moment, and it sometimes tells travelers what they can expect on their trip. Both the app interfaces and travelers' expectations for greater accuracy push travelers to use the apps continually while travelling, rather than just for planning in advance. These behaviors are driven by a desire within the travelers that is then reinforced by the apps themselves. They suggest two situations that travelers want to avoid: making a mistake, and being surprised. The following section examines travelers' shifting balance between trusting themselves and trusting apps to avoid these situations.

Trusting apps, trusting yourself

Travelers turn to their apps when they seek certainty, but this digital information is always mediated by the travelers themselves. With or without apps, travelers use their perceptions of the environmental and their own knowledge to inform what they expect and what they do. Environmental cues include orientation using street signs and landmarks, looking down the street to see if their bus was coming, or crossing the street to avoid a construction site. Travelers also drew from their own experiences, as, for example, cyclists knew the hills they wanted to avoid, drivers knew which lane to travel in, and commuters recognized the habits of specific bus drivers. The ways that they interpret these sources of information, especially when they conflict, is a matter of trust. Some travelers often distrust their apps, and all of them continue to interpret their information through the lenses of their own experience. A different story that emerges here, however, is that the apps teach travelers not to trust themselves. When travelers try to learn, their efforts are frustrated by the availability of apps that seem to always have a better answer. Moreover, individual knowledge cannot satisfy the new expectations for identifying the best option with real-time accuracy. The result, then, is travelers' reduced trust in themselves or in their capabilities to learn, even when they might not fully trust the apps.

All of the subjects knew that app information could never be perfectly accurate, but some were more skeptical than others. Travel times should not be trusted to the minute, since, as Brandon said, "you can hit two red lights instead of one and that makes all the difference." Some participants considered the messiness of data sources to conclude that predicted travel times would be less reliable during rush hour, or that not every construction detour could not be known in advance. Some would trust the general frequency of bus arrivals indicated by the app, but not the specific times. Several are in the habit of adding a sizable buffer to whatever times the app offers. About bus arrival times, Alice said "You can't take it too seriously. Usually I'll just go and wait rather than stress about making the exact timing." Betty was among several seniors who expressed some bewilderment at anyone who takes these times at face value. "It's laughable," she said. "These young kids are [she mimes checking a phone], 'OK, it'll be here in three minutes.' Ha! Sure it will, son!"

Travelers lose confidence in apps when the information they provide is inconsistent. One told how, when driving with her husband, she follows directions from Google Maps, but her husband in the passenger seat is giving different directions according to Apple Maps. Another described trying to catch a bus when one app said the bus had already left, but the other said it would arrive in two minutes. "I didn't know what to trust," he said. Lisa was frustrated with OneBusAway, complaining that "sometimes it'll say, like, one minute away and then it sort of changes its mind and now it's suddenly six or seven minutes away, and so ... I'm never really ready to trust it, because it changes its mind." By contrast, her neighbor, Chuck, said that he would interpret these changing times as a result of new location data and updating estimates, and would see the more recent time as more accurate. He said he notes whether the given arrival time is an estimate based on real-time bus location data, or simply the scheduled time. Travelers like these who interpreted information and its sources carefully had less expectation of total accuracy.

Most travelers, however, did not give much consideration to where the data came from, only whether it was right or not. Many had a lack of trust rooted in past experiences of their apps' errors: mistaken routes, incorrect arrival times, or bikes that appear on the app but not on the street. Seniors complained of following walking directions that unnecessarily sent them up and down a hill, and have learned to study routes more carefully in advance. Just about everyone had some story of a mistake. "Probably 90 to 95 percent of the time it'll be right, but I've been burned too many times to totally believe them," Alex says. He attributed his skepticism to growing up in the era of Mapquest directions that were often inaccurate. Younger travelers, however, were on the whole more trusting, even when they had accumulated their own stories of app errors.

The more confident travelers were those who interpreted app information in the context of their own knowledge and environmental awareness to arrive at a decision that felt like their own. Considerations of safety, for example, clearly call for some active personal perception and interpretation beyond checking an app interface. Alex might begin a walk suggested by Google Maps, but then "if, as I'm walking, I'm like, 'oh, this looks a little bad to walk through,'" then he might abandon his walk and call a Lyft. Cyclists, similarly, had their own sense of roads they would or would not feel safe riding on, and would carefully compare this to the app's recommended route before setting off. More broadly, some travelers simply prefer to consider themselves to be the primary seat of knowledge and decision-making, with apps as one input into that decision. "I have my own mental optimization, but these are tools that help," Li says. Brian says he checks the GPS's recommended route "to see if it passes the smell test... but I like to feel like I'm in control," not "blindly following" its directions. This means that travelers sometimes disregard apps' information and recommendations. Chuck said that his bus directions "wanted to push the 512 or some other routes, but I knew I wanted the 70 to make the connection, which was definitely better." Several second-guess driving routes. "Sometimes, because I am familiar with the area, I'll be like, 'this is dumb I think I can probably get there faster this way'," Jay says. He says he will also exit the freeway to take backroads at a spot on his commute where he can see traffic ahead, even if his navigation app has not alerted him to the slowdown. At a minimum, travelers know that when an app that says a bus is delayed but they can see the bus just a block away, they should trust their own eyes.

At least as often, however, travelers described simply following exactly what the app directs them to do, with little apparent interest in inserting their own judgment. This is especially true when getting turn-by-turn directions on an unfamiliar route:

> In a new place, I would one hundred percent adhere to whatever route they're giving me. (Jay)
>
> Just tell me where to go, turn here, turn here. (George)
>
> [Turn on] Google and tell me where I'm supposed to go now. (Betty)
>
> You just follow the steps, one by one, and it tells you what to do ... Turn right, turn left, whatever. (Doris)

For some, following the exact directions is preferable even in their own neighborhoods. "I don't trust myself to know," as one traveler said of such situations. Even when trying to follow app instructions directly, though, travelers have their own knowledge, and can become distressed when it does not align with the app's information. Alice was using Google Maps while driving to a doctor appointment in heavy traffic. She knew that she was driving in the opposite direction of her destination, but did not know why. "I didn't feel like this is what I'm supposed to be doing," she said, but suspected that maybe the app was taking her to a different freeway entrance, or avoiding an accident. Eventually, she realized she would miss her appointment, gave up, and went home. “I just felt really in the dark,” she said. Looking back, though, she still felt that “it might have been the right way. I mean, usually it makes sense.”

Similarly, Jing describes learning how to get from the bus to her office in the first week of her internship. In general, she doesn’t trust her own sense of direction, and prefers to have the app just tell her where to go.

> I walked straight, I mean I feel like, ‘How come I’m not going to the right direction?’ But that’s the stop I get off, so, I turn on the walking mode [of Google Maps]. Then still, it won’t show me the construction area, and so I have to take the detour. Eventually I get there. Then, the second day, I still get off at the same stop, because I think, ‘Oh, maybe something’s wrong.’ ... And I walk a different route, but still, that’s not the stop that I’m supposed to get off, or not the best one. ... I feel like I’m walking based on the map, but somehow I’m not getting to the right direction, so I don’t know what’s going on, like, with my brain! ... I think I study a little bit on the map to see what stop is the best one, so it turned out if I take two more stops, it will get me closer to my building. (Jing)

Even though she wants to defer to Google, not outsmart it, Jing’s trip is complicated by her own observations of the environment (“how come I’m not going to the right direction?”), local conditions Google has not accounted for (the construction detour), her questioning of this route (“maybe something’s wrong”), and her eventual investigation (“I study a little bit”). In the end, this leads her to take a different route.

Not surprisingly, apps are sometimes wrong, and their use is always mediated through a human’s situated interpretation of their information. What these examples also show, however, is the fluid work of navigating the boundary between self and app. This fluidity emerges in part because apps in recent years are providing more information and more accurate information than before, and this new information is not always aligned with what travelers think they know about the city. Travelers know that the information is not perfect, but they cannot yet determine the precise boundaries of its imperfections. Different people allocate their trust differently, but that balance for most of the subjects in this study was shifting. Sometimes this is seen in their efforts to learn more, and sometimes in their questioning of their own knowledge.

The phone dependence illustrated here occasionally provoked some unease—the concern for tech dependence introduced above—and, in part for this reason, several travelers described deliberate efforts to learn. Learning is a way to internalize knowledge that is otherwise available only externally, usually through an app. Seniors, especially, felt like studying the route before a trip and paying attention along the way were important for developing their own self-reliance. A few were proud not to use GPS navigation in the car. Among both seniors and professionals were travelers who described deliberately traveling without turn-by-turn directions, or meandering without destination and getting themselves lost, in order to learn their way around. These were the same travelers who studied maps, on paper or on screens, to familiarize themselves with a place in general, even if not for a specific trip. Their results were mixed—both in the effectiveness of their routes and in their success refraining from checking the GPS—but the desire to learn was there.

Some comments, again mostly from the seniors, pointed to the difficulty of using the apps to do this kind of learning. Between the small screens and their focus on a specific trip, the apps are not well designed to teach their users, they said:

> Part of the problems with using these little phones is it doesn't give a big enough view, and I think people who are new here need to look at a map that is large enough to show them more than just the little area that they're going to. … And that is the downfall of [these phones], you don't get a very big picture. (Jeanie)

> We moved here from Pennsylvania, and really needed orientation, and we went to the ...convention center, and [got paper maps]. We have so many maps, but it really is helpful to see the big picture. ... I use Google Maps all the time, but it takes you—it's just that area. (Chuck)

These, however, are the people who don't want to simply turn to their phone for the answer regarding a specific trip as needed. Both interest in and aptitude for such learning varied. Some were proud of how quickly they could learn: "If I've been someplace once, I can find it again and again," said Mary. Others wanted to, but knew that the process for them would be slower. Armin said he took "two or three months" to learn his bus route to campus:

> After a semester, when you get used to the bus routes, you don't worry about where you need to get down. You have a visual sense of the area. But initially, for the first couple months, I had to use that "go" button [on the Transit app], to know, OK, this is where I get down now. (Armin)

Alex's first few months going to a grocery store in a new neighborhood provide a similar use effort to learn while using an app:

> I'll kind of start walking in the direction that I know it is ... I would just walk until I realized that I wasn't sure if I should have turned already, or if I needed to soon. So I'll open Google Maps to see where I am, versus where the thing is, and just use that to triangulate. (Alex)

Even though he knows he likely will not find his way entirely on his own, Alex still begins his trip without Google, and he wants to learn the entire route. But both he and Armin have their phones ready when needed, since these are travelers who would rather not risk a mistake or get lost. The app is the crutch that perhaps helps them to take a few more steps on their own, but whose constant availability means that they perceive no real need for independence.

One way that the apps fail to help people learn is that they so often provide such good answers. Travelers try to do something themselves, then find that their phone, which is always nearby, can do it better. Helen, for example, is a confident cyclist with a good sense of routes through the city. She described getting cycling directions on Google Maps, which sent her on a route she initially questioned, but begrudgingly realized was actually better than what she would have chosen on her own. She described her discomfort with this realization:

> I have this identity as a self-actualized urban explorer, and by now I should have a city map in my head that's better than that. … My mental map failed me. … It just highlighted how much it's [her mental map] externalized, and how I now rely on Google Maps for validation. (Helen)

As travelers rely on apps for validation—those cases above when the phone check confirms what they already know—and as they accumulate experiences of the app correcting what they think they know, they trust themselves less.

This loss of self-reliance is especially visible regarding information that no traveler could know themselves. Environmental cues and past experience can only take you so far in determining what current traffic is like or where your bus is, but your phone knows. As travelers expect to know not just the best way to get there generally, but the best way to get there *right now* given real-time conditions, they also find that their own knowledge is insufficient. Dockless bikeshare offers a clear case of a new requirement for real-time info. Some travelers prefer to simply look for a nearby bike when they need it without opening an app, an approach that works well enough in dock-based systems with set station locations riders can learn. With a free-floating system, this works in locations with a high enough bike density that one would likely be visible, but becomes more difficult in places with fewer bikes, where a prospective rider would need to know, from the app, which side street to walk down. Without checking the app, it is also difficult to tell from any distance whether a bike is already reserved, or is out of service for repairs. Jason learned that his preference for the spontaneity of seeing a bike on his walk and hopping on doesn't work. He says he used to

> just walk until I find one...I didn't know that ones that don't show up on the app are likely out of service ... I realized they weren't showing up on the phone. So it took maybe three times and I'm like, 'oh, you can't just pick a bike that's on the ground

> anywhere.' They have to be charged and ready to go. … I wish I could predict where they were going to be, you know, without looking at my phone. (Jason)

He now defaults to checking the app, rather than learning by looking around.

As the expectations for certainty have increased, the sense of disappointment when they are not satisfied has increased as well. In some cases, this has eroded travelers' trust in apps, whose information they are always interpreting through their own perceptions and experiences. But they are also learning not to trust themselves. The apps do not teach them how to navigate the city in the way that might increase confidence in their own abilities. Instead, they provide specific directions for a one-off trip, from this A to this B at this moment. The real-time information they offer teaches travelers, first, that such information is necessary, and second, that they can't possibly know what they need to on their own. Even when travelers do want to learn, to rely on themselves more and their phones less, they find themselves returning to the phones to avoid making a mistake. What emerges from this gap between the certainty travelers expect and the flawed and partial information they get is a desire for more certainty not from themselves, but from their apps, as the following section shows.

"A gap technology can fill"

As travelers begin to rely more on their phones to provide the certainty that they have come to expect, they also consistently wished they had more information than what apps could currently provide. The apps had already offered them so much information that it didn't seem unreasonable to expect them to give more. Seeking information in apps that was not currently available could produce an anxiety of uncertainty in the specific moment of travel. In the broader picture, though, it perpetuates a vision in which such uncertainty can be eradicated, and digital technologies are the means of doing so.

Jay regularly rides skateboard as a means of transportation in the neighborhood, and Luke and his girlfriend recently got kayaks. Each said that they would love to have an app specific to their chosen mode. They gave existing websites for hiking trails, which provide several filters for criteria like distance and elevation to help users identify a hike that suits their wishes, as examples of the type of data and interface they like. “It’d be nice to have road quality, different kinds of slope—degrees of slope, not just elevation” for his skateboard app, Jay said, while Luke wants a go-to source of information about boat launch points and their rules. “I feel like this is a gap technology can fill,” he said.

Others said they appreciate the wealth of information provided by navigation apps like Google Maps, but can also think of more kinds of information that they would like. As mentioned above, Jing wants to know more about parking at her destination—how close is it, and how much does it cost? Walkers like Jennifer want to know more about which streets are more pleasant and interesting to walk on when traveling, and Darcy is concerned about “safe routes” for walking, especially at night. Several walkers pointed out that just basic information on sidewalk conditions and crosswalk locations are missing from Google Maps. Several drivers mentioned a preference for scenic routes, especially on longer trips. While some had developed their own ways to identify these, such as looking for natural features identified on maps, they complained that these apps have no straightforward way to prioritize the visual experience of the drive. Seniors, some of whom were careful students of all available information in Google Maps, had additional suggestions for beneficial data. Many wanted more attention drawn to hills and their steepness in walking directions, information that can be found in some interfaces, but was not obvious to many of these travelers. In each of the three focus groups, residents shared tips on publicly accessible elevators and escalators in downtown buildings that allow pedestrians to bypass steep streets. Such tips were generally learned from direct experience or from other people, but these residents wanted these routes to be shared in a more accessible format.

The seniors were also often eager for more real-time information. Since many of these travelers are careful planners, they found themselves frustrated when conditions on the ground like event traffic or construction detours required a sometimes painful improvisation. Jim talked about using Google Street View to investigate sidewalk conditions before traveling to a new restaurant, and expressed his frustration upon realizing that the images were not necessarily recent. Many expressed a wish for real-time street view images that could let them know about current construction conditions that would affect their route. Encountering a block-long sidewalk detour that might be a mere inconvenience for a more able-bodied walker could be much more disruptive to some of these senior travelers. As Betty puts it, “we may have to go out even on a bad day. So you’ve gotta know, it would be wonderful to know, in real time, what’s the street view? What’s really going on here?” Her neighbor, Susan, was particularly frustrated by construction that blocks sidewalks, often with little warning, necessitating backtracks or detours. “It’s changing weekly,” she said. “That is one of the things that Google Maps doesn’t provide, you get to a place and there’s construction.” At the time of our conversation, the Alaskan Way Viaduct, a major landmark on the Seattle waterfront, was in its months-long process of demolition, and its slow removal was disorienting to some travelers as they tried to navigate to the ferry. “It’s just interesting that every single traffic accident is reported instantly, for cars,” one remarked, but there is no equivalent current information for pedestrians.

The professionals, too, wanted real-time information beyond the wealth of info that they already had. Some said that they liked the ability to see that a bus was four minutes away, but they really wanted to track its current movement on a map, as they could with

Uber and Lyft. Armin said he liked that he could see where his Lyft was on the map as it arrived, but wanted the icon's movement to more clearly indicate its direction and location within the roadway. Drivers checking the traffic sometimes found themselves wondering if Google could tell them whether or not the traffic would clear by the time they got there. They wanted to know before they left if there would be a good parking spot available at their destination when they arrived.

Some of these kinds of information were already available in some form during these interviews, and some have been developed and improved in the years since. Most of them are not difficult to imagine being developed in new tools that will provide greater certainty about ever more details of travel. The point to emphasize from these accounts, however, is not about what the technologies can or cannot do, but about what these travelers expect them to do, and how they feel when there is a gap between the certainty that is expected and what is experienced. There is an unease when travelers imagine what they could know, but do not. Sometimes, a quick check of an app can relieve this anxiety—looking up the next bus, or seeing how far the traffic goes. Travelers do this often, and have enjoyed many new opportunities for certainty. When such information is not available, however, travelers imagine a new technology that will provide it. Doing so both highlights their dissatisfaction with their present uncertainty and assures them that this problem can be solved digitally.

Mobility: The promise of apps that can get you anywhere

The previous section showed a reliance on app information rather than either trusting information from other sources or simply dealing with uncertainty. This section builds on these observations to examine how information—the currency of apps—translates to actual movement in urban space. As with information, mobility is not purely digital, but is socially and spatially situated. Much of the appeal to travelers of app solutions, however, is their promise that the messy differences among environmental affordances and bodily abilities can be managed and their challenges mitigated through a standard screen interface. This promise is more convincing to some travelers in some circumstances than others, and no one imagined that the street really was as simple as the screen. But in one way or another, all of the travelers used apps to simplify messy mobility problems. Across the board, they said that ready access to travel information through their phones gave them more confidence in getting around the city. Travelers did not necessarily expect *city mobility* to be reliable, but they did expect that their *phones* would be reliably available to help them deal with this instability. A bus arriving 9 minutes late would be less upsetting than an app saying that the bus will come in 3 minutes when it then takes 12. The certainty that apps offer is the basis for achieving their mobility goals—usually getting somewhere while satisfying various travel concerns—in an environment that is uncertain. The section begins with some examples of travelers' expectations of turning to their phones to help them deal with any transportation issue that arises before then spending more time examining the frictions between app solutions and actual mobility. The invisibility of these frictions—social, bodily, and infrastructural—in the apps encourages among many travelers a view of trouble-free, individualized travel that is divorced from its social and spatial situation, leaving travelers unprepared to manage this mess on their own.

The "escape hatch" app

Travelers see their phones as the key to getting around the city, a ready solution to any mobility problem that might confront them. In examples of travelers seeking certainty, we saw that while some plan well in advance, most look for information in the moment of travel. Few expect to nail down everything, but rather to take an improvisatory approach to travel, enabled by these tools, that is ready to deal with the unplanned and unexpected. “With an Orca card in my pocket and Lyft on my phone, I don’t need a plan,” George said. “There are always two or three options for getting where I’m going next.” Jake’s view is similar. “With your phone, you’re never stranded,” he said. “You can always get out of a situation. Even if you lost your wallet, if you have your phone, you’re fine. You can get a plan B and jump on it.” He later said that a phone acts as a “security blanket.” Helen, similarly, says that with her phone, she is “more willing to take geographic risks,” since she has confidence that her phone will be able to get her home. Although travelers know they will still need some vehicle or their own feet, the phone itself is almost imagined as means of transport. Ian illustrates this when comparing it to a car. Growing up in a place where driving was the only option, he got used to the sense of predictability and control it offered, and so avoided the bus after moving to Seattle because he expected it wouldn’t provide these. For him, the smartphone changed this. With it, he discovered he could “plan it with more certainty, or wing it with more certainty,” offering at least some of the control a car would. “It’s OK if the bus doesn’t show up, because here are five other routes nearby, or I can call a Lyft, or whatever,” he said.

Central to this sense of app-enabled mobility is the ready availability of ridehailing; Ian called it an “escape hatch.” Particularly among the professionals, ridehailing was the bail-out option when other choices weren’t going to work. They described calling a Lyft when running late, or if they overslept. George was leaving a crowded event and watched two full buses pass without taking passengers, and so called a Lyft instead. In the neighborhoods where these subjects traveled, drivers were usually available nearby, and the convenience of door-to-door travel was hard to beat. The always-available options Lyft and Uber, especially, made travelers less enthusiastic about less flexible transportation options—clearly transit, but sometimes also driving your own car, if parking would be difficult. Some travelers were more sensitive to the price, but others found it affordable. Some said they liked Uber for international travel since the app interface enables communication across language barriers. “If they have Uber, it’s amazing,” Luke said of traveling internationally for work. “You don’t have to talk to the driver, you don’t have to figure out how to get around. They just show up.” Darcy made a similar observation comparing two trips to Mexico City, one before and one after Uber came to the city. She doesn’t speak Spanish, and was intimidated to learn local taxi customs. With Uber, however, she liked that she could get around just by entering a destination in the app.

Smartphone access means that travelers don’t need to know directions, since the phone can tell them, and they don’t need to think about the vehicle that will get them home, since their phone will get them to a bus, a bike, or a ride. They expect that their phones would always be there to help them out of a jam. Traffic delays, missing buses, cancelled Ubers, and broken bikes were all expected hazards of travel. The digital travel resources, however—the smartphone batteries, cellular data services, data servers, app logins and the like—were expected to be ready at their fingertips. This dependence becomes visible when the phone is not available. Armin’s cell service is unreliable near his office, and will plan his route ahead more carefully. George says he finds himself “frustrated” in the brief moment when his phone is not available when walking away from his office building. His phone is slowly losing its connection to a weakening wifi signal but has not yet switched to cellular, and this reduction in service often occurs just at the moment when he is trying to use his phone to find his lunch spot. He said he finds himself surprised by his own impatience. Ian told a story of his phone crashing just as he was leaving for a meeting with a client, and he was left scrambling to manage his travel and coordinating the rendezvous with his client without it. While he said he loves having these tools, he also remarked that “my new paradigm is fragile.”

Seniors, and some of the older professionals, expressed some surprise at this increasingly common expectation that a phone is a necessary piece of travel equipment. One was out without a phone of any kind when his original travel plans were derailed, and so he simply borrowed a phone to call for a ride. Some seniors used travel apps more than others, but all of them described a willingness to look beyond their screens to find travel solutions. Several showed a clear frustration that so many others seemed to think that their phones had all of the answers. This was clear in their accounts of riding with Uber and Lyft drivers who they perceived to be overreliant on GPS navigation:

> "Normally, when I get into one of these cars, and they put the satellite on, I tell them, 'No no, I know a better way.' So I steer them my way and then ignore the [app]...See, I've lived in Seattle 90 years." (Steve)

> "I let him go on for a block or two, and then I said, 'you know you're going in completely the wrong direction.' ... I have had an Uber driver with some heat say to me, 'Would you like to just give me directions, or shall we just go ahead and use the map?'" (Judy)

> "[The GPS] kept saying turn right...And I said to the driver, 'Don't listen to that.' And he finally said, 'I'm listening to you from now on.'" (Linda)

After Mary was picked up at a restaurant on Madison Street (a major thoroughfare), her driver turned in a direction that made no sense to her.

> I said, 'Why don't you just go back down Madison Street?' He said, 'Where's that?' … He just continued, he said, 'I'm following the map,' and his little Google Map had him going all the way around, where all he had to do was turn around and go back down Madison into the city, and he did not know what street he was on. (Mary)

The younger subjects, by contrast, might occasionally tell a driver to go a different way, but for the most part, they rarely had stories of attempting to intervene in the driving. Instead, they revealed a contentment in disengaging with the trip entirely once they had entered the vehicle. Relieved of the need to pay attention, they could use this time in the back seat to do something else. In cases like those, their effort for their mobility is focused on the screen, rather than on managing movement through the streets.

Translation from screen to street

Although travelers often have an implicit assumption that the solution on the smartphone will be transferred to a mobility solution, their experiences show the ways in which this translation is complicated. Movement through the city is, of course, embedded in social relations, built environments, and the bodies of individual travelers. For the solutions envisioned by mobility apps to work requires all of those. By showing how mobility apps' digital solutions constantly return travelers to the mess of embodied, social, and built enablers of mobility, the following examples show the unsurprising necessity of digitality's connections to the city. More than this, however, the illustrations reveal the omission of such connections in so many of the answers that apps promise, and travelers hope for. This invisibility corresponds with a diminished tolerance among some travelers for dealing with such messiness. Others, especially seniors, were rooted more firmly in the mess, and so did not imagine such an escape.

These examples draw heavily from the ridehailing. More than other modes, ridehailing has created an impression through its apps of easy mobility focused on satisfying your individual need right away. Their interfaces highlight your current location, show the route to your destination, and promise to send one of a number of nearby waiting drivers to take you from door to door. The ease of calculating a route and coordinating between driver and passenger suggests that actually getting somewhere will be just as easy. The riders, drivers, vehicles, roads, and curbs in which this mobility is realized are much less predictable than these scripted and controlled interfaces, and there are frictions in translating the answer from the screen to the street. Travelers remember the app's promise of door-to-door, on-demand convenience, however, and are left working through the gap.

The ridehailing pickup is perhaps the best site for illustrating this friction. The app shows the rider an arriving car's location on the map, with various information about the car and driver, but at some point that rider must find their way into the back seat. Most of the time, pickups go smoothly, travelers said, but just about everyone had a story of a difficult pickup. "It's fairly often it will say your ride is here, and you can't see them," one said. Residents of Mirabella and Horizon House, each a large facility covering most or all of a city block, were frequently frustrated with cars that were said to have arrived, but were in fact at a minor side entrance instead of the front door. Sometimes, travelers are careful to move the pin on the map in the app interface to more closely indicate the door they will be at. Drivers do not always stop at travelers' requested point, however. While carrying several shopping bags downtown, Jing has set her pickup location manually but then could not find her driver. "The app shows he's there, but I didn't see him," she said. Through a phone call, she realized that he had been unable to stop at the curb by the requested point, and so was across the street. Jing carried her heavy bags across the street to meet him. Several other incidents involved some driver communication about location outside of the app's interface. In some cases, traffic prevented a driver from stopping at a certain point. In others, the environment was confusing, with multiple streets, driveways, and parking areas serving a single location, making it difficult for riders and drivers to find each other. At many sites there is ambiguity about where a car can or should stop for passenger loading. In part to facilitate this exchange and in part to reduce traffic impacts, officials have created designated pickup locations in certain congested locations, such as the airport and South Lake Union, and the apps ask travelers to walk to these areas. Such limited examples show an ordering of the city to match the order in the apps.

Pickup difficulties occasionally lead to cancelled rides when drivers complain that riders did not arrive quickly enough. Seniors especially described difficulty meeting their rides. One experience highlights the assumptions that ridehailing services often make about riders' bodily abilities:

> I had a terrible experience with Lyft, the only time I've used them. I had a cataract surgery, and, I should have known better, but anyway I walked out of the eye institute down there at Harborview, and it was blinding. And I had called a Lyft, and I thought, 'Well this is great!' But then they come, and, there's all this traffic stopped there. ... It's stop and go, and I didn't know what to look for. I didn't know, there's no sign on a Lyft car, and so I missed the first one, and I called for a second one, you know. And finally I saw this person stopped over there, with all this traffic, and I went over there and asked him, I said, 'Are you a Lyft driver?' It was very frustrating. ... I just didn't know how to handle the app, number one, and I couldn't see, number two, I didn't know what to look for, you know, when he did show up with a car. (Barb)

Such confusions translating between screen and street were present in other apps too. Some seniors in particular found interfaces to be a site of confusion and friction. One said that she grew frustrated trying to identify the correct bus stop on the map using OneBusAway:

> I'll press different ones, and it, maybe it'll say 'southwest,' 'northwest,' and I'm just really wanting to go... Sometimes I can see the street, you know I can press one of them, but I really, really have trouble with that. (Eleanor)

While the seniors who were frustrated with interfaces often gave themselves the responsibility for better learning the tool, the young professionals were more likely to blame poor design when they encountered obstacles.

Beyond these pickups, the differential capabilities of travelers' bodies was often a reason that a trip that works on the screen might not work on the street. Seniors described awareness not only of their abilities, but of the changes in their abilities, both in day-to-day variations and the gradual diminishment of abilities. As Betty said, "some of us have good days and then we have bad days." Various seniors mentioned arthritis flares, recovering from knee surgery, recovering from eye surgery, and days of exhaustion or low energy as occasions when they might not be able to travel as normal. Others observed longer-term changes. Senior drivers ranged a great deal in age and ability, but most indicated an awareness that their days of driving were numbered. These communities were designed to allow residents to age in place, and so the study participants, who tended to be more independent than their neighbors, could see their possible futures every day in the dining hall. When discussing some of the travel assistance services available at Mirabella, Mary said "I still have enough acuity to sort out things for myself. There's gonna be a time when I might want that, but right now I'm on my own."

Seniors responded to their awareness of what their bodies can and cannot do by, first, paying more attention to planning trips, and second, by relying more on others for help. In the trip planning activity, discussed above, apps are a way to investigate sidewalk conditions, hills, and transfer times in advance so that they can avoid putting themselves in a situation beyond their abilities. At the same time, seniors also knew that they need help beyond what the apps can provide. Uber still provides a solution in this context; one senior called it "a lifesaver" after she gave up her car. But for the most part they did not see apps and their services the "security blanket" or "escape hatch" that some professionals did. Several complained that, for example, ridehailing drivers were not very accommodating of seniors' needs. Carol was miffed that she needed to ask for help with her luggage:

> When I'm standing there with a suitcase that looks tiny to them and is gargantuan to me on a bad day, and he opened up the trunk and said 'OK,' and, [I said] 'Could you put this in please?'… I mean this seems like it should be a real basic part of understanding old people are different. (Carol)

Betty said that she often needs to ask drivers to be patient while adjusting her seatbelt, or maneuvering out the door on a steep hill. "One of the things I've always hated is having to state my needs," she said. "I just need a little bit of time." Experiences with drivers varied, and certainly Uber and Lyft might become more accommodating, especially considering that both companies have focused on seniors as an important market. All three senior focus groups discussed one third-party service, GoGoGrandparent, that serves as a bridge between seniors and Uber or Lyft. It uses phone-based operators to allow travelers to bypass the app interface, and it works with drivers to meet seniors' needs for, say, higher vehicles to facilitate entry, or enough trunk space for a wheelchair. This kind of gap-filler highlights the ways that people whose bodies present obstacles to their mobility can help reveal the assumptions of abilities that are invisible in apps.

The limits of the body appeared among other travelers in other situations too, though perhaps less obviously. Alex tended us use Lyft when he was "too tired" to walk or take the bus. Armin, like many others, said that a Lyft is "infinitely more comfortable than a bus" during rush hour when he would likely need to stand. Kyle gets carsick in buses even when seated. Walkers and cyclists know their tolerances for distances and hills, which might or might not correspond to the routes their apps send them on. And those limits can change with the weather. As one subject asked, "who wants to sit in the bus stop for 15 minutes in the rain?"

In a different way, travelers' differential tolerances and preferences—physical but also mental—showed up when they were following driving directions. Like the ridehailing pickup, this is a situation in which what works on the screen must be translated to the street through the traveler's specific behaviors, but people sometimes find this plan difficult to execute. Jake told a story of a drive through in an unfamiliar city. There were many turns, some of which he missed because he was not paying attention, or not in the correct lane. "I'm sure it knows where to go, but can you follow instructions properly?" Several drivers said they disliked convoluted routes that required them to make frequent turns or difficult maneuvers in traffic. Some were frustrated at the delay between making a turn and hearing the instructions for the next turn, which left them feeling anxious that they wouldn't be able to make the move in time. When planning, such drivers described sometimes optimizing for "un-stressful" trips and avoiding routes that "makes the drive less enjoyable." Jing described why she avoids following her app's instructions to detour around freeway traffic on surface streets:

> The route downtown's pretty complicated, and … people drive crazy! [She shakes her arms and tenses her face with remembered anxiety.] So I don't feel comfortable doing it, so, even though it might take a couple minutes longer, I still stick with the route I usually go. (Jing)

This was a common decision. Martha didn't take the fastest option shown on Google Maps "because it was so cumbersome, it was awful. … I thought it was more of a pain to take than two minutes was worth." Luke also might avoid a faster route if it's unfamiliar, qualifying his decision by saying "I know it's counterintuitive." Besides being a personally situated interpretation of app information, as discussed earlier in the chapter, these examples also indicate both a belief among drivers that they are expected to follow the optimal directions and a resistance to this expectation.

Outside of a car, travelers having trouble following directions often have the option of asking someone for help. Occasionally, this was passive and indirect, as when Susan describes finding her way from the UW Link station to campus by simply following the crowd. She says she checked various apps and websites for directions, but "there's no instructions for how to get over to the university from the light rail. You've just gotta follow somebody." Some travelers more than others said that they were comfortable learning from strangers rather than their apps. When Doris was taking a Lyft in a different city, the app told her to walk a few blocks for the pickup, but she was not quite sure where she was or which way she was supposed to go. She asked a friendly stranger for help. Betty was the strongest advocate for talking to people rather than messing around with a smartphone. In our focus group conversation, she often told her neighbors that when they were lost, all they needed to do is ask someone:

> We're not afraid to ask questions if we're really desperate, and we need to be really desperate. … I talk to anybody or everybody, and see if they know anything. ... I've gotten in the habit of depending on bus drivers. I also talk to people at the bus stops, "Are you going to be taking the number 11?" They'll have really, real recent information, because they may have been there yesterday. ... We're all in the same boat, we're depending on that bus, and so they know the situation. (Betty)

Most travelers, however, described talking to strangers as inconvenience to be avoided when possible. When they were comfortable with app interfaces, there was usually no need. Some would try to manage themselves using directions on an app, but would resort to approaching a stranger when this failed. Armin was an outlier among professionals for deliberately seeking people out. In the first few weeks of his summer internship at Amazon, he was often lost getting from the bus to his office building in South Lake Union. The internet was unreliable on his phone, and so he would just look for someone on the street with an Amazon badge and ask them for directions. He needed help, but he says he also just genuinely enjoys talking to people. Originally from Delhi, he described trying to learn the social norms around such interactions in Seattle. Should he ask someone, or just use his phone?

> In an ideal world, if I had both the options, and I had super friendly people around me, then I would have talked to people every time, for sure. Because like, I think if I'm getting the right directions from people, it will take the same amount of time, so I would have liked to have spoken to people for sure. But that's an ideal world. But here, I mean, as I said, you don't know the boundaries, it kind of feels weird to, like, ask people. ... Because like, nobody does that, right? My brother's been here [in the U.S.] for like five years now, in San Jose, and he never asks for directions. Even if he is like totally lost, that is probably the last resort for him, to ask people. ... I think it's the general culture over here, to not talk to a lot of people. ... In Delhi it wasn't the case, like you could just talk to somebody. I mean it was never about, not just about routes and stuff, you can talk about anything. (Armin)

In Seattle, Armin says that he will sometimes find people in South Lake Union—often other Indians, or at least other Amazon employees, identified by their lanyards—and ask them for directions, but for the most part, he has adopted the apparent local custom of ignoring strangers and using the phone.

Mixed preferences for avoiding other people also appeared in shared rides, the Uber and Lyft options for sharing a car with unknown travelers going in the same direction, for a reduced fare. One senior, Judy, said that she thought it might be "interesting" to share an Uber and talk to "the drunk kids who were in there." The more common response, however, was that of people like Alex, who were interested in saving money on a shared ride, but preferred to be alone. He tries to guess whether others will join the ride (since Uber and Lyft can book "shared" rides that end up with no other passengers, effectively becoming a discounted solo ride) and whether, based on the route and time of day, any other passengers might be drunk or unruly. Besides sharing a small space with someone who might be too talkative, threatening, or otherwise unpleasant, the other disadvantage of shared rides was the additional time spent picking up and dropping off passengers. One traveler knew to avoid them when in a hurry, and another complained that "I have no idea how long it's going to be" and that it on occasion it felt slower than a bus. For most, coordinating with other people's schedules and negotiating an interaction with them was not worth the benefits.

Shared rides have been an example of Uber's and Lyft's promises to transportation officials that they can reduce traffic,[2] but they do not work when travelers chose not to use them. Similarly, one ridehailing variation asks passengers to walk a few blocks to a main street to be picked up, rather than waiting at their door. This is envisioned to improve the efficiency of the system, but for travelers this extra effort was a frustration. "You might as

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[2] Uber and Lyft shut down their shared services in March, 2020, in response to the Covid-19 pandemic, but each relaunched the offering more than a year later.

well catch a bus!" one said. Travelers have come to expect a personalized convenience. This is the selling point of Uber and Lyft, but it's also the century-old promise of personal freedom through personal automobiles. Apps do not draw attention to broader social impacts of mobility choices, and few travelers raised such issues. A few complained that their ridehailing drivers were blocking travel lanes, and therefore inconveniencing other people, while picking them up or dropping them off, and sometimes asked their drivers not to do this. Two travelers said they were concerned about routing algorithms sending cars through neighborhood streets, which they worried might disturb residents or cause extra wear on roads not engineered for such traffic. There was occasional awareness and perhaps mild discomfort with ridehailing's contribution to traffic. There were no accounts, however, of travelers saying they changed their behaviors because of a concern about their individual contributions to broader social problems.

Whatever the apps can offer travelers, getting somewhere always requires something else in addition. What exactly this "something else" is will vary with the traveler and their situation. It might be that there has to be a suitable place on the street for the Lyft to stop, your eyes have to be good enough to read the license plate, your knees have to be strong enough to take you there, or you'll have to talk to the driver. Travelers spend plenty of time on the street, and they can recount many experiences of its messiness. There is always some gap between what the apps say should happen and what actually does, but this is more surprising and more frustrating for some travelers than for others. Some find ways to avoid some small part of this messiness by, say, setting the Uber pickup pin more carefully on the map instead of calling the driver, opting for the solo Lyft ride instead of carpooling, or checking Google Maps instead of asking a stranger. The appealing solutions here are those focused on the individual, blurring out the surrounding threat to straightforward mobility. In other cases, like seniors reckoning with their own bodies not moving as quickly or as easily as others assume, apps are of little use in escaping the messiness of mobility. Imagining that apps are a solution that can translate from screen to street—which they very often do—requires either not seeing the rest of the mess, or being prepared to deal with it yourself.

Conclusion: An intensified desire for digitality

The stakes in this chapter might appear low. Why does it really matter if people use smartphones to help them get around the city, or if those phones sometimes aren't as helpful as expected? To return to Chris's comment about the apps being a crutch, "it's there and it helps, so what's the harm?" In many cases, there is no obvious harm. There are clearly also benefits. I did not ask the question directly, but I expect that every last participant in the study would say that, on balance, their use of travel apps makes their lives better. They felt more confident that they could get wherever they wanted, and they felt like they had control over how they did it. Most of time, any app or service that for whatever reason they didn't like was one they could simply choose not to use. The tools are flexible enough that specific practices—the time and frequency of bus checks, or the interpretation of driving directions—could vary nearly as much as the travelers themselves. Despite the many examples in this chapter of annoyances, disappointments, and confusion, these travelers were on the whole adjusting their uses of the tools to fit their needs. Even when things went wrong, no one suggested that travel apps were anywhere near the top of the list of things they worried about in their lives.

Yet even in this seemingly mundane state of affairs, these accounts did give reasons to worry about how apps are changing urban mobility. Specifically, travelers' responses to the frequent cycle of promise and mess that they experience in their app-mediated mobility paints a picture of digitality pulling subjects away from challenging engagements with other people, built environments, and their own embodied knowledge and capabilities and towards the allure of an easier digital domain. This retreat, and the intensification of the desire for it, is problematic for the individual traveler, but also for a much broader range of questions about how we live with digitality in other circumstances.

Mobility apps make promises to travelers, promises of certainty and solvability. They promise that the bus will come in 4 minutes, or more generally that trips can be optimized with informed decisions and that surprises can be avoided. They promise that a Lyft is always nearby to take you to your door, and that problems of personal mobility through a messy urban environment can be solved as easily as a data can be manipulated on a screen. These promises respond to concerns for easy, stress-free travel that already exist within the travelers, but they also intensify those desires. Travelers found themselves frustrated with imprecise information about bus arrivals when just a few years before, they did not expect any such information at all. Travelers who had spent most of their adult lives without traveling by taxi or rental bike expected an Uber or a Jump bike to be available nearby for flexible travel at the moment they needed it. When the apps did what the travelers wanted them to do, they were satisfied. But in creating these desires for more, those apps also risk producing new kinds of unhappiness when those desires are not satisfied. The apps of course cannot always deliver the information or the mobility they promise, and a perpetual disappointment takes root in this stubborn gap between what you expect and what you get. The real trouble with the apps, however, is when they can only respond to this gap with further promises, instead of teaching us to live well with the mess. Apps sometimes do deliver more—better predictions, more convenient pickups—but a different approach is found in those travelers who manage their own expectations for these tools with a developed sense of skepticism. The apps' promises, and their amplification of certain desires, are dangerous when they continue to tell travelers that they do not need to act under uncertainty or trust their own knowledge when getting around, or that there will always be an easy and personalized solution on call.

As apps provide information, they also contribute to an expectation that certainty and its comforts are available in your hand at any time. Knowing this, travelers seek information more often, and seek more information, and begin wishing that apps could tell them if there will be a seat on the bus or a parking spot on the next block. Subjects reported that traveling without information at hand could feel risky and uncomfortable. With so much information available, the travelers sometimes begin to doubt their own knowledge, or at least to doubt its usefulness. There is no need to memorize bus routes or street names when the app can give the best answer in the moment. Having eroded the trust in themselves, however, travelers were even more lost when their apps delivered incorrect or confusing information. In short, travelers both expected to know more and needed to know less. They expected to know more because the apps had so successfully eliminated surprises in the past, and so travelers sought tools and practices that could further eliminate anxieties of uncertainty. They needed to know less themselves because their own knowledge might not be as trustworthy in providing it.

This certainty further created an expectation that the ready availability of real-time information and communication would be able to solve any mobility challenge that arose. Travelers knew that getting around is full of complexity and unpredictability, and they had enough experience of this to not expect a smooth and simple journey. But the image on the screen nevertheless depicts such an ordered and controllable city, and this casts a new light on travelers' experiences of the actual mess. When apps don't give travelers the tools for dealing with messy streets—for finding the Uber that says it's here on the map, for following tortuous driving directions, for making sense of a confusing app interface—then they begin to experience ordinary urban mobility as an imperfect version of what their apps promised them. Whether this is surprising or frustrating depends on the traveler and the situation. Seniors with mobility limitations, for example, were more ready to expect getting around to be messy. But in any case, the apps left travelers on their own to deal with the translation of information into mobility. This integration is inevitable, but the problem is when apps teach travelers to aspire to overlook this mess and depend on digital solutions.

This research has focused on individual travelers, and their experiences are relevant in themselves. It is worth understanding how these tools help or hinder travelers' efforts to get around, and how they make people feel good or bad. The study does not answer whether mobility apps can or do improve urban mobility according to the metrics of city transportation officials—congestion, equitable access, emissions, safety. But, despite its personal focus, it does have implications for the broader questions about what digitality does in the city. Seen in the context of the previous two chapters, for example, the experiences of individual travelers have analogues in the experiences of city DOTs. In both, we can see an anxiety that drives a search for the right answer, or an appeal of digital solutions that order urban messiness. Studying these observable personal stories then is a way to generate observations about how we respond to digitality's promise that might equally apply to other tools, other users, and other situations.

CHAPTER 8

Conclusion

Research engagements

This project has claimed that seeing the digital's work in promising is a way to foreground the politics of technologies without overdetermining the agency of people. It further argues that digitality's promises of certainty and solvability are dangerous when they get in the way of our learning to live well in the mess. I supported this argument with an empirical study of emerging technologies for mobility, using three interwoven research threads: an evaluation of new mobility's visions for using information technologies to achieve mobility goals, a study of planners' practices of datafication for visibility and regulation, and an account of travelers' personal experiences using apps to get around the city. I will conclude by first returning to my research questions and answers, then highlighting the digital visions this research has revealed. Having spent so much of this project mounting a sustained critique of digitality's promises and their dangers, I devote the majority of this chapter to offering what I consider a more positive vision: the utility of the promise for foregrounding politics, and the theories and practices of living well with the mess. It is with those attitudes, I argue, that planning should engage with digital technologies.

Autonomy and apps

RQ3. How are travelers' desires and agency coproduced with mobility apps?

The chapter presenting my traveler study appeared last, but I begin with it here because its personal focus gives us the best view into the affective and desiring experience of digitality that I argue is essential to understanding the function of digitality in other domains.

The desire for certainty was evident in various ways among all travelers. They wanted to be sure that any given trip decision was the correct one, and they wanted to avoid encountering any surprises along the way. Apps gave them new ways to achieve that certainty. Besides satisfying that desire, however, the apps also generated and intensified the desire in the first place. Transportation planners are familiar with the phenomenon of induced demand, which describes how expanding capacity on a roadway to relieve congestion will make driving easier for a time, but then, precisely because travel is easier, more drivers will want to use the road, eventually adding enough new cars to return it to the same state of congestion as before the expansion. Apps demonstrate a version of induced demand for certainty. As they offer more, travelers ask them to do more, and the gap between what information is expected and what is received is rarely closed. Further, many subjects showed that their capacities for negotiating this gap—either by acting in conditions of uncertainty or by seeking information from non-digital sources—had diminished. Experiences varied, but many travelers had learned to distrust their own capabilities, leaving them more reliant on apps and more frustrated when they fell short of expectations.

The second frame of the traveler study looked at how app information translated into movement, and observed that travelers often see their phones as an "escape hatch" or "security blanket" that was always available to make sense of the current mobility options and get them wherever they needed to go. As with travel information, these travel services frequently worked as promised, and most subjects felt more confident and capable getting around the city. But they also remind travelers that app-based mobility always requires activity outside of the screen, and so inevitably turns travelers to the extra-digital resources of the built environment, other people, and their own embodied abilities. An Uber pickup, for example, requires an appropriate curb location for safely entering the vehicle, an ability to see and walk to the car, and some kind of social encounter with a driver. This dependence of the screen-Uber on the street-Uber is obvious in principle, but travelers' ordinary experiences of this messiness are a counterpoint to the tidy solutions promised by the app. Most travelers had a story of some frustration when their trip experiences were not as straightforward as promised, and most also recognized this as inevitable. More broadly, these scenes of translation from screen to street are a caution against the temptations of solvability promised at the scale of transportation professionals, who too often see the decontextualized digital tool itself as the most important intervention.

On that note, the traveler study is an illustration of the posthuman subject, a figure whose desires and agency do not *encounter* a separate technological object, but are produced together with them (Braidotti, 2013; D. J. Haraway, 1991; K. Hayles, 1999; G. Rose, 2017). The case also functions as an examination of personal autonomy, linking the subject's vision of what she wants to do with the socially and materially situated capacity to do it (C. Mackenzie, 2014b; Nedelsky, 1989; Oshana, 2006), which I have argued is a localized version of the promise and mess bifocal. I emphasize these framings in order to show what is missing from planners' and tech companies' accounts of new mobility: an understanding that its technologies transform the city only by acting with and through a desiring, agentive person situated in some specific mess. Changing urban mobility requires changes in behaviors, relations, environments, and artifacts. Digitality is part of this, but not all of it.

Illustrating this messiness at the personal scale of the travelers and trips helps us to understand what digitality is doing at the larger scale of planners and cities.

Digital structures of publics

> RQ2. How do digital mobility technologies envision ordering relations within a heterogeneous urban public?

My research assumes that understanding what digitality does in the city requires seeing the personal and the digital together. While the traveler study used a personal lens for understanding new mobility, my investigation of datafication focused on digital artifacts. I examined development processes and products related to OneBusAway, the General Bikeshare Feed Specification, and the Mobility Data Specification, as well as data's applications in municipal bikeshare regulation, to ask both what these systems envision and what they do. I agued that datafication, essential to these systems, is a process that points to both visions and situated practices at once. Seeing the systems as both platforms and infrastructures (Plantin et al., 2018; Star & Ruhleder, 1996) allows me to focus especially on their structuring of social relations.

In the work of developing tools for visibility—seeing buses, bikes, travelers, and their movements, in various ways—I found echoes of travelers' concerns for certainty. As planners gain tools for seeing more and more of mobility, they seek even greater certainty, and have less confidence in how to act without it. The expansion of MDS shows that there always seem to be more categories to define and data to collect. But studying this development also revealed how the general drive towards greater certainty must be translated into specific choices written into code, and doing so requires resolving tensions latent in the promise. In particular, the promise of visibility collides with a desire for invisibility, forcing questions about which people and which activities should be visible to whom. OneBusAway sees bus travelers as people to deliver an information service to, operating as an infrastructure, while for-profit apps are interested in the visibility of travelers themselves, operating as platforms. When GBFS faced the question of whether it saw bike riders as recipients or providers of information, it was forced to articulate its ideal of digital certainty more clearly. Through these lenses, at least, digitality sees little of travelers' participation in the messiness of urban mobility, but sees them instead as nodes in information networks, entering into often hidden exchanges with digital systems.

Examining data's role in the regulation of micromobility helps to reveal what is missing in this view. Cities have a number of policy goals regarding the availability and use of shared bikes and scooters, mostly reflecting the infrastructural ideal that these mobility resources should serve all members of the public equally. In some cases, such rules can be quantified, then monitored and enforced digitally. This is the case with the distributional goals of equity zone requirements, which simply require the counting of bikes in different neighborhoods. In contrast, datafication works poorly for policies that require attention to varied built environments and relations among people at the scale of the human body, such as those related to bike parking on sidewalks. Since datafication is a tool for counting, its use in regulation favors goals, such as equitable distribution, that can be readily quantified, but is less compatible with a more ambiguous and open-ended view of the public as participants with agency. New mobility providers, influenced by the platform paradigm of Silicon Valley, respond to this limitation of datafication by focusing on the uses of data to capture travelers' activities within their systems—collecting fares and trip data—rather than by attempting to direct that behavior towards certain ends. Planners, on the other hand, are interested in ends-oriented visions of systems serving the public interest. Data exchanges can only do so much to actually achieve those ends. Their quantified and abstracted vision and their blindness to ambiguity of relations and situations on the ground are important to keep in mind when considering planners' visions of using new data tools for active management of urban mobility beyond current uses in bike and scooter share.

The promise and the mess

> RQ1. What is the relationship between the promise of digitality and the messiness of urban mobility?

The first research question is the broadest, serving as a guide for the project as a whole, but it drove my examination of new mobility visions among professionals in particular. By studying agency plans, vendor pitches, and industry discourse, I sought to understand how emerging technologies make promises that speak to transportation professionals. I showed how they leave planners' longstanding visions largely unchanged: the provision of accessible, safe, sustainable, and equitable mobility using transit, carpools, walking, and biking rather than single-occupancy cars. New information technologies, especially ubiquitous smartphones, location services, and the applications built around them, are promised to be the means by which this vision can be achieved. I traced out the specific ways in which these digital objects have become attached to that mobility vision, including coordinating travel modes for travelers using Mobility as a Service apps, expanding the reach of transit using ridehailing and micromobility, and offering new data tools for city monitoring and control. One key observation in this study was that, despite some novel mechanisms, new mobility's visions are not fundamentally new, and this resonance with preexisting desires is what gives these promises their power (Ahmed, 2010; Ames, 2019). The newness of the technology allows planners to envision that, this time, their goals can be achieved, and ideally without more struggles building infrastructure and engaging with politics that have challenged their efforts in the past.

I was careful, however, not to overstate the sway of these utopian visions among transportation professionals, whose recognition of themselves as still mired in the messes of funding, politics, and geography was evident in my material. Still, the anticipatory thinking of the promise revealed desires to transcend these present messes by embracing new mobility's simpler ideals, and I found this vision to be at odds with the kinds of mobility interventions that require a more grounded approach. For one thing, the focus on information technologies diverts energy and attention away from the concrete infrastructures and transportation services that will always be the heart of urban mobility, promising that deficiencies in these can be mitigated by developments in digitality. Similarly, the near-total absence of any mention of land use in the new mobility visions indicates a hope that the need for slow, complicated changes with political opposition can be obviated by a quicker, less controversial fix. New mobility sidesteps material concerns, but also politics. The danger here is that digitality is embraced not just as a fix for the problem of movement from A to B, but as fixes for individual behaviors and conflicting values that get in the way of a particular transportation vision. As planners cannot forget, urban mobility is a mess of materiality and agency, but they risk missing opportunities to make progress towards their own visions when they overstate the degree to which digitality can transcend this.

The desires for certainty and for solvability, the themes that I argue are central to understanding the promise of digitality, are clear in the new mobility plans and visions I studied. My argument is not that either of these are bad, or that planners should not pursue them, but I do want to show what we miss when we only anticipate their arrival and do not learn what to do in their absence. My research is not a transportation study, and so I do not offer evidence in support of better transportation interventions. The transportation experts within my study, however, were consistent in their view that creating urban mobility systems that provide access to everyone without destroying the planet will require substantial changes in current patterns of travel infrastructures and behaviors. New mobility becomes dangerous when it convinces us that new digital tools are sufficient change.

Study limits and openings

I undertook this research within a constructivist framework, through which I am interested how these particular subjects understand their experiences and generate meaning. I did not design a study that would produce a generalized finding about how travelers or planners engage with digital interventions, and so I cannot claim with confidence that the patterns I found here are likely to appear elsewhere. Even so, the similarities found across the two divergent samples of senior and young professional travelers and the theoretical saturation I reached in talking to them suggest that studying different groups of travelers might reveal similar patterns. The material from transportation professionals, too, spanned enough sources to be considered reasonably representative of a certain population of big-city, progressive transportation planners. However, my sampling and data collection were driven by an inductive inquiry, and so I do not make any strong claim of generalizability.

More than external validity, my research is concerned with theory generation. To that end, further research could study how well its theories apply to other sites. The major themes that emerged form this work are that digitality promises certainty and solvability in ways that speak to preexisting personal desires, and that situated engagements with these promises divert attention away from messier ways of interacting with the city's agency and materiality. I positioned new mobility as a case of the digitization of urbanism, but surely these themes will appear differently at other intersections of the digital and the city, such as everyday experiences of online shopping or local business review sites, platform-mediated participation in local politics, real estate platforms, software for policing and security, digital systems for environmental monitoring, and so on. Staying within the domain of urban mobility, an obvious next step for my research would be to study the personal experiences of transportation professionals more closely to understand their engagements with certainty and solvability. My research's direct engagement with these subjects was limited, relying instead mostly on published materials. Interviewing these planners as I did the travelers would test my claim that their experiences of digitality are analogous. Additionally, studying a range of other kinds of travelers and travel circumstances would help reveal what is or is not particular to my case.

What digitality sees

Throughout this research, I have viewed new mobility through two lenses, the project's theoretical bifocal. The lens of the promise imagines something someone wants in the future and attaches it to a present object, and, in abstracting a vision away from so many of its complications, it helps us to see the desires that are the engine of action here and now. The lens of the mess shows the agency of people and things that contravenes these visions, and this helps us both to find actual technological effects outside of totalizing narratives and to recognize the origins of promises in situated experiences. I positioned this bifocal as a response to different kinds of deficiencies in narratives of technologies and the city. One, represented by both critical takes on smart cities and much of the industry literature on new mobility in my study, is a tendency to see technologies as forces bringing about some change, for better or worse, without devoting sufficient attention to the many other agents of change in the city, particularly those at the scales most apparent to personal experience. This risks overstating technologies' power and understating the degree to which technological artifacts and social practices alike are products of desires and activities that are more personal. Technologies become too dominant a target, while the people who make and use them are let off the hook. A different problem is represented by descriptivist work that produces accounts of how digital artifacts have actually become integrated into a particular social practice. This reminds us that the work of technologies is always contextualized and contingent, and that individual components cannot be separated from their networks, but it doesn't tell us, in the bigger picture, whether this activity is good or bad. More to the point, it gives us nothing to aspire to, as its technologies are no longer objects to which we can attach desires, but become instead just another thing.

This project has made two observations of the promise and the mess: they sit together in practice, and they are productive together as analytical tools. We saw them work together in practices of creating and using mobility data, and in travelers' experiences of switching between screen and street. I draw from other theoretical frames that work through similar pairings of the envisioned and the actual, including infrastructure studies and personal autonomy, and I follow prior work connecting the utopian and the ethnographic (Holston, 1998) and "pull[ing] together the normativity of the imagination with the materiality of networks" (Jasanoff, 2015, p. 19).

My research identified where the mess becomes the basis for new promises, and where promises are imperfectly realized in the mess. Through this bifocal, I identified what I characterized as dangers of new mobility's visions and tools. The danger, in short, is that we will focus too narrowly on the digital. Such a focus is problematic when the digital is seen as a neutral, mathematical answer, leaving no way to sort through visions and values. This focus is also misguided in that it leaves us unprepared to deal with digitality's shortcomings. When technologies fail to provide the expected answer or to solve a specific problem, we need responses other than looking to another technological intervention. These include recognizing non-digital sources of knowledge, acting with uncertainty, and turning to other kinds of interventions. (I will sketch out some such alternatives below.) Like a craving for sugar, a desire for certainty or solvability is not wrong in itself, but sometimes getting too much of what you want now prevents you from satisfying some deeper desire later. My studies of both travelers and planners revealed how the digital realization of certainty and solvability is never complete, and that subjects must situate digital resources in broader contexts of built environments and personal abilities. When they don't, they often find themselves disappointed and unequipped for working through the mess.

When we focus too narrowly on the digital, we risk seeing people as digitality does: as abstract and individualized. This view is often apparent in app interfaces, as the following scene from a *New Yorker* blog post illustrates:

> Think of the experience of waiting for an Uber driver, in which you follow a single vehicle making turns on an empty Google Map. Everything is evacuated from the picture except for streets: there is nothing standing between you and the vehicle but time and empty space. For a consumer, the image is ethereal. But the streets are actually full of buildings, people, and other cars. Getting around in a city requires taking up space, which by nature is subject to scarcity. Every new passenger diminishes the experience for the existing pool of customers. ... The app's interface—that empty map—declares its priorities: the individual, the vehicle, and a place to be. It erases public space and public lives. (Saval, 2019)[1]

This is the abstract and individualized liberal subject that so much of the theory in this dissertation has taken aim at. In the interface is not just an ideal of transcending the ordinary mess of human life, but of doing so for the purposes of satisfying the desires of a single user. This ideal is not particular to Uber or to apps. The digital is by nature a representation that simplifies through the stripping away of context. The key observation of my research is not that digitality abstracts, but that this abstraction is appealing. Pulling a problem out of its actual circumstances can make it appear more solvable. An Uber

[1] This post was brought to my attention by a transit agency official at the 2019 SUMC conference, who referenced its image in arguing that ride-hailing is not the solution to the challenges of urban mobility.

interface that showed your driver stuck behind a hundred other cars might be more accurate, but would not be more pleasing. So many of the actual achievements of new mobility technologies have been focused on *individualizing* mobility: ridehailing instead of buses, riding a shared bike to your own door instead of to a neighborhood dock. These are imitations of that greatest achievement of individualized mobility, the private automobile. Planners, too, have new access to disaggregate data on individuals rather than the aggregated samples that were once all that were available. App interfaces abstract you from your context then passes this image back to you—your origin, your destination, your departure time, your driver, your payment information, all on your phone. The relations you are situated in have not gone away, but seeing them here takes more effort. Those relations are messy, and make the world seem less knowable and controllable.

I have thoroughly examined these dangers, so let me turn in these final pages to a more positive analysis. How could we do better? What might it look like to handle the dangers of digitality's promises with care, and to reach beyond digital technologies when inhabiting and envisioning the city? Continuing with my theoretical bifocal, I will sketch out first how to repoliticize the promise and then how we might live well with the mess.

Repoliticizing the promise

I have shown with the case of new mobility how digitality promises an escape from politics, but when introducing the general idea of the promise in chapter 2, I argued that it also offers a way to engage with politics, to give us a handle on the values and desires that can slip away when we deal only with the mess. My argument is not that we must eschew promises or regard them only with suspicion. Instead, we can put the promise to productive use as a tool for wrestling with collective visions and values. I introduced this possibility with Vincent Mosco (2004) and his use of mythology to understand technological visions. "We cannot solve life's fundamental divisions, but myths tell us that we can talk about them in ways that are manageable" (p. 28), he writes, and this can either "foreclose politics" or can "open the door to a restoration of politics, to a deepening of political understanding" (p. 16). My study has in itself been largely an effort to repoliticize the promise of new mobility, to use it to reveal rather than obscure. I want to show that this is what the promise can do for us. It can be a way to talk about what it is that we want, and to recognize the contradictions of the city. Doing so, however, is not easy. It requires an active engagement with the promise, resisting the temptation of its passive assurances.

Consider the example of last-mile microtransit. The vision is of app-enabled personalized rides through the suburbs to transit centers. We can study where this does or does not work in practice, but a more critical attention can reveal this vision as a political statement in itself. When we look closely, the microtransit promise tells us something about relative values of single-occupancy vehicle use, investments in new or existing infrastructure, the working conditions of laborers, the time and comfort of commuters, and the preservation of existing land use patterns. Even before we get to the mess of its implementation, this promise shows us a low tolerance for inconveniencing travelers and a near total lack of appetite for a transformation of the built environment status quo that serves existing property owners. This is not to say that such a vision is right or wrong, only that it is political.

Discussions of new mobility among transportation officials are often a way to reinforce hidden values, but more critical attention can reveal some of its inherent tensions. Among the most difficult of these is the tension between the individual and the collective. What I have described as "the promise" of new mobility is really a suite of different promises directed at different audiences, and they are not always compatible. I described promises as being animated in some cases by planners' mobility visions—safety, access, equity, sustainability—and, elsewhere, by travelers' concerns for managing travel costs and times as well as for a simple, hassle-free, even enjoyable trip. These desires can conflict. While Lyft promises planners that its software can pool rider demand into shared rides that reduce congestion, it promises riders that its app will deliver door-to-door convenience without delay. Bikeshare providers tell cities that their bikes will be available across the city, but travelers want to ride only on certain routes and neighborhoods. Planners envision more people taking buses, which are efficient users of space and energy, but travelers don't like waiting, walking, and transferring. Digital tools present their own sets of tensions, especially between the promises of using data to see broader patterns and of protecting individual privacy.

Visions of collective and individual benefits need not be always in direct conflict to recognize that the realization of one does not necessarily imply the realization of the other. Yet without encountering actual messes, digital ideals can sustain a belief that both are at once equally possible. It becomes too easy to imagine that planners won't need to face any opposition and that travelers won't need to endure any inconvenience. Engaging critically with such promises, especially when grounding them in actual practice, can become a way to wrestle with that fundamental political question of how to balance individual and collective goals. My research does not offer answers to such questions, but it does show how the promise and the mess can give planners, software developers, and travelers a way to ask them.

Repoliticizing the promise is easiest when situating it in the mess. The phrasing of my claim that "digitality promises" deliberately positions a promise not as an idea but an action, something that must be done. As an action, it takes place in concrete contexts that can be observed. This move echoes Lucy Suchman (2007), who argues that a plan (in her rather prosaic case it is a plan for using a photocopier) is not a *theory* of action, but is itself a *part* of the action. Her idea of a plan here works as a rough substitute for my notion of the promise, but note also the resonance with the plans of urban planning when she says that

> to treat a plan—or any other form of prescriptive representation—as a specification for a course of action shuts down precisely the space of inquiry that begs for investigation; that is, the relations between an ordering device and the contingent labors through which it is produced and made reflexively accountable to ongoing activity. Naturalizing plans as representations (mental or otherwise) existing prior to and determining of action obscures the status of planning as itself a form of culturally and historically situated activity, manifest in specific practices and associated artifacts. Taking plans as artifacts, in contrast, recommends a research agenda dedicated to examining the heterogeneous practices through which specific ordering devices are materialized, mobilized, and contested, at particular times and places, with varying effects. (Suchman, 2007, p. 187)

"Taking plans as artifacts," which offers a way "to investigate how people produce and find evidence for plans in the course of situated action" (Suchman, 2007, p. 70), has been a primary purpose of my study. My attention to the messiness of new mobility is not just a way to trace how *digitality* works, but to trace how *digitality's promises* work. This is where I observe the desires for greater certainty and simpler solutions that drive it, and the reactions—of assurance, aspiration, or anxiety, for example—in response to it. I then take these observations of personal-digital encounters a step further than Suchman, whose study doesn't draw out any normative claims about photocopier use, in using them as the basis for my caution of the dangers of digitality's promises. This is a way of politicizing technologies through an evaluation of their socio-technical agency, rather than only through their structures.

The technology scholar Geoff Bowker (1994) introduced the idea of an "infrastructural inversion" to describe the figure-ground switch required to study infrastructural systems that usually recede into the background. Within urban mobility, digitality has often become such a mundane and taken-for-granted background, and much of the work of my study has sought to foreground technologies enrolled in ordinary phenomena. Yet at the same time, digitality remains in many cases the celebrated object of techno-promises circulating among transportation professionals and traveling end-users alike. This is the context in which Rose (2017) critiques digital geographies literature for looking too narrowly at what the digital does, sidelining people. What is required in those cases is not the inversion of an overlooked digital infrastructure to bring it into focus, but a kind of *reinversion* that sends the digital object to the background and brings forward the human desires, organizational contexts, and concrete city that surround it. Paradoxically, taking the object out of focus can be one way to better see what it does.

In response to the spatial, social, and technological scholars asking what digital technologies are doing in the city, I answer that, in part, they are promising. This answer directs attention away from how a specific artifact works, the kind of attention that investigates the accuracy of bikeshare data, or the proportion of Uber riders who used to ride the bus. Such investigation is useful and important, but it is also a bit too easy. If the target is only a measure of a tool's effectiveness at a specified task, then the work of making technology better is straightforward, even if technically challenging. By turning attention to how technologies promise, however, the target instead becomes what we *want*. What we want, the question of why a technological vision is appealing, is a question that can be answered at the scale of an individual or a collective, but it is always personal. It requires a critical reflection on desires and on one's relations to others; it is political. This is more difficult work than adjusting a tool, but also more potent.

Living well with the mess

We need ways of recognizing and engaging the politics within the promise, but we need more than this. Throughout this work I have taken issue with the promise's invitation to transcend messiness, as well as with the reluctance of travelers, planners, and technologists to wrestle with it. But might the alternative look like? What could it mean to live well with the mess?

The suggestions I offer in response to this question revolve around the two themes that I have argued digitality's promise threatens to obscure: materialism and agency. My argument is for dwelling in the thoroughly immanent experience of city relations, in contrast to the transcendent promises of certainty or solvability. It is through such experiences that we can learn to work through the uncertainties of not knowing what someone else will do, or to wrestle with the obduracy of objects that fail to conform to our intentions. Transcendent planning, which deals with generalized stories and idealized end states, remains the dominant theoretical perspective of the field (Fischler, 2012; Hillier, 2005). Its opposite, immanent planning, is situated in the here and now. As such, it must deal with conditions of partial knowledge, material constraints, value conflicts, and the slipperiness of affects. It is messy planning.

In what follows, I outline what such an immanent planning might look through a tour of several partial and overlapping thoughts: working with materiality, attending the present, the joy of agency, immanent uncertainty, relations of trust, situated learning, and unresolved strife. Admittedly, my presentation of these ideas is messy in more ways than one, but I offer these fragments as openings, rough sketches that I hope will evoke what we risk losing in the digital city and what we might gain in living beyond its promise.

Working with materiality

The first step in living with the mess of mobility, and one that applies to all that follows, is to shift attention from the data and discourse of its promises to the dirt and pavement of the city where it actually happens. In my study, materiality was obvious to any given traveler waiting in the rain for a bus or struggling with a shared bike that won't unlock. Any idealism they had about their transportation was quickly brought down to earth, and so they by necessity developed means of acting with material constraints. It is the planners and especially the tech companies who are more easily tempted to avoid the concrete contexts of their work. Ash Amin (2016) argues that planning has lost sight of materiality of cities, becoming instead interested primarily in practices of political deliberation. Attention to materiality means recognizing that planning must build material environments, but also that such artifacts are always already participating in the production of urban life.

As I have noted, transportation planners are often skeptical of any vision of transcending the infrastructures they know are still the basis of mobility. Working with materiality in this context is the basis for arguments that despite all of our new data and apps, buses are still the best technology for moving large numbers of people through any moderately dense city (Walker, 2018b) and that self-driving cars, even if they succeed technically, will do little to change our infrastructures of automobile dependence (Norton, 2021). The materiality of one city is different than that of the next, and so working with it can be frustratingly inefficient, but for this same reason also necessary. Digital abstractions still have immense utility, but much more so when we are willing to ground them in concrete situations.

Attending the present

Living well with the mess means living in the here-and-now, a shift in perspective from the temporality of what might be to that of what is. I refer to such living as *attending* to the present, both in the sense of noticing and of caring for our current mess. Donna Haraway, in her recent book on responses to looming global catastrophes, asks us to “stay with the trouble.” Our troubled times are mixed up, disturbed, and unclear, she says. Staying with the trouble “requires learning to be truly present, not as a vanishing pivot between awful or edenic pasts and apocalyptic or salvific futures, but as mortal critters entwined in myriad unfinished configurations of places, times, matters, meanings” (D. J. Haraway, 2016, p. 1). For Haraway, well known as a theorist of posthumanism, such a response is necessarily collective, demanding that we act not as individuals, but by “making kin” with the human and non-human beings whose situation we find ourselves sharing. In this she echoes a long line of feminist relational thought. Of particular note here is geographer Doreen Massey’s notion of the “throwntogetherness” of space, “the unavoidable challenge of negotiating a here-and-now” (Massey, 2005, p. 140) that is inherently plural and present. The lived experience of space, especially urban space, is messy in ways that preclude abstract escapism.

Such experience stands in contrast to the rhetoric of Silicon Valley, where, as one critic has it, “purveyors of the future have their backs to society, enchanted by technological promise and blind to the problems around them” (Wajcman, 2017, p. 126). Attending the present demands a refusal of such enchantment, and this is not often easy. Sara Ahmed’s (2010) work on the promise of happiness gives us one example of what such refusal might look like. She is interested in the “experience of a gap between the promise of happiness and how you are affected by objects that promise happiness” (p. 42). In short, the promise disappoints, and the experience of this gap was evident in my study of the promises of new mobility. These moments produce what she calls "affect alienation," a condition in which when someone becomes a stranger to the collective orientation towards an object as good. In revealing the gap and disturbing this shared understanding of a happy object, the affect alien kills joy. For Ahmed, this is no loss, at least not necessarily. Her killjoy is a hopeful figure. When happiness so often involves "repetition" and "following lines that have already been given" (p. 48), then "to kill joy...is to open a life, to make room for life, to make room for possibility, for chance" (p. 20). Or, applied to my own framing, it is only by noticing the mess—by recognizing the here-and-now as separate from the promised future—that we can begin to find ways to care for it.

Again, travelers more often than planners were the transportation killjoys. In such occasions, these figures are attuned to the situation around them, for better or worse, and so are not constrained by the pre-given narrative of the promise. That attention allows them to better negotiate the inevitable trouble.

The joy of agency

Attending to the mess need not always kill joy. For Ahmed, the promise of happiness offers a superficial kind of joy, a fantasy that is preserved only insofar as it is unavailable. But a grounded and personal experience can offer a different, deeper joy, one that comes not from rapturous transcendence but from the immanent experience of someone doing and feeling something right now. Cultural theorist André Brock offers one illustration of such joy and its power.

In his book on Black internet culture, Brock (2020) describes an often-invoked emancipatory promise of social media, in which these technologies expand democratic opportunities for resistance by providing a open forum for speech, facilitating political organization, and holding power to account. Such framings miss the individual, embodied experience of social media, Brock says. Without denying the potential utility of Twitter for resisting structures of racial oppression, Brock is interested instead in activity that begins from the energy and desire of a particular Black subject engaging a community. By showing "the ways Black folk use the internet as a space to extol the joys and pains of everyday life" (p. 6), he challenges rationalist framings of the internet to point instead to a desire that is visceral and subconscious. Such desires are immanent, present in the joy, anger, and catharsis of situated online expressions of racial identity. Brock approaches such practices using the notions of the *libidinal* and *jouissance*. He takes up Lyotard's (1993) characterization of the libidinal as an "excess" to the stabilized interpretation of an economic exchange—the "intensities" that drive the encounter but are not captured in the account—and applies the same notion of excess to online information exchange. The "libidinal is energy—generated by phobias and desires—that has a visible effect on the world" (p. 32), Brock says, and "can be understood as the combustion powering the engine" (p. 10). The related idea of *jouissance*, Lacan's notion of transgressive pleasure and desire, helps Brock argue that

> one should understand the distribution and arrangement of Black digital practice as digital labor *and* desire, as online politics *and* desire, or as digital representation *and* desire. Removing desire from Black digital practice reduces agency—online members become "users" or, even worse, "data." (Brock, 2020, p. 34)

In this he does not reject outright the structural views of internet cultures, but reveals them to be incomplete. Brock's attention to the libidinal is notable for asking first what the subject desires (shared culture, catharsis) and then how the technology satisfies that desire, rather than beginning with what the object promises (a techno-democratic forum) and asking whether the subject's use accords with it.

This is life in the mess, not the promise. While I have often focused on the *pull* of digital promises, Brock's emphasis is on the *push* that fuels Black Twitter from the ground up. In flipping this coin to the other side, Brock reminds us of our own power to create new spaces for our desires. Putting such power to use means being attentive to the desire within an agent, seeing that combustion that powers the engine. Here we can return to the philosophers of personal autonomy, introduced in chapter 3, who argue that a subject *acting* in accordance with her desires is only half the story of autonomy; she must also reflect on those desires and affirm them as authentically her own. Such reflection might for these theorists be conceived as more rationalistic than the senses of jouissance or the libidinal imply, but there is pleasure to be found here nonetheless. Living well with the mess means celebrating the ability to desire and to act, even or especially within systems whose views of such abilities range from hostile to indifferent.

New mobility is perhaps less personally expressive than social media, but I nevertheless found glimpses of joyful agency among travelers. In the young professional who takes pleasure in optimizing his trip for time and cost, the senior who tells the Uber driver to go a different way, or the driver who considers her own tolerance for stressful traffic maneuvers when choosing her route, for example, I saw people making their travel personal, purposeful, and messy. Travelers do not always live well with the mess, but they have little choice but to live with it. When they did find joy in pursuing their own desires, even in small ways, we can take from them a lesson in recognizing the pleasure of making our own way through a situation that we cannot fully predict or control.

Immanent uncertainty

Dealing with situations beyond prediction and control is the core challenge of living with the mess. Uncertainty is often productively eliminated through efforts to seek and find more knowledge, but some amount of not-knowing is inevitable. One response is to attempt to shape a situation to become more predictable. Another is a kind of resignation, and perhaps a sincere acceptance, in the face of what is fundamentally unknowable. Dealing with uncertainty not by eradicating it but by finding its sites of productive engagement is a challenge for planning, but some theorists have argued that

> planning might seek to accommodate uncertainty as a core ontological state of the world. This might be via the caring encouragement of immanence, an engagement with the constant permanence and indwelling of the unknown that pervades and haunts reality, not the seeking of idealized utopian end states. (Hillier & Gunder, 2003, p. 197)

The idea of immanence, which "is about dealing with and even encouraging the new, not treating it as a risk or opportunity that needs to be controlled in relation to preconceived grand narratives" (Gunder, 2008, p. 199), suggests a planning that is dynamic rather than stable, concrete rather than abstract, responding to situations rather than manipulating them. Surprise, novelty, and mystery are what become available when we let go of certainty (Clegg, 2010). These are not welcome to all people in all circumstances, but, like agency, they can bring joy.

How can we live and plan well with uncertainty, without needing always to transcend it? Two places to begin are in relations of trust and a practice of situated learning.

Relations of trust

When introducing the promise of certainty, I noted the inherent tension between wanting to know what will happen in a situation and wanting the actors in that situation to have their own agency. While increased knowledge or greater control are obvious alternatives to uncertainty, another is trust. This perspective, which appeared briefly in chapter 2, sees relations with other people not as threats to our ability to know and control the world, but as resources for living well within it. Trust begins with the recognition that other parties have agency beyond your control, and that the future cannot be known. It then provides the basis for taking action regardless. In Pink, Lanzeni, and Horst's (2018) account, trust has an affective quality. It is the feeling of assurance, emerging in relation with familiar or unfamiliar people and artifacts, that is needed "to generate the human confidence needed to improvise" (p. 12). Building on Marris's (1996) argument for "a more hopeful politics of collaboration and reciprocity" (p. 2) as the antidote for the anxieties of not knowing how to act, Robert Beauregard's (2021) discussion of uncertainty in planning foregrounds the social and material embeddedness of people. The planner's ability to know or to act is always situated in collaborative relations, intentional or not, and this "collaboration is also the most appropriate response to uncertainty" (p. 224), he says. These networks of relations (illuminated through actor-network theory) are for Beauregard a way to keep open multiple possibilities, a flexibility that strengthens our responses to surprise without locking actors in to unworkable plans. Acting alone and with distrust—as Beauregard and Marris each fear our social structures have encouraged—is what demands certainty, and what in turn produces the anxiety of uncertainty.

Here again are echoes of theories of posthumanism, which describes the co-constitutive nature of a subject and her social and technological relations, and of feminist relationality, which recognizes the copresence of care and vulnerability in such relations. Judith Butler (2004, p. 21), for example, writes that "we're undone by each other" and explores our ambivalence towards being made and unmade by that which is out of our control. Certainty can feel safe, but it often demands the foreclosure of a mixed-up embeddedness that is at once ineradicable and the basis of richer possibilities of collective life.

In the practices of new mobility, examples of trust and distrust can be found in cities' monitoring of riders' bike parking, the use of trip data to plan transportation infrastructure, and travelers' interpretations of bus arrival apps. A different example, also from transportation but decidedly low-tech, is the work of Hans Monderman. Monderman was a traffic engineer who spent the 1980s and '90s removing street signs, traffic signals, and lane markings from the streets of Dutch cities. The result was not chaos, as many predicted, but the emergence among drivers, cyclists, and pedestrians of an "intricate and unspoken set of protocols" (Hamilton-Baillie, 2008, p. 169) for navigating the space, in contrast to the simple and explicit rules of traditional traffic control. Without knowing exactly what others will do in an intersection and without the power to direct them, travelers communicate and coordinate in subtle ways. The streets are at once more dangerous and safer. More than a case study for traffic engineers, Monderman's streets have been a lesson for political theorists interested in how people learn to cooperate in the absence of an exogenous order. James C. Scott (2012) champions Monderman's belief that within an excessively ordered system, the implicit lesson is "to seek the maximum advantage within the rules" (p. 83), but that the removal of these rules "expands the skills and capacity of drivers, cyclists, and pedestrians to negotiate traffic without being treated like automata by thickets of imperative signs…and signals" (p. 82). Bonnie Honig (2017, p. 93), a theorist of agonistic pluralism, similarly notes that the presence of more signs directing traffic indicates a belief that people's intentions or abilities cannot be trusted. Taking the signs away is itself an act of trust, and in turn asks people to trust one another. These are the skills that a narrow-minded pursuit of certainty cannot teach.

Situated learning

Monderman's streets are learning experiences, as Scott noted. Crucially, learning here happens not in advance, but in a specific situation. A traffic signal deploys a standard approach to anticipate and direct behavior, and so drivers do not approach the intersection as an event requiring much of their attention. One lesson from Monderman is that the best way to solve a problem—in this case that of navigating a street without collision—might be to leave the problem unsolved, and therefore visible for individual subjects to negotiate anew under specific circumstances. This negotiation requires their situational awareness, draws on their pre-existing knowledge and capabilities, throws them into relations with each other, and, in doing all of this, allows them to learn. In-the-moment learning of this kind is not always more effective in the end than the deployment of a prepared, generalized knowledge. It is, however, often necessary, and so we should practice it.

Shifting from the experience of a traveler to that of a planner, professional practice demands attention to when particularities of a situation do not correspond with a general theory. This is the lesson of Donald Schön, whose work on the practice of planners and other professionals recognizes situated messiness as the necessary resource for effective learning. He writes that

> in the varied topography of professional practice, there is a high, hard ground overlooking a swamp. On the high ground, manageable problems lend themselves to solution through the application of research-based theory and technique. In the swampy lowland, messy, confusing problems defy technical solution. (Schön, 1987, p. 3)

Too much of our attention in theorizing, researching, and teaching is devoted to that "high, hard ground," while the majority of practice takes place in the swamp, he says. Nevertheless, practitioners make do. Schön is fascinated by how planners respond to "situations of uncertainty, instability, uniqueness, and value conflict" (Schön, 1983, p. 49) for which the general theories of their training have not prepared them. A successful practitioner, he says, is flexible and self-aware in a way that allows her to take stock of the particularities of a current situation to note the gap between this novel experience and her familiar patterns of knowing and acting. She then acts not by rote, but with "the art of practice in uncertainty and uniqueness" (Schön, 1983, p. 69). He calls this *reflective practice*, and says that is it necessary, to some degree inevitable, and undervalued.

Not just a description of how practitioners actually learn and act, Schön's work is an indictment of the overemphasis in planning (and other fields) on what he calls "technical rationality." This generalist and solutionist paradigm is not only insufficient, it can be blinding, since "technical rationality does not contain theory about practice problems that cannot be solved through technical rational approaches" (Cameron, 2009, p. 125). Further, Schön's account is a call to embrace the unresolved and uncertain as sites where meaningful change is actually possible. A student of Schön's says that his work asks professionals "to eschew standard, ready-made answers" (Fischler, 2012, p. 325). He says further that

> the professional must give up the illusion of control and must see herself as a "learning agent." She must be able to listen. She must be able to "tolerate the anxieties of confrontation" with messy realities and conflicting viewpoints. (Fischler, 2012, p. 320, quoting Schön)

This is not new advice, but my research suggests that recent advances in digital technologies do not help us to follow it. Reflective practice in planning with digitality would require an active and contextualized probing of what data and algorithms see and what they miss. It would put non-digital sources of knowledge—sensory, emotional, historical, social—to use in solving problems, and, equally, in framing what counts as a problem. In my research, some of the subjects did this some of the time, but such practices ran counter to the pressures of expanding digitality and its promise. They should be nurtured.

Unresolved strife

I have focused a good deal on digitality's promise of solvability, including the limits to the kinds of problems that digital technologies are able to solve and the dangers of expecting them to do more. At times, a better response is to look elsewhere for a solution—to buses rather than apps, or to bike racks rather than data interfaces, for example. Attending to our own desires, trusting our connections with others, or learning from the specifics of a situation might be the means of finding better solutions. But often the drive towards a solution, an end that closes off further possibilities, is itself the problem. Chapter 2 introduced the idea of solvability using literature from development studies that takes issue with the use of a technical problem-solution frame to obscure irreconcilable value differences. My own research has often been concerned with such attempts to use technology to escape politics. In this last sketch of what living well with the mess could mean, I want to offer the political theory of agonistic pluralism as a way to recognize and accept the absence of resolution.

Agonistic political theory, which is in conversations with theories of democracy, power, and diversity, is intellectually rich (see Wenman, 2003, for an overview), but my interest here is limited to a glimpse of one aspect: its challenging of resolution as necessarily desirable. Agonism can be understood as "the possibility of permanence of conflict, non-reciprocity and domination" (Hillier, 2003, p. 38), and planning arguably does not deal well with such conditions of strife (Pløger, 2004). The politics of agonism begins with a recognition of difference within any polity—difference of identity or of interests—and sees political engagement as driven by passions that are always present (Mouffe, 1993). Agonism criticizes stabilizing political structures that seek to resolve conflict through consensus, since this unifying process erases difference. "Every consensus exists as a temporary result of a provisional hegemony, as a stabilization of power and that always entails some form of exclusion," writes Mouffe (1999, p. 756). The argument is not just that politics *cannot* eradicate difference, passion, and conflict, but that it should not try to. For Mouffe (1999, pp. 755–756), "the prime task of democratic politics is not to eliminate passions nor to relegate them to the private sphere in order to render rational consensus possible, but to mobilise those passions towards the promotion of democratic designs."

In different words, agonism is comfortable with the mess. It tells us that, in politics, what looks like a solution might be just an erasure, and that our response should not be to seek a different solution, but to accept certain tensions as unresolvable and to make this friction productive. When I criticize the use of technology to avoid politics, the issue is more than digital tools that fail to provide solutions, or that provide the wrong solutions. It is also that they fail to teach us that, sometimes, a solution is not what we should not be seeking at all. Instead, we should seek tolerance for difference and strife, and then an embrace of it, as we learn to put that messy energy to use.

Planning with the digital

The conclusion of this project is not that planning should abandon digital tools. Rather, it is that planning should handle these technologies with care, and to look beyond them when they have reached their limits. Just as the travelers I studied usually recognized that they needed more than an app to get somewhere, the professionals responsible for creating the structures of urban transportation must make the effort to see mobility's problems and solutions as products of personal desires, social relations, political conflict, layers of concrete infrastructures and artifacts, and, as just one more part, digital information. Digitality promises transcendence, and sometimes delivers some bit of that fantasy, but planning founders when it neglects its immanence.

I have offered the promise and the mess as the paired analytical tools for understanding what digitality does in the city, and I believe that planning is already well positioned to see through both of these lenses. As in many professional fields, digitality in planning has a reasonably long history and a more recent rapid expansion. Yet when we avoid focusing so closely on novel digital tools themselves, we can see that the themes of this project—the collective performance of a desirable future vision; the relatedness of personal experience, political arrangements, artifacts, and infrastructures—have a history in planning that goes much deeper than these contemporary digital phenomena. Planning, planners, and plans are already promise and mess, dealing with the city as it is and the city as we hope it will become. The field "is intrinsically concerned with the imagination and desire [in asking] what the future city should look like" (Hillier & Gunder, 2003, p. 226), and has examined how plans are not just technical instructions but function as documents of aspiration and persuasion (Hoch, 2016; Throgmorton, 1996). Planners have long sought to reframe their practice as a site for sorting out the values that particular constituents bring to the process rather than as a depoliticized engineering exercise (Davidoff, 1965; Forester, 1989). Planners and allied scholars have also connected the built and the social, showing that material interventions in the city shape urban lives, but also that people find meaning and value in their relations to built environments (Hester, 1985; Manzo, 2006). Neither are the dangers of digitality's promises new; they are the reverberations of many decades of pre-digital efforts within planning to order the mess, to monitor and control from above, to replace politics with engineering, and to avoid present troubles by envisioning a better tomorrow.

We should avoid a view that inserts the digital into this scene as something radically different, an external solution or threat that we have never seen before. Instead, we should see that the digital is now already there, a constituent part of the city's gathering of people and things. This view positions digital technologies as simply another site for urban planning's engagements with the collective, the future, and the built.

This research has examined the promise and the mess of new mobility technologies, and in doing so it has sought to destabilize the digital as an object in itself. Instead, I have shown that digital technologies are inseparable from the people and the material environments that coproduce them. As promises, they are vehicles for collective visions, and as artifacts, they are mechanisms for structuring social relations. This is also a fair description of planning. In a way, what my research illustrates is that the digital *is* a kind of planning. That's not because it gives planners tools for seeing and anticipating, or because it facilitates novel spatial practices, although it does those things too. The digital is a kind of planning because it is a site where a future is imagined, and where relations among people are enabled and ordered through material interventions. For planning, this means that the task is not to plan *for* technologies arriving from elsewhere, nor to plan *by* simply adopting and implementing them, but to develop theories and practices for planning with, through, and alongside technology. A recognition of digitality's promises is the first step.

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Appendix A: New Mobility Names and Acronyms

The following acronyms, organizations, and terms appear in the text or in citations.

API Application Programming Interface. The specified procedures for exchanging data between two computer systems.

Bird Scooter share provider. Founded by Travis VanderZanden, a former Lyft and Uber executive, in 2017. No Seattle operations.

C40 Cities Global organization of cities committed to fighting climate change.

Chariot App-based commuter shuttle service. Acquired by Ford in 2016, shut down in 2019.

Citymapper Smartphone app for trip planning by transit, driving, and other modes. Venture-backed startup, founded 2011, based in London.

FHWA Federal Highway Administration

GBFS General Bikeshare Feed Specification. Specifies a format for data exchanged over APIs between mobility service providers (bike and scooter share) and third-party applications. Used to indicate micromobility availability to riders. Modeled after GTFS. Originated from NABSA in 2015 and managed as an open-source development project on GitHub.

GIS Geographic Information System.

Google Maps App and website for maps, location information, trip planning by a variety of modes, and more. Partnered in the development of the open-source GTFS standard beginning in 2006.

GPS Global Positioning System. GPS units in phones and vehicles are essential to new mobility.

GTFS General Transit Feed Specification. Specifies a format for transit agencies to publish route and schedule data in tabular format (CSV) for consumption by third-party applications. Developed as the Google Transit Feed Specification in 2006 by Google together with TriMet (Portland). Has always been an open-source development project; name changed in 2010.

GTFS-RT General Transit Feed Specification Realtime. An extension to GTFS that specifies a format for transit agencies to publish continually data on current status of transit vehicles. Developed together with GTFS.

GUI Graphical User Interface. The use of icons, images, colors, and other graphic elements, together with text, to allow information between humans and computers.

ICLEI – Local Governments for Sustainability Non-profit network for municipal sustainability efforts.

ITDP Institute for Transportation & Development Policy. Founded 1984. Global non-profit focused on safety, environment, and quality of life concerns related to urban transportation.

Jump Bikeshare provider. Founded by urban cycling enthusiast Ryan Rzepecki as Social Bicycles in 2010, originally focused on manufacturing bikes and equipment for sale to city-operated systems. Developed early dockless and e-bike technologies. Rebranded as JUMP and was acquired by Uber in 2018, when it began its own bikeshare and scooter share operations. Transferred to Lime in 2020. Operated in Seattle since 2018.

King County Metro Public transit agency for King County. A division of the general-purpose county government. Operates buses and passenger infrastructure, coordinates provision of schedule data with SoundTransit and other transit agencies.

LADOT Los Angeles Department of Transportation

Lime Bikeshare and scooter share provider. Founded in 2017 by former VC executives Brad Bao and Toby Sun. One of the original dockless bikeshare vendors, as LimeBike, in Seattle's 2017 – 2018 pilot.

Lyft Second-largest ridehailing provider in the US. Active in micromobility since acquiring Motivate, which operates dock-based systems by contract with cities, in 2018. Offers Lyft-branded dockless bikes and scooters in select markets. Won a Seattle permit in 2018, but did not begin operations.

MDS Mobility Data Specification. Specifies a format for data exchanged over APIs between mobility service providers (currently bikeshare and scooter share) and government agencies. Used for monitoring, compliance, and planning purposes. Originated from LADOT in 2018 and managed as an open-source development project on GitHub. Transferred to the Open Mobility Foundation in 2019.

MobilityData Non-profit organization that coordinates GTFS and GBFS development. Founded 2015 within RMI, incorporated as a separate non-profit in Montreal in 2019.

Moovit Smartphone app for trip planning by transit. Incorporates crowd-sourced data. Based in Israel, founded 2012, acquired by Intel in 2020.

Motivate Bikeshare provider. Founded as Alta BicycleShare in 2010, it contracted with cities to operate dock-based bikeshare systems, including Citi Bike (New York City), Capital Bikeshare (Washington, D.C.), Divvy (Chicago), Pronto (Seattle), and several others among the largest North American systems. Acquired by Lyft in 2018.

NABSA North American Bikeshare and Scootershare Association. Founded as the North American Bikeshare Association in 2014, renamed to include scooters in 2018. Home of GBFS.

NACTO National Association of City Transportation Officials. Issues guidance for city mobility and right-of-way management.

NRDC Natural Resources Defense Council. Global environmental non-profit.

NUMO New Urban Mobility Alliance. Founded in 2019 as a product of the Shared Mobility Principles for Livable Cities, which are intended to direct new technologies towards transportation goals. The principles were the product of a 2017 coalition between several organizations (C40 Cities, ICLEI, ITDP, SLOCAT, RMI, NRDC, SUMC, Transportation for America, and WRI) with dozens of corporate, non-profit, and governmental signatories. Hosted by WRI.

Ofo Bikeshare provider. Based in Beijing, with operations in many Chinese cities before expanding to the U.S. One of the original dockless bikeshare vendors in Seattle's 2017 – 2018 pilot. Left all North American markets in 2018.

OMF Open Mobility Foundation. A non-profit organization founded in 2019 as the home for MDS, which was previously within LADOT. Creation was led by cities; members its board of directors are municipal staff. In addition to leading MDS development, leads conversations about benefits of data sharing for urban mobility.

OneBusAway Smartphone app for real-time bus arrival times in Seattle, New York City, and select other locations. Created by UW graduate students beginning in 2006. Open-source, volunteer development. No independent legal identity until ownership was transferred to the newly formed Open Transit Software Foundation in 2019.

PacTrans The Pacific Northwest Transportation Consortium. Federally designated research alliance for Washington, Oregon, Idaho, and Alaska.

PBOT Portland Bureau of Transportation.

Populus VC-funded provider of data analytics and consulting services for urban mobility. Founded and led by Regina Clewlow and Fletcher Foti, who each hold a PhD in transportation planning.

Pronto Seattle's dock-based bikeshare system operating from October 2014 until March 2017, with approximately 50 stations and 500 bikes. Operated by Motivate (called Alta BicycleShare until 2015).

Remix Provider of mobility data platforms and analytics services for transportation planning and right-of-way management. A startup that began from the nonprofit Code for America fellowship and was acquired by Via in 2021.

RMI Formerly Rocky Mountain Institute. Clean-energy non-profit, founded 1982. Advocate for mobility data standards to encourage sustainable mobility. Hosted standardization efforts for GTFS in 2015.

SDOT Seattle Department of Transportation

SFMTA San Francisco Municipal Transportation Agency.

SLOCAT Partnership on Sustainable, Low Carbon Transport. Belgium-based transportation non-profit founded in 2009.

Spin Bikeshare and scooter share provider. Founded in 2017 by software engineers, including one from Lyft. One of the original dockless bikeshare vendors in Seattle's 2017 – 2018 pilot. Acquired by Ford in 2018.

SUMC Shared-Use Mobility Center. Non-profit founded 2014, with research, publications, and events. Roots in car-sharing, but has expanded to broader issues of urban mobility.

Transit (app) Smartphone app for trip planning by transit, with integrated micromobility and ridehailing options. Venture-backed startup, founded 2012, based in Montreal.

Transportation for America Advocacy organization for state and local government transportation priorities.

TRB Transportation Research Board

Uber Leading global ridehailing provider. Entered the bikeshare market by acquiring Jump in 2018, which it then transferred to Lime in 2020. Major investor in mobility and tech providers, including Lime.

Via Provider of microtransit shuttles and other app-based mobility services. Founded 2012. Operates shuttles to transit centers in South Seattle.

Waze Smartphone app for real-time driving directions. Uses crowdsourced data to estimate fastest current travel time. Founded 2006 and acquired by Google in 2013.

WRI World Resources Institute. Non-profit whose Ross Center for Sustainable Cities works on urban mobility issues.

Appendix B: List of Sources: Events and Reports

Events

My research included attendance at the following conferences and webinars, each of which featured several presentations by professionals from government, for-profit, and non-profit organizations.

Event	Organizer	Type	Date
Moving Forward Together	North American Bike Share Association	Conference (Portland, Ore.)	September 5 – 7, 2018
National Shared Mobility Summit	Shared-Use Mobility Center	Conference (Chicago)	March 5 – 7, 2019
Inside MDS 1.0.0	Open Mobility Foundation	Webinar	September 24, 2020
Micromobility	PacTrans	Virtual conference session	October 19, 2020
Using Mobility Data to Solve Pandemic Challenges	Open Mobility Foundation	Webinar	November 12, 2020
Privacy Principles into Practice	Open Mobility Foundation	Webinar	November 20, 2020
National Shared Mobility Summit	Shared-Use Mobility Center	Conference (virtual)	July, 2021 (weekly sessions)
Using Mobility Data to Advance Equity: Lessons Learned	Open Mobility Foundation	Webinar	October 13, 2021
State of the Industry Roundtable Discussion	Shared-Use Mobility Center; North American Bike Share Association	Webinar	November 15, 2021

Reports

The following list of documents includes reports, presentation slides, and working documents that were consulted in the course of research. They were retrieved from organizations' websites. Some of these were cited and referenced in the body text, while many others were used for background or context research but are not listed in the references.

Organization	Year	Document
Austin Public Health	2018	Dockless Electric Scooter-Related Injuries Study
Center for Democracy and Technology	2018	Privacy Considerations in Dockless Mobility Pilot Program *(Letter to LADOT)*
City of Chicago	2020	E-Scooter Pilot Evaluation
City of Minneapolis	2019	Mobility Data Methodology and Analysis
Denver Metro Chamber, Colorado DOT, Denver Regional COG, Regional Transportation District	2019	Mobility Choice Blueprint
ECONorthwest	2019	Fair and Efficient Congestion Pricing for Downtown Seattle *(Report prepared on behalf of Uber)*
Federal Highway Administration (USDOT)	2016	Smartphone Applications To Influence Travel Choices Practices and Policies.
Jump	2018	Free-floating bike share program permit application
Jump	2019	JUMP Comments to Los Angeles Department of Transportation Re: Data Protection Principles *(Letter to LADOT)*
LADOT	2016	Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles
LADOT	2018	Mobility Data Specification Information Briefing
LADOT	2019	Technology Action Plan
Lime	2018	Lime: Seattle: 2018/19 Free-Floating Bike Share Program Permit Application.
Lime	2019	Dockless bikes and scooters: The transportation option New Yorkers need now.
Lyft	2018	Lyft free-floating bike share program bike permit application.

Organization	Year	Document
Lyft	2020	Lyft 2020 Environmental, Social, & Corporate Governance Annual Report.
Lyft	2021	Lyft 2021 Environmental, Social, & Corporate Governance Annual Report.
Lyft	2021	Lyft Annual Report 2020
Lyft	2021	Lyft Multimodal Report
Mobility Data Collaborative (SAE International)	2020	Data Sharing Glossary and Metrics for Shared Micromobility
NABSA	2018	2018 Research Agenda
NABSA	2019	Shared Micromobility State of the Industry Report
NABSA	2019	Shared Micromobility State of the Industry Report
NABSA	2021	Data Good Practices for Municipalities: Understanding the General Bikeshare Feed Specification (GBFS)
NACTO	2017	Blueprint for Autonomous Urbanism.
NACTO	2018	Guidelines for the Regulation and Management of Shared Active Transportation
NACTO	2019	Blueprint for Autonomous Urbanism, Second Edition
NACTO	2019	Shared Micromobility in the U.S.: 2018
OMF	2019	The Open Mobility Foundation Overview
OMF	2019	The Open Mobility Foundation Principles
OMF	2020	MDS Working Groups *(Status report presented at contributor meeting)*
OMF	2020	MDS Maturity Survey Results
OMF	2020	MDS/GBFS Real-time Status Comparison
OMF	2020	Mobility Data Specification: Architectural Landscape
OMF	2020	Metrics API Overview

Organization	Year	Document
OMF	2021	Beyond Micromobility: Extending MDS to New Modes
PBOT	2018	Dockless Bikeshare: Observations from Seattle
Populus	2018	Measuring Equitable Access to New Mobility: A Case Study of Shared Bikes and Electric Scooters
Populus	2018	The Micromobility Revolution: The Introduction and Adoption of electric Scooters in the United States
Populus	2020	Curb and Mobility Management: The Role of Pricing, Incentives, and Data for Improving Curbside Utilization in Cities
Populus	2020	Mobility Data Sharing and Cities
Shared Mobility Principles Collaborators (C40 Cities, ICLEI, ITDP, SLOCAT, RMI, NRDC, SUMC, Transportation for America, & WRI)	2018 – 2020	Shared Mobility Principles for Livable Cities *(A website, sharedmobilityprinciples.org, and template slides for presenting the principles)*
SDOT	2017	New Mobility Playbook
SDOT	2018	Free-floating bike share pilot evaluation report
SDOT	2018	Bike share annual permit recommendations *(Report to Seattle City Council Sustainability and Transportation Committee)*
SDOT	2018	2017 Free-Floating Bike Share Pilot Evaluation Report
SDOT	2018	Free-Floating Bike Share Program Permit Requirements for the 2018-2019 permit year
SDOT	2018	Seattle's Playbook to Shape Automated Mobility
SDOT	2019	Bike share direct enforcement & SDOT sidewalk management plan *(Presentation to Seattle City Council, Sustainability and Transportation Committee)*

Organization	Year	Document
SDOT	2019	Emerging technology and mobility options operating in city right-of-way: Response to statement of legislative intent 35-3-A-1-2019 *(Report to Seattle City Council, Sustainability and Transportation Committee)*
SDOT	2019	City of Seattle Mobility Data: Privacy and Handling Guidelines
SDOT	2019	Seattle Transportation Information Infrastructure Plan Draft
SDOT	2020	Scooter Share Pilot Permit Requirements.
SDOT	2020	Seattle free-floating scooter share pilot: 2020 permit overview *(Presentation to Seattle City Council)*
SDOT	2020	New Mobility Survey Research
SFMTA	2019	Guiding Principles for Emerging Mobility Services and Technologies
SUMC	2016	Shared-Use Mobility Reference Guide
SUMC	2020	Towards the Promise of Mobility as a Service (MaaS) in the U.S.
Spin	2020	Mobility Data for Safer Streets 2020: Lessons Learned
Supreme Court of the State of Washington	2018	Lyft, Inc. and Raiser, LLC, v. City of Seattle
Transportation Cooperative Research Program (TRB)	2021	Transit and Micromobility
Uber	2018	Uber Movement: Travel Times Calculation Methodology
Uber	2021	2021 ESG Report
Uber	2021	Transit Horizons: Towards a New model of Public Transportation
Uber	2021	2020 Annual Report

Appendix C: Traveler Recruitment and Materials

Tech Worker Recruitment

Sample social media call for participants (Posted to Slack channel for New Tech Seattle):

Hi there New Tech Seattle – Do you use your phone to help you get around town? Does an app tell you how to avoid traffic or when the bus is coming? Does it hail an Uber/Lyft or unlock a shared car or bike?

If so, I'd love to talk to you for research I'm doing at the University of Washington on digitally mediated mobility. The world of transportation is changing fast, and this study will help make sense of it. I'm especially interested in the experience of people working in the tech industry—that's you!

Just go to bit.ly/uwmobilitystudy and we'll schedule an interview. Thank you!

Flyer distributed at New Tech Seattle Event (June 11, 2019):

Share your experiences with the travel tools that have transformed the ways we move through the city—everything from apps that give you directions and tell you when the bus is coming to services like Uber, Lyft, car share, and bike share. You'll be helping researchers understand how these apps are changing your everyday life, and how to make them better.

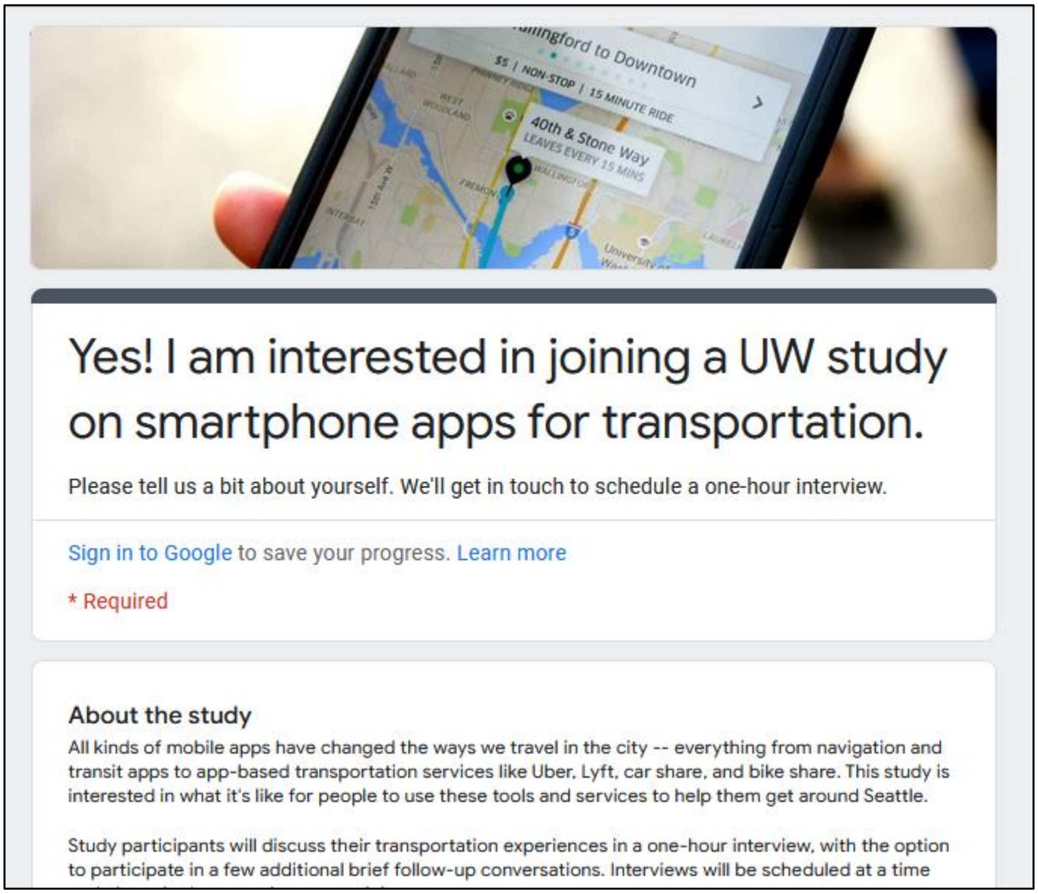
Interested? Learn more and sign up at

bit.ly/uwmobilitystudy

Questions?

Contact Peter Dunn, PhD Candidate in Urban Planning, ptdunn@uw.edu

Web form for participants to indicate interest:



Yes! I am interested in joining a UW study on smartphone apps for transportation.

Please tell us a bit about yourself. We'll get in touch to schedule a one-hour interview.

About the study

All kinds of mobile apps have changed the ways we travel in the city -- everything from navigation and transit apps to app-based transportation services like Uber, Lyft, car share, and bike share. This study is interested in what it's like for people to use these tools and services to help them get around Seattle.

Study participants will discuss their transportation experiences in a one-hour interview, with the option to participate in a few additional brief follow-up conversations. Interviews will be scheduled at a time and place that's convenient to participants.

Anyone traveling around the Seattle area is invited to participate, no matter how much or little you use transportation apps. Participation is voluntary, and participants may withdraw from the study at any time.

By participating, you'll be helping researchers understand how these apps are changing your everyday life -- and how to make them better. Thank you!

(Please share this participant survey with others who might be interested: bit.ly/uwmobilitystudy)

About you

* Required

Name: * [*open text response*]
Email: * [*open text response*]
Age: [*open text response*]
Sex: [Female / Male / Other]
Home ZIP code: [*open numeric response*]
Occupation: [*open text response*]

Questions?

Contact Peter Dunn, PhD Candidate in Urban Planning, at ptdunn@uw.edu.

[Submit]

Senior Focus Group Survey

A version of this survey was provided to participants at the start of each focus group.

Group discussion of tech and transportation

Council House, September 20, 2019
Peter Dunn, PhD Candidate, University of Washington

Welcome, and thank you for participating in this research!
Before we begin, please complete this brief survey.

1. How often do you go someplace by...

	A few times per week	*A few times per month*	*Occasionally*	*Never*
driving your own car?	☐	☐	☐	☐
taking a taxi?	☐	☐	☐	☐
taking an Uber or Lyft?	☐	☐	☐	☐
taking a community shuttle bus or ride service (e.g., Access)?	☐	☐	☐	☐
taking public transportation?	☐	☐	☐	☐
walking?	☐	☐	☐	☐

2. When you are traveling someplace, how often do you use a computer or smartphone to...

	Every time	*Most of the time*	*Occasionally*	*Never*	*N/A*
find the location of your destination?	☐	☐	☐	☐	☐
get directions to your destination by walking, driving, or transit?	☐	☐	☐	☐	☐
check current traffic? (when driving)	☐	☐	☐	☐	☐
check if the bus is on time? (when taking transit)	☐	☐	☐	☐	☐

(over)

(continued)

3. Do you have a smartphone (iPhone, Android, etc.)?

   Yes *No*

(If no, please skip to question 7.)

4. How long have you had a smartphone?

   5 years or more *3 – 4 years* *1 – 2 years* *Less than a year*

5. How often do you use your smartphone?

   Frequently throughout the day *A few times per day* *Once in a while*

6. Please indicate how closely you agree with the following statements:

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
My smartphone helps me do more of the things I want to do.	☐	☐	☐	☐	☐
Smartphone apps are easy for me to use.	☐	☐	☐	☐	☐
I enjoy learning how to do new things with my smartphone.	☐	☐	☐	☐	☐
Using smartphone apps is sometimes frustrating.	☐	☐	☐	☐	☐
I wish I didn't need to use my smartphone so much.	☐	☐	☐	☐	☐

7. Lastly, please think about the following questions about technology and transportation. You will be able to share your thoughts in our group discussion.

   - What do you love about using transportation apps (like Google Maps) or app-based transportation services (like Uber and Lyft)?
   - What frustrates you about them?
   - When using these apps, have you ever felt that your smartphone was telling you to do something that didn't make sense to you?
   - If something isn't working the way you expect, how do you get help?
   - What do you wish were different about these tools?

Appendix D: List of Interviews

Transportation and Technology Professionals

Name	Role and Organization	Interview Date
Benjamin de la Peña	Chief of Strategy and Innovation, SDOT	May, 2018
Kate Garman	Policy Advisor, Smart Cities, City of Seattle	May, 2018
Alejandro Chouza	General Manager, Pacific Northwest, Uber	September, 2018
Kyle Rowe	Senior Transportation Planner, King County Metro	November, 2018
Alan Borning	Professor Emeritus, Computer Science, UW; and board member, Open Transit Software Foundation (OneBusAway)	July, 2019
Brian Ferris	Co-founder, OneBusAway; Staff Software Engineer, Google Maps	July, 2019
Joel Miller	Micromobility Program Lead, SDOT	December, 2020

Staff at Senior Communities

Name	Role and Organization	Interview Date
Marya Purrington	Communications Manager, Horizon House	July, 2019
Erika Campbell	Resident Services Director, Mirabella	July, 2019
Audrey Dunbar	Executive Director, Council House	July, 2019

Traveler Interviews (Professionals)

All names are pseudonyms.

Name	Industry	Age	Sex	Interview Date
Ian	Tech	30 – 34	Male	June, 2018
Helen	Education	35 – 39	Female	June, 2018
Jake	Tech	30 – 34	Male	June, 2018
George	Tech	40 – 44	Male	July, 2018
Luke	Tech	35 – 39	Male	July, 2018
Alice	Medicine	35 – 39	Female	July, 2018
Brian	Tech	35 – 39	Male	July, 2018
Chris	Tech	30 – 34	Male	July, 2018
Jennifer	Creative	25 – 29	Female	July, 2018
Darcy	Tech	35 – 39	Female	July, 2018
Kyle	Tech	25 – 29	Male	July, 2018
Brandon	Law	35 – 39	Male	July, 2018
Li	Tech	30 – 34	Female	July, 2018
Jay	Tech	25 – 29	Male	June, 2019
Alex	Education	25 – 29	Non-binary	June, 2019
Jing	Tech	20 – 24	Female	June, 2019
Armin	Tech	25 – 29	Male	June, 2019
Jason	Tech	25 – 29	Male	July, 2019

Traveler Focus Groups (Seniors)

All names are pseudonyms. All focus groups were conducted at the community.

Name	Sex	Community	Focus Group Date
Judy	Female	Horizon House	August 8, 2019
Linda	Female	"	"
Kathy	Female	"	"
Steve	Male	"	"
Doris	Female	"	"
Mary	Female	Mirabella	September 18, 2019
Chuck	Male	"	"
Nicole	Female	"	"
Lisa	Female	"	"
Melissa	Female	"	"
Martha	Female	"	"
Heidi	Female	"	"
Bill	Male	"	"
Eleanor	Female	Council House	September 20, 2019
Betty	Female	"	"
Barb	Female	"	"
Carol	Female	"	"
Jim	Male	"	"
Pablo	Male	"	"
Dolores	Female	"	"
Susan	Female	"	"
Isabel	Female	"	"

Appendix E: Data Analysis Codes

Data on the promise of new mobility among professionals and data from traveler interviews were analyzed separately. The final codebook for each is included here. Codes are grouped by code family and sorted by frequency.

The promise of new mobility

These 74 codes were applied to more than 900 quotations in 51 documents, including published reports, conference notes, and interview transcripts. Code groups are actors (people or organizations); goals (specific objectives); promises (broader visions, hopes, attitudes towards a future); tools (the means of achieving goals); and practices (accounts of and issues with actual use, implementation).

Code	**Description**	**Quotations**
actors: sectors	differences between public/private sectors, broadly: their goals, styles, what is needed from each of them, etc.	97
actors: travelers	people going places, using certain modes (see also: users)	25
actors: city	a government agency	23
actors: users	people using an app or other digital tool (see also: travelers)	15
actors: community	"the community" as a general term, similar to "the public," similar to "travelers" collectively, different than agencies, providers, developers, etc.	15
actors: producers	generally - agencies, providers, public, private, etc., anyone who somehow produces the mobility/technology	9
goal: equity	various mentions of equity, low-income, minority, "for all," etc.	67
goal: implied	a flag that one of the goals (not identified) is inferred by me, not explicit in the text	38
goal: mode integration	bringing together multiple modes in a single trip (and maybe in a single app: see also "use integration")	36

Code	Description	Quotations
goal: safety	usually traffic safety, sometimes interpersonal safety	33
goal: satisfaction	user satisfaction - do they like the app and/or the travel experience as a goal in itself	32
goal: anti-car	against SOVs, car ownership, use of ROW for cars, car dominance, etc.	30
goal: transit	promoting the use or expansion transit called out specifically as a goal	25
goal: choice	traveler choice as a goal in itself	23
goal: use integration	getting information together in one app, and/or integrating travel payment/access and information	21
goal: efficiency	system efficiency, cost efficiency	21
goal: privacy	data privacy, concern with revealing location	19
goal: data integration	behind the scenes data integration issues	18
goal: mode fairness	efforts to address perceived advantages of cars in subsidies, road space, convenience, culture, etc.	18
goal: sustainability	environmental, climate change, etc.	16
goal: neutrality	platform language, allowing multiple players, not picking winners	13
goal: shared	shared and sharing as important in itself, community, collective	12
goal: use	simple measurable use (number of users, frequency of trips, etc.) as a goal	11
goal: access	in the sense of access to destinations through mobility, usually goal is "universal access," NOT specific to disability accessibility	10
goal: congestion	dealing with traffic	9
goal: business	corporations' profit motives, as stated from within or without	8
goal: community	something about serving "the community's" goals, usually general, as opposed to provider or agency or rider	8
goal: cost	reducing costs for agencies	5

Code	Description	Quotations
goal: system	attention to larger transportation system, in contrast to individual trip behaviors	5
goal: scale	implementation speed, scope, scale	3
practice: mess	examples of reality being more complex, difficult than promised	51
practice: change	examples of and commentary on things in mobility/tech being different now	25
practice: use	examples of how something is actually used	21
practice: pilot	examples of pilot programs and lessons	14
practice: parking	parking issues, esp. for scooters/bikes	14
practice: data integration	behind the scenes integration of mobility data	13
practice: service	transit or other transportation supply, service, frequency, in practice	12
practice: infrastructure	general references to infrastructure in mobility practice	10
practice: politics	general references to political conflict or engagement	10
practice: ops	agency/provider choices in operations, service levels, deployment, etc.	8
practice: mode integration	examples of connecting different modes in a trip	6
practice: use integration	examples of app/info integration issues, for travelers	5
promise: vision	imagine what it can look like (positive and negative)	114
promise: change	change is happening, for better or for worse	56
promise: solvability	tech can solve the problem	54
promise: certainty	can know everything, with certainty	40
promise: skepticism	people who see reasons not to believe the promise	38
promise: control	Image of being in control of travel (from traveler's point of view) or of transportation system (for professionals)	34

Code	Description	Quotations
promise: history	use of certain narratives about the past to lay groundwork for the promise	16
promise: transcendence	imagine all the problems going away	14
promise: mess	people bringing expectations of messiness/reality into conversation with the promise (see also: skepticism)	14
promise: joy	joy, happiness, excitement...not a specific emotion, but something of a positive feeling wrapped up in the promise	8
promise: choice	suggestion that futures can be chosen, comparisons of visions, perhaps good/bad (see tool: proactive)	6
promise: shared	collective, communal	4
tool: regulation	policies, permits, regulations, enforcement, etc. as agencies' tools for directing providers	78
tool: data answering	we can use data to answer questions, specific or not	76
tool: data collection	providers/producers/agency's efforts to collect data	58
tool: data sharing	sharing data between various orgs, or integration across apps, as a way to achieve something	37
tool: infrastructure	infrastructure (esp. transit) as tool or obstacle to achieving goals (see also ROW)	24
tool: metrics	establishing measures, metrics, quantifiable goals as a tool for managing mobility	23
tool: row	use, division, management of ROW by agency/provider as means to mobility ends	22
tool: data standards	GBFS, MDS, or data standards generally as tools	20
tool: goals	discussion of setting goals generally, so that goals and goal setting becomes a kind of tool	17
tool: travel info	for travelers, trip info and its communication as a tool	16
tool: communication	marketing, persuasion, narratives, the ways agencies/providers communicate with travelers (not specific trip info)	15

Code	Description	Quotations
tool: interface	screen interface, what's on it and what's prioritized, how info is presented	14
tool: land use	broad recognition of factors beyond immediate transportation concerns, including housing, employment, density, etc.	12
tool: proactive	general proactive attitude as important for cities to shape mobility; not reacting to tech	11
tool: nudge	efforts to shape traveler behavior	8
tool: defaults	assumptions about travelers, discussion of choices for defaults and presentation within app (see also interface)	8
tool: fees	use of fees, fines, tolls, etc. as tools	7
tool: service	supply, frequency, availability of transit or other transportation	5
tool: computing	hardware issues and limitations	5
tool: vehicle	commentary on vehicles themselves	4

Traveler interviews

These 90 codes were applied to more than 950 quotations in notes or transcripts for 18 interviews and 3 focus groups. Code groups are concerns (the objectives or goals that drive action, something the traveler does or does not want); feelings (a description of an emotional state or experience); app (accounts of app interaction); and travel (accounts of movement).

Code	Description	Quotations
concern: ease	concern with ease of use of app, mode, etc. e.g., ease of unlocking bike, avoiding choices (not route-specific, see concern: complexity)	85
concern: mode	a preference for the mode of transport, often based on other concerns	78
concern: schedule	concern for when to leave, when to arrive, being on time	68
concern: interface	concern with or preference for/against a certain app interface, including screen and voice, input and output	65

Code	Description	Quotations
concern: awareness	concern for knowing or not needing to know where you are or how to travel	65
concern: price	concern for financial cost of a trip	56
concern: social	concern for coordinating with other people, or impacts on other people, or others' impacts on self	54
concern: speed	concern for total travel time, quickest route, and general efficiency	52
concern: certainty	preference for predictability, knowing in advance, avoiding need to be flexible/spontaneous, making reservations	45
concern: control	a desire to retain control, have the power to decide/direct (or not)	37
concern: dependence	concern with needing the phone/app to do something	37
concern: availability	concern for availability of a transport mode - e.g., is there a bike nearby, where do the buses go, how long for an Uber	35
concern: safety	concern for safety of self or others, includes general unease, e.g. with late-night buses or biking in traffic	34
concern: body	concern for care of the body and bodily comfort - seeking/avoiding sitting, walking, aches, crowds, laziness, etc. (see also ability, walking)	34
concern: hills	specific issues with travel on hills	32
concern: learning	desire for learning, generally, about a place, route, tool, changes, etc.	31
concern: walking	for or against walking, usually related to body or time issues	31
concern: paper	observations on (non)use of or (non)preference for paper maps & schedules	29
concern: mobility freedom	a sense of freedom in getting around, ease, convenience, access	28
concern: traffic	concern for traffic - either delay or emotional frustration	28

Code	Description	Quotations
concern: digitization	wishing that the app could provide more/different info that isn't currently available	28
concern: luggage	concern for carrying stuff - suitcases, groceries, etc. also strollers, wheelchairs	25
concern: corporate	concern about the corporate practices of app/travel providers	23
concern: accuracy	is app info correct? e.g., bus arrivals	22
concern: ability	concern about whether or not you can use app / mode, bodily or cognitive	22
concern: parking	concern for finding parking	21
concern: complexity	concern for complexity/simplicity of a trip - e.g. turns, transfers, directness	21
concern: labor	concern for labor conditions (pay, precarity, hours, etc.) of drivers or other labor	20
concern: knowledge	concern with someone else's (lack of) knowledge of travel, app, e.g. taxi/uber/bus driver, or friend (not referring to own knowledge, see concern: awareness; concern: certainty, etc.)	19
concern: drinking	avoiding drinking and driving, or avoiding encounters with intoxicated people	16
concern: culture	observations on culture or social behavior, especially comparative	15
concern: hardware	concern for saving battery, maintaining connection, use of device OR concern for transportation hardware - car, bike, etc.	14
concern: weather	weather affecting travel decisions or attitude	12
concern: infrastructure	mention of shared physical infrastructure as basis for transportation	12
concern: waiting	avoid waiting for bus/ride	11
concern: norm	commentary on normal ways of doing things (see also concern: culture)	10
concern: tracking	interest in recording past activity (or avoiding)	9
concern: sustainability	concern for environmental impacts of travel: emissions, GHG	5

Code	Description	Quotations
concern: policy	concern for the rules, what they are and whether they're being followed	2
feeling: anxiety	stress, worry, and trying to manage it	41
feeling: joy	traveling that is more fun, more pleasurable, nicer, etc.	34
feeling: trust	trust in another person or in app, surrender	31
feeling: anger	also frustration	22
feeling: dependence	a sense of needing the app/service, not being able to function without it.	18
feeling: assurance	comfort, feeling better knowing something	16
feeling: confusion	and doubt, questioning	11
feeling: belonging	a sense of inclusion or exclusion, is this app/service made for you	9
feeling: pride	self-esteem, confidence	7
feeling: impatience	unwillingness to wait, a need to take action	7
feeling: social connection	a non-transactional connection with another person (e.g., driver)	7
feeling: relaxed	not anxious, not impatient; overlap with assurance	5
app: learning	learning (about place, routes, interface, people, etc.) by using an app (learning from the app, not about the app)	102
app: entry	accounts of inputting information into the app - origin/destination, location pin, time, etc.	51
app: investigation	the user looks more closely in an app to learn more - making comparison, getting more detail. implies more initiative than simply taking the first recommendation.	48
app: mistake	The app makes a mistake OR something is missing in the app OR there is a mistake in interpreting the app (excludes issues with vehicle/driver/infrastructure)	32
app: current location	comments on seeing location on screen; the blue dot	32

Code	Description	Quotations
app: familiarity	gaining familiarity with the app (not about place)	25
app: ease	discussion of the user-friendliness of the app (separate from concern for ease more generally, which includes modes)	13
app: breakdown	The app/phone is no longer available, hardware or software issues (battery, connection, login, etc.). excludes mistakes when system is still functioning; excludes vehicle/roadway issues	12
app: digitization	things/practices getting turned into data (in actuality, not a preference)	11
app: personalization	cases where the app interface is or could be customized for the preferences/location of the user	8
travel: place familiarity	familiarity with an area, route, transit system, schedule, etc. (vs. familiarity with app) (the state of familiarity, not the process of learning)	148
travel: planning	making a plan for a trip in advance	104
travel: interpreting	interpreting app instructions before/during trip, adding own preferences or information, includes confusion and contradiction (see also questioning, following)	78
travel: driver interacting	person-person interactions between passenger and driver, either functional or social	76
travel: app-free	getting around without an app, intentionally or not; or disregarding app when traveling	67
travel: monitoring	Using the app in-journey	66
travel: app directing	The app directs the subject to do something, e.g. turn now or pull stop cord (regardless of compliance)	66
travel: place learning	learning (about place, routes, interface, people, etc.) through environmental cues and awareness (learning from the environment, not about the environment) (learning is process, familiarity is state)	61
travel: adjusting	flexibility, last minute decisions, adjusting plans, modifications to routine, willingly or not	55

Code	Description	Quotations
travel: social learning	learning (about place, routes, interface, people, etc.) from other people, e.g. asking directions from strangers, talking to coworkers about commute options	54
travel: departure coordinating	deciding when to leave a place based on expected bus arrival, travel time, etc.	52
travel: deciding	making a choice when traveling	51
travel: social use	using an app or mobility service together with other people	48
travel: comfort check	checking an app for information when there is no intention to change behavior	44
travel: breakdown	mechanical, infrastructural, system breakdown - bike/car doesn't work, road closed, driver not available, etc. (vs. app/phone breakdown)	27
travel: traffic check	checking traffic before or during travel (a more specific case of some overlapping codes: concern: traffic, concern: awareness, travel: comfort check, travel: monitoring)	23
travel: app-env conflict	conflict between information from the environment and info from the app	20
travel: questioning	skepticism towards the app's instructions, either in advance or en route (includes questioning a driver, indirectly, if driver is following the app)	20
travel: bus check	checking bus arrival before travel (often with travel: comfort check or travel: departure coordinating)	19
travel: pool	comments about ride-hailing carpools (i.e., with strangers)	18
travel: rescuing	a sense of ride or other mode being ready to rescue you from a given situation, or a specific story about it	18
travel: pickup friction	friction between digital and urban in instances of ride-hailing pickups	16
travel: sensing	getting around by paying attention to surroundings, rather than app. e.g., looking for bike on street instead of app (trip-specific, vs. long-term "learning")	16

Code	Description	Quotations
travel: rating	creating / reading ratings in app interface	14
travel: app-env translating	exchanges to/from digital & urban - e.g., license plate for Uber listed in app	14
travel: extra-app management	sorting things out outside the mobility platform, e.g. paying back friends, calling customer service	13
travel: driver protesting	Cases when the uber/taxi driver is reluctant to do something that the app or rider requests	11
travel: lost	incidents when the subject (or someone else) doesn't know where they are and/or where they are going	11
travel: subverting	case of subverting normal traveling, illicitly or against social norms (not just driving around traffic)	3