

Building a “smart” campus with care: Contradictions and communication in infrastructuring

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Abstract

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The concept of a “smart” campus is used broadly to describe initiatives to make all aspects of campus life easier, however, some salient features include ease of data collection and distribution, fast and reliable energy consumption measurement, minimizing excess energy consumption, physical security of the built environment, and cross-campus and remote communication and computing abilities. The questions that animated this dissertation project emerged from ongoing fieldwork that has evidenced a gap in our collective understanding of the ways in which different publics of a university campus specifically, and built environments generally, understand the goals of new technology introduction and implementation. This dissertation is based on the analysis of data gathered at a large research university. Studying a single university provided the opportunity to deeply integrate myself into a complex institution during a time of rapid sociotechnical, infrastructural, and organizational change. Practices of care are relational and responsive to technology and organizational changes. The shape this change takes is informed by power. Alignment around a shared definition of success was a heuristic for power in this process and illuminated opportunities for alignment and misalignment in the values

driving various groups to engage with “smart” infrastructuring projects and the data extracted from them. In leveraging a feminist politics of care, this project eschews productivist logics and their too often exploitative and oppressive ends to instead highlight the power of a focus on care to encourage reciprocity and mutuality. This is an orientation to working within an institution that is inherently resistive and points us toward imagining systems that are regenerative and life-affirming.

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I. Introduction

To name *something* “smart” places inherent value on it. It connotes capacities that may not be entirely perceptible to the user but have been marketed as valuable. It is a rhetorical move to evade complexity and contradiction in hopes of gaining consumer acceptance and boosting sales. The obfuscation of the complexity of building a “smart” infrastructure serves the interests of those who stand to benefit from selling more “smart” things, and those who value access to the data extracted by them. However, this limited perspective overlooks the complexities of maintaining and caring for the built environments and social relations that create community. My hope is that this dissertation can contribute to a collective effort to move away from such innovation-centric assumptions and instead slow down the pace of our relationship with technology to question its efficacy and examine its real impacts in practice, and the ways that even the “smartest” technology fall short of their promises, breakdown, and need repair and maintenance. It is through the process of complicating oversimplifications and overpromises as they relate to what “smart” technology can do that we get closer to a comprehensive understanding of their impacts.

Studying the sociotechnical implications of “smart”-ification necessitates engaging with the world of critical infrastructure studies, which I will attend to more fully below. I bring it up here to ground this dissertation temporally. In the late 2010s, partisan squabbles in U.S. politics over the limits of what counts as infrastructure created a backdrop for my own deep engagement with the study of infrastructure as social, informational, and material. That these infrastructures are becoming “smart” adds to the complexity of approaching this area of study. I use “smart” rather than more technical terminology like Internet of Things (IoT) devices and systems of devices, Ubiquitous Computing (UbiComp), and networked technologies because the social and economic context of “smart”-ification – that is, the exponential growth of “smart” technologies

across industries (Benson, 2019a) – is as much a social phenomenon as a technical one. Using “smart” technologies maintains a focus on the underlying economic and social drivers of this growth.

“Smart” technologies are not merely an upgrade to analog tools but are part of a larger shift toward making our environments, our bodies, and our activities more connected through data extraction (Sadowski, 2020). Used as a prefix, “smart” connotes a heightened capacity for connection and data collection and signifies that the smart thing, system, or environment in question has the capacity to be networked with other things, systems, or environments. “Smart” technologies are nodes of the Internet of Things (IoT). Most broadly, IoT is the network of technologies that are connected to the internet and each other to connect and share data (Osburn et al., 2021). As nodes in the IoT, “smart” technologies represent the pervasiveness of heightened connective capacity. Depending on your purview, the connective capacities of “smart” technologies is viewed as having “vital financial and environmental benefits” (Abuarqoub, 2017, p. 1) or as “overlapping infrastructures of urban surveillance” (Guariglia, 2021). This dissertation will complicate these views and examine the ways in which various stakeholder groups in a single institution of higher education relate to their workplace as a “smart” space. Workers’ position to the institution, the relative power over sociotechnical system decision-making, and their valuation of data extracted from the environment, all have impacts on the relationship for workers to their workplace and the “smart” technology therein.

Throughout this dissertation "smart" is used in quotations as a shorthand for infrastructures that are increasingly networked with IoT devices and systems of devices. In the context of this project, those devices are internet-enabled, embedded in the built environment, and typically include sensors used for the extraction of data. Using quotations around "smart" is

meant to signify that this is largely a marketing term used by vendors of such devices to connote their utility, despite critiques of their technological shortcomings (Townsend, 2013). Despite this, “smart” is increasingly popular in discourses about emergent networked data-extraction technologies. Most participants in this study understood to some degree the terminology and if not, could easily identify with it after a bit of unpacking. Thus, rather than use language that is particular to specific stakeholder groups or industries, I have chosen to stick with “smart.” An added benefit of this language choice is that it can remind the reader that these are products introduced to a wide array of environments to extract data. That data is a key commodity for a wide array of stakeholders – both internal and external to the institution.

The proliferation of “smart” technologies -- that is devices embedded in our built environments for the extraction of data -- is the outcome of innovation towards the creation of a subfield of computer science: Ubiquitous Computing (UbiComp), attributed to Mark Weiser (1993). Seamlessness, he posited, was to be a pillar of UbiComp. In his view, computing was moving toward a level of integration into sociotechnical infrastructures that was so widespread-yet-unobtrusive as to be imperceptible -- or seamless (Weiser, 1993, p. 71). His research agenda as part of the Xerox research team was to make UbiComp a reality and played a large role in the development of our current wireless network infrastructures and the sensors, controllers, and communication technology that made the proliferation of “smart” technology possible. The aspirations of seamlessness in UbiComp and “smart” systems still pervades. However, as Vertesi (2014) and others argue, this goal is not only a long way off, but in focusing too much on seamlessness we may miss interesting insights at the enduring seams. Seams are often the loci of inquiry for science and technology studies (STS) scholarship, one of which has been the privacy implications of UbiComp and the “smart” technologies that emanate from it.

This dissertation engages deeply with conversations about the importance of infrastructure to the sustaining of life and requires thinking intricately about our shared reliance on infrastructures, and what it means for infrastructures to become “smart.” The implications for infrastructural decision-making are vast and uneven. For the most privileged these changes may barely be felt as wealth and power create protection. However, for most, these decisions are quite literally life changing. On an individual level, infrastructure is the difference between access to critical services like education, healthcare, and transportation. For communities, infrastructure projects are arbiters of justice or perpetrators of divisions impeding collective progress. Globally, infrastructural investment is an opportunity to create regenerative rather than extractive futures. This dissertation leverages my curiosity about the differential impact infrastructures have on communities and how communities might work toward the creation of just infrastructures for the future to make sense of the ways “smart” technologies - embedded in our shared built environments - are impacting us.

I began the data collection for this study just before COVID-19 was declared a pandemic. Less than two months into the ethnographic field work, the field site, a large research university in the Western United States that I will refer to as Cedars University had announced a closure of campus to most teaching, learning, and administrative activities. A collective scramble to recalibrate what work was deemed “essential” and therefore allowed to continue onsite, and how the rest of us could adjust the modality of our work to online platforms ensued. This not only impacted the data collection for this project, as will be discussed in more detail in Chapter II, but impacted societal awareness of infrastructures that had long been taken for granted. The temporal setting of this dissertation posed many obstacles practically speaking, but it also created a challenging setting for studying infrastructure as debates about the subject developed rapidly.

The COVID-19 pandemic fomented a reanimation of discussion about social and material infrastructures that were actively disintegrating or falling into disrepair. These processes are magnified by the crisis confluence of a mismanaged pandemic, long overdue calls to end racist violence, growing wealth disparities, and wide-scale climate destruction. These crises are entangled with the corrosive effects of data colonialism (Couldry & Mejias, 2019), and what Ruja Benjamin (2019) has termed “the New Jim Code” – the embeddedness of racism into code. The result is an increasing precarity where there should instead be a thriving infrastructure of care to sustain our social and ecological world (Precarity Lab, 2020).

Two distinct responses to our collective precarity have emerged. New institutional partnerships between the state and Big Tech have been catalyzed, doubling down on technosolutionist logics, a concept that will be explored in Chapter III. This is visible in the treatment of urban centers as laboratories for “smart” infrastructure projects (Mattern, 2021). Such responses to our interdependencies privilege the political interests and design insights of a notably hegemonic group. Despite mounting evidence that “smart” infrastructure solutions repeatedly fall short of promises (Townsend, 2013), they continue to be employed. The algorithms that power them do violence onto minoritized persons (Buolamwini & Gebru, 2018), instantiate settler colonialism through dataveillance and “smart” border projects (Everuss, 2021), and entrench technocapitalist obsessions with innovation (Vinsel & Russell, 2020). And yet, they continue to spread. Leveraging the knowledge of these shortcomings from extant scholarship, this dissertation explores how “smart” technology impacts the work of maintenance/care workers on a university campus. University campuses often function as incubators for emerging technology and as such, are a useful context to make sense of the myriad ways these infrastructural changes impact those who engage closely and regularly with it.

Looking to scholarship that engages a feminist politics of care, research in STS “harkens to a past where description reigned over prescription and those who took up advocacy position were often accused of normativity” (Martin et al., 2015, p. 630). However, normativity in the feminist tradition deepens the engagement with the field and the ability to do analysis work; therefore, the quality of the analysis that emerges. As Martin et al. (2015) stated: “Care...does not offer closed and teleological solutions; an attention to ‘matters of care’ remains open-ended and responsive: one does not know in advance where this attention will lead” (p. 630). In using this approach, I recognize my own positionality as a researcher interested in care.

Issue Context: The “Smart” Campus

In the context of a university campus, the expansion of “smart” technologies into the built environment is championed as part of a “smart” campus and “smart” building initiatives. In the case of university campuses, “smart” buildings are typically part of an effort toward future “smart” campus plans. Whether those goals are achieved is another question. The concept of a “smart” campus is used broadly to describe initiatives to make all aspects of campus life easier, however, some salient features include ease of data collection and distribution, fast and reliable energy consumption measurement, minimizing excess energy consumption, physical security of the built environment, and cross-campus and remote communication and computing abilities (for a systematic literature review of smart campus features see Muhamad et al., 2017).

“Smart” infrastructures are often discussed through the lens of the “smart” home (Ricquebourg et al., 2006) or the “smart” city (Hollands, 2008). Generally, “smart” infrastructure initiatives are centered around an interest in generating knowledge and control over the built environment through data extraction (Sadowski, 2020). This underlying principle animates the growing market for, and introduction of, “smart” technology. These networks of things allow for

environmental sensing, data collection, data visualization, and data-informed decision-making. The idea of a "smart" campus, especially at a large public university, is like (though not entirely interchangeable with) a "smart" city. Hollands (2008) decidedly does not offer a singular definition of "smart" cities but instead undertakes a polemical exercise to “counter some of the taken for granted and self-congratulatory rhetoric of the "smart"-label bandwagon” (p. 307). Despite this, Hollands (2008) does in effect help make sense of potential definitions of "smart" cities as the “utilization of networked infrastructures to improve economic and political efficiency and enable social, cultural and urban development” (Hollands, 2008, p. 307, citing Komninos, 2002). A “smart” campus involves a multitude of infrastructures: energy, transportation, housing, etc. It relies on information and communication technologies (ICTs) in the networking of these heterogeneous systems (Graham and Marvin, 1995; Komninos, 2002). University institutions offer insight into how "smart" infrastructure initiatives impact a community (Benson, 2019a). Ferraris et al. (2020) examine the important role universities play in Smart City Projects (SCPs), especially in the development of social license for SCPs by serving as a laboratory for developing innovation. Thus, the divide between the "smart" city and the "smart" campus, especially large public universities, is often fuzzy. As such, Ferraris et al. (2020) help bridge the gap between "smart" city literature and the present focus on a "smart" campus. This collaborative and emergent definition is useful to this analysis, particularly in that it highlights sustainability as an incentive for "smart" infrastructure development.

An enduring aim of many "smart" infrastructure projects is environmental and social sustainability (Thorns, 2002). Sustainable development, codified in the UN Sustainable Development Goals (SDGs), lays out a framework for social, economic, and environmental sustainability that drives infrastructure projects globally. In the context of this study, the

predominant sustainability interests driving new infrastructure design are concurrently environmental and economic. Insofar as sustainability is referenced either explicitly or implicitly in the data collected for this dissertation, it is often in reference to energy infrastructures in the built environment (i.e., the water, heat, and power that keep campus operations running). Efforts toward environmental sustainability as it relates to new infrastructure projects include plans to make new buildings on campus “green”, a designation commonly demonstrated by Leadership in Energy and Environmental Design (LEED) certification, energy use metrics, and the integration of renewable energy systems. To make sense of the myriad implications of “smart” infrastructure, it is necessary to understand the larger political economic context in which these projects emerge.

Maintenance, Sustainability, and Innovation

Despite the Great Recession of 2008 and the current financial and sociopolitical crisis accompanying the COVID-19 pandemic, universities across the U.S. are still dotted with construction cranes as new infrastructure projects continue to forge ahead. Many of these campuses have been closed to most students, faculty, staff, and visitors since early 2020 and were transitioning to hybrid and in-person teaching and learning. The exception to this shift to online work has been custodians, maintenance, and “essential” workers who have kept the shared spaces of campus clean and safe throughout shutdowns. Many public universities across the country, which are often some of the largest employers in their state, are experiencing a deficit made worse by the financial depression of a pandemic (Nguyen et al., 2021). Such deficits often include deferred maintenance, which at many large state university systems is in the billions if not tens of billions (Gardner, 2017). The problem of deferred maintenance is not unique to college campuses. In fact, policies around deferred maintenance transparency is starting to

change in the home sector in response to tragedies like the Surfside condominium collapse in 2021 that left nearly 100 dead (Rivero, 2022). More recently maintenance failures have been at the center of lawsuits alleging that California utility provider Pacific Gas and Electric (PG&E) is to blame for the devastating Dixie Fire due to inadequate maintenance of aging infrastructures and vegetation risk management (Seidman, 2021). The stakes are extremely high. In the context of the university campus, these deferred maintenance deficits are the funds allocated to maintain, repair, and retrofit aging facilities across campus, including energy infrastructures, classrooms, and laboratories. The cranes dotting the skyline of many large universities are the product of capital campaign funds: the monies that are by and large the result of gifts from individual or corporate donors. They result in many state-of-the-art buildings on campuses with attributions to big tech entrepreneurs, billionaire philanthropists, or large corporations. Capital funds are usually earmarked for new construction and are inaccessible for the maintenance and care needs of the infrastructure in the future. The dichotomy between what is funded and what is not funded on many campuses is the direct result of economic systems that have been in place for decades. The aim of this dissertation is not to put forth a new economic model for the preservation and continuation of public universities but to examine how this political economy is constituted communicatively and has differential impacts on various user/occupant groups on campus. The activities that perpetuate this dynamic will be examined more closely in chapter III.

As we strive toward climate resiliency within the bounds of extractive capitalism, we see fissures forming between technosolutionist approaches to sustainability (i.e., demand for more networked devices to make infrastructures "smart" and "green") and cybersecurity concerns that increasingly threaten our collective and personal privacy (Atlam et al., 2020), physical safety (Nawir et al., 2016), and the very infrastructures these vulnerable technologies were introduced

to improve (Palleti et al., 2021). Under the pressure to make buildings more energy efficient -- a necessity in that nearly 40% of global carbon emissions come from buildings and construction activities (UN Environment Programme) -- industry leaders have turned to technological innovations as a solution. Building and construction teams as well as institutional leaders are inundated with vendor pitches promising their networked sensors, IoT systems, and cloud-based computing solutions are the answer to both strains on energy infrastructures and the climate crisis. A technosolutionist approach to “greening” buildings makes use of networked technologies to access and analyze energy usage. Ironically, the demand for data and data visualization, and the preference for always-available, real-time data, is its own ecological crisis (Williams, 2011; Whitehead et al., 2014; Lucivero, 2020). Increased sensing in the built and natural environment necessitates data centers that use an incredible amount of energy and are often conveniently out of sight for those leading the charge on "smart" building projects (Hogan, 2015).

"Smart" infrastructures enable institutional leadership to make use of more data than ever before. Energy-related building systems are increasingly networked with IoT devices or systems of devices as part of an effort to increase efficiency, affordability, and data collection potential. Initiatives for making energy infrastructures "smart" are often closely linked to sustainability efforts. However, the sheer number of IoT devices can collectively result in security and operational vulnerabilities for the entire infrastructure (Benson, 2019a; Kimani et al., 2019).

Cyber-Physical Data Security

When it comes to energy infrastructures, the consequences of vulnerability can be quite tangible. In 2021 the eastern region of the U.S. recently experienced gasoline shortages and panic buying

due to a ransomware cyberattack on a critical pipeline (Krauss, 2021). Months earlier, a small municipality in Florida was hacked resulting in contamination of the water system (Robles and Perlroth, 2021). Cybersecurity concerns accompanying "smart" energy infrastructure initiatives will continue to present themselves in similar events. Higher education specifically has been targeted by ransomware; in one case an attack impacted critical functions of a university medical center (Abrams, 2021). Despite an overall decrease of 43% in malware attacks in 2020, IoT malware attacks increased by 66% (SonicWall, 2021). In response to the global race for COVID-19 related research findings, higher education institutions saw a rise in malware attacks (SonicWall, 2021). Despite threats, more IoT systems are being introduced to energy infrastructures of university campuses every day.

Smart initiatives involve change across sociotechnical systems. Operations of a building, much less a set of buildings such as on campus (or in a city), rely on simultaneous and coordinated maintenance of 'things', 'connections between things', and communication between user/occupant groups. This is to say, it is no longer enough to define building operability as water coming out of faucets or lights turning off and on reliably, but that sensor data is secure and accessible to various interested parties. Thus, a cyber-physical perspective better attends to the realities of "smart" infrastructure systems (Lun et al., 2016; Shih et al., 2016). Much like infrastructures of a "smart" campus are cyber-physical, so too is the labor this infrastructure necessitates. It is no longer sufficient to consider the work of managing data emerging from "smart" technologies embedded in built environments as separable from the work of maintaining, repairing, and caring for those built environments. For those working to maintain or care for a "smart" infrastructure, "resolving an issue often takes both data analysis and a wrench" (Benson, 2019b). Building operations data, which is generated by IoT systems, is increasingly important to

the operation of buildings' critical infrastructures including water, electricity, heating, ventilation, and air conditioning (HVAC) systems, door access systems, lighting control systems, and energy management systems. Data collected by these systems are used to monitor buildings for operational issues, maintain physical security (i.e., prevent trespassing or theft), maintain cybersecurity (i.e., prevent cyberattack), report to internal and external entities for compliance requirements, and provide information for research.

Cyber-physical systems (CPS) are “engineered systems that are built from, and depend upon, seamless integration of computation and physical components” (National Science Foundation, Cyber-Physical Systems Division). “Smart” campus initiatives are an example of a CPS being integrated with “smart” technology networks, creating infrastructures to sustain built environments across campus. Collapse of the cyber-physical infrastructure divide is not without its own assumptions. The rise in cyber-physical infrastructure projects, through proliferation of “smart” systems, is the result of values and expectations for data they generate. “Smart” systems get introduced and celebrated because of the data they generate. The work of generating and managing these data are laden with values and expectations that vary across stakeholder groups. These values and expectations will be examined closely in the coming chapters.

A Framework for the Study of Maintenance and Care in a “Smart” Built Environment

The nature of this study – an examination of emergent technologies in a sociotechnical system with many contingent infrastructures and stakeholders – necessitates weaving together several streams of literature.

Studies from a sociotechnical perspective provide a foundation for the investigation of ethics, not only as the result of human action but in the relationship between human actors and more-than-human actors. These relationships, and the subsequent discourses and practices that

emerge from them, are the focus of this project. Looking to STS scholarship, a sociotechnical approach allows for continued consideration of the artifact without losing sight of the role of “meaning, practice, and the connection of particular technological systems” (Boczkowski & Lievrouw, 2008, p. 952).

In what follows I will introduce scholarship that has helped me parse this complex research setting. Read together, these related works create a foundation upon which I was able build my analysis and should serve as an introduction to the reader. This section goes beyond a review of related literature and extant works to leverage disparate streams of thought and push them in new directions. The concepts introduced and woven together in the subsequent sections create my analytical framework for this project. I extend some of these frameworks—like data valences—for others I make use of them as an explanatory framework—like the contradictions of Cultural Historical Activity Theory. In what follows, I not only outline the seminal works from each area of study but explain how I used each in the context of this dissertation.

Conceptualizing Care

This dissertation weaves together many scholarly tracts, including a feminist politics of care. While theories of care, as previously noted, have largely focused on healthcare, domestic labor, and feminized and invisibilized work, there have also been efforts to bring these theories to bear on the study of institutions more broadly. Joan Tronto has been foundational to this work in introducing the concept of “caring institutions” (2010).

Previous work on care institutions has measured institutions’ capacities for care through comparison to families and market sensibilities. Tronto, however, rejects both of these approaches and puts forth a set of key features of a care institution. According to the care institution as a family approach, the most caring institutions were those that functioned like a

caring family as opposed to a cold bureaucracy. Moving away from the family approach, a turn toward market logics took hold in the assessment of care institutions. Following other non-care institutional assessment models, the market approach is marked by turning receivers of care into customers. This is perhaps best illustrated by the adoption of customer satisfaction measurement tools being taken up as patient satisfaction tools. The problem, as Tronto sees it, is this approach upholds: “Market assumptions about the consumer -- that she is rational, autonomous, capable of making a choice, and possessed of adequate information to do so -- may not characterize the situation of people in care settings” (2010, p. 159). Tronto bases this argument on to Tronto and Fisher’s famous definition of care:

“On the most general level, we suggest that caring be viewed as a species activity that includes everything that we do to maintain, continue, and repair our ‘world’ so that we can live in it as well as possible. That world includes our bodies, our selves, and our environment, all of which we seek to interweave in a complex, life-sustaining web.” (Fisher & Tronto 1990, p. 40; Tronto 1993, p. 103)

Building on this seminal definition, and putting it into conversation with the concept of “caring institutions” Tronto introduces institutional care through four phases: caring about, caring for, care giving, and care receiving. The central question with care institutions is how to move past the assumption that care is somehow outside of the purpose of institutional functioning. In Tronto’s words, to ask “If caring is the ‘extra’, then how can we ever discuss it in institutional terms?” (2010, p. 160)

This gets complicated by Marxist feminist theory of social reproduction which complicates the boundaries of family, market, and institution and have effectively argued that familial care functions as an integral part of of a capitalist society, and as such family is a social institution, defined by the labor that is often gendered and un/underpaid. As we increasingly outsource the

caring labors once thought of as implicit to the family care institution, we bleed the lines between marketized and institutionalized care, thus proving Tronto's very point. The commodification of care follows classic Marxist thought that commodification leads to alienation. Tronto posits that one can imagine a care institution where money is introduced without alienation following. Though it is not stipulated what this would look like. What then is lost in our considerations of care when it spans institutions? Tronto calls for a reformulation of old questions of care: "care institutions have to think about the nature of the caring process as a whole in order to guide their actions" (p. 162). Tronto calls for consideration of not just the outcomes of care for its recipients but for those who provide care labor as an important part of making sense of the efficacy of such institutions.

As will be evidenced in the analysis presented in this dissertation, locating care in institutions is complicated by questions of scale and subjectivity. While organized under the banner of a single institution, the university is not necessarily a cohesive entity as evidenced by communication siloes, hierarchies, and cultural differences among sub organizations. Thus, depending on a user/occupants subjectivity or positionality within/to the institution, care may be defined at a different scale. In the context of infrastructuring, phases of care (to use Tronto's language) are diverse. By identifying how care can be in tension within a single institution, we can better understand the importance of care and routes forward via better communication and collaboration.

The Turn to Maintenance and Care

The concept technosolutionist sustainability is used to describe an orientation to sustainable development that assumes technoscientific innovation and distribution, for the purpose of data extraction, is the best solution for endemic social, economic, and ecological issues. This

orientation to sustainability is aligned with capitalist logics and thus eschews traditional, indigenous, or more-than-human orientations to sustainability which often center care over consumption. This dissertation engages in a larger conversation about the merits of technosolutionist sustainability and maintenance/care sustainability which draws inspiration from feminist STS. Maria Puig de la Bellacasa (2015) identifies this contradiction as oppositional temporalities. Similarly applying a feminist theory of care to the infrastructuring of a "smart" campus, oppositional temporalities are evident between those aligned with technosolutionist sustainability approaches that privilege the productivist bias in technoscience and those who favor the slower temporality of maintenance and care. Puig de la Bellacasa (2015) illuminates the ways that capitalist systems encourage technosolutionism, resulting in maintenance and care efforts being "compressed and rendered precarious" (Puig de la Bellacasa, 2015, p. 700). Expanding from these temporal oppositions are cultural and historical forces often pitted against each other. The tensions between innovation and maintenance/care have recently garnered renewed enthusiasm in STS (Martin et al., 2015; Viseu, 2015; Hall & Smith, 2015; Kaziunas et al., 2019; Pinel et al., 2020). Although interest in innovation continues to eclipse the mundane and seemingly small works of maintenance, Jackson (2014) complicates this binary to make a case for the place of "broken world thinking" even in processes of innovation. According to Jackson, repair *is* innovation and innovation *is* repair. Jackson argues for an epistemological shift toward consideration of the sociotechnical assemblages that sustain people as "always-almost-falling-apart" (p. 222). Critical infrastructure studies have heeded Jackson's call to study the sociotechnical world in the wake of breakdown. Henke and Sims (2020) argue that infrastructure comes into the purview of most people when there are concerns about "socially essential systems" falling apart (p. 9). They align themselves with a bottom-up sociological perspective

that is concerned with the ways that infrastructures can limit or expand the possibilities for certain groups as also argued by Edwards et al. (2009).

Those STS scholars interested in maintenance and upending what Vinsel and Russell (2020) call the “Innovation Delusion” are beginning to engage with feminist STS treatments of care as an important practice in technoscience. In the coming analyses maintenance and care are often used in conjunction (as in maintenance/care) based on a definition of maintenance as an act of care. This definition posits that to do the work to make something continue to work, a person/collective/institution must care enough to not let it go into disrepair (Denis & Pontille, 2015). Care, however, goes beyond maintenance. Care expands from a responsibility of keeping things from falling apart and towards the possibility of what could be. According to Fischer and Tronto (1990), care encompasses “everything we do to maintain, continue, and repair ‘our world’ so that we can live in it as well as possible” (p. 40). In being careful not to fall into assumptions of altruism as inextricably linked to care (Murphy, 2015), it is illustrative to think about care as an effort toward holism. Maintenance/care is the work of keeping things going *and* of making them better. Mattern (2018) weaves together the scholarship and practice of maintenance, repair, and care towards this end and makes a case for the consideration of care and maintenance that I aim to continue and deepen through a consideration of the role of maintenance/care in an analysis of ongoing sociotechnical change in a campus in the process of becoming “smart.”

This orientation to care straddles both the institutional/municipal scale in that it responds to increasingly stringent top-down policies and codes urging efficiency across energy infrastructures. On the other hand, in many ways it also is a genuine orientation to care on an ecological scale, reflecting an effort to look beyond the building and beyond the lifetime of its current user/occupants. “Smart” campus initiatives as a site for the study of critical data

practices, illuminate fissures in orientations to care through sustainability efforts that are enmeshed with technosolutionism.

Infrastructural Care

This dissertation leverages and extends what Dye (2020) has termed *infrastructural care (IC)*. Despite a very different empirical setting, IC offers a conceptual framework to make sense of data care in conflict in that it involves, “caring for others through the continual management of resources, relationships, and infrastructures” (p. 246). Care for others in relation with a "smart" infrastructure is often invisible, as is the case with much infrastructure work. To understand the context from which "smart" campus data emerges and is given value, it is necessary to unpack care work that goes into maintenance of a "smart" infrastructure. Infrastructure is used both as a theoretical and material construct for exploring tools, materials, relationships, and processes that are often out of sight, are integral to quotidian operations of institutions, and emerge with new meaning when the status quo is disturbed (Bowker and Star, 1999; Star 1999; Star and Strauss, 1999). Critical data studies and human-computer interaction (HCI) scholars have particularly taken up IC in health care settings (Chen et al., 2013; Kaziunas et al., 2017; Weiner & Will, 2018), evidencing how ethics of care are visible upon breakdown (Jackson, 2014; Denis & Pontille, 2015; Dye, 202). Applying this theoretical tradition to the setting of a "smart" infrastructuring process, the rapid introduction of IoT devices and systems into built environments is such a disturbance. Smart infrastructures are important to study within a critical infrastructure framework because they blur the distinctions that have guided infrastructure studies in the past. Data generated by a "smart" infrastructure does not emerge seamlessly from IoT devices (Weiser, 1993; Vertesi, 2014). Generation of data necessitates care for building systems, data pathways, and organizational structures of the institution.

Scholarly attention to infrastructural care has its roots in Marxist feminist studies of social reproduction, complicating notions of value in neoliberal economic terms to include those labors which were traditionally gendered, devalued, and made invisible (see England, 2010). Making care work visible illuminates the necessary, and indeed life-giving, work of sustaining vital human and more than human relations (Fisher & Tronto, 1990). Theories of care have been taken up by feminist STS scholars, and effectively used as an “analytic or provocation, more than a predetermined set of affective practices” (Atkinson-Graham et al., 2015). While care work can be an assertion of the softer and more affective relations of more-than-human networks, they are, as Michelle Murphy has argued, never innocent (2015). Care conceptualized as non-innocent means values are embedded in care practices and labors. As it relates to sociotechnical systems, like a "smart" campus, non-innocent care is particularly important when the object of inquiry is an effort toward locating values in caring for data, the built environment, or sustainability. Furthermore, as Houston et al. (2016) have articulated, values in the process of making a sociotechnical system cannot be injected into a project in a singular and isolated moment but are part of the “ongoing work of fixing and maintaining the objects and systems around us” (p. 1403). When it comes to studying infrastructure, especially "smart" infrastructures, the ongoing work of asserting values and putting them into practice is of particular importance. Because infrastructures are always in the process of breaking down (Jackson, 2014), assertion of values in infrastructure care work is continual.

The built environments we share for work, play, and life are increasingly networked as the result of "smart" technologies and Internet of Things (IoT). Like all infrastructure, "smart" infrastructures necessitate care in order that they may continue to serve the needs of users/occupants. This care is inclusive of, and extends beyond, the maintenance and repair of the

walls, pipes, and foundations to include networks, firewalls, and servers. Making spaces "smart" has made traditional distinctions between physical infrastructure and cyberinfrastructure increasingly obsolete.

Critical Data Studies

Critical data studies have challenged data science paradigms that hold that data is objective and self-evident to introduce a focus on values that “*enliven* the landscape of things, building forms of meaning and attachment that help *thicken* human relationships to technology” (Houston et al., 2016: 1404, emphasis original). In a cyber-physical infrastructure like that of a "smart" campus, thick human relationships to technology involve ongoing relations of care for data, the built environment, and the social and organizational relationships that they require. A focus on care is relatively underexplored in critical data studies despite recognition of a shift toward making environments, bodies, and activities more connected through data extraction (Sadowski, 2020; Couldry and Mejias, 2019). Increasing introduction of IoT systems result in increasing data extraction and thus a change in human-technology relations. Data extraction has been met with a mix of celebration and critique. In university settings, big data is a critical component of emerging research (Kitchin, 2014), and has resulted in new research paradigms including data science for social good (DSSG) (Tanweer et al., 2016; Neff et al., 2017; Zegura et al. 2018), and eScience (Hey and Trefethen, 2005). Pinel et al. (2020) argue that data work in a scientific context is a ‘matter of care’ (Puig de la Bellacasa, 2011) and there are advantages to understanding the caring practices inherent to data curation and creation. Data care work “helps shed light on the invisible human labor of data-intensive research” and “puts to the foreground the relational, affective and attentive dimensions of data work, and helps us question the constitutive nature of these specific data practices” (Pinel et al., 2020: 179). While critical data

studies and feminist STS share a normative goal of making visible the invisible, it is important to return to Murphy's (2015) call to "unsettle" care and reject tendencies to reify care as intrinsically "good" for all. Part of this unsettling work requires complicating our definitions of data care work to engage with the possibility of data care works in conflict.

Data Valences

Exploring impacts of data requires attention to how data gains meaning. Thanks to the burgeoning field of critical data studies, tendencies to reify data as objective, free of bias, and arbiters of indisputable truth have been challenged (boyd and Crawford, 2012; Dalton and Thatcher, 2014; Kitchin 2014). Rejection of "raw" data (Gitelman, 2013), while garnering scholarly support in STS and critical data studies, persists in public discourse.

To move away from tendencies to stabilize data as material object, communication scholars have applied the concept of mediation to data to "see data as emerging from communication media, shaped by and embedded into communication practices and materiality" (Fiore-Gartland and Neff, 2015, p. 1469). Rejection of stability reframes data as social and creates space to consider what increasing access to data means, to whom, and to examine meaningfully the mutual constitution of data and practice. Following research on mediation of data and other objects (Leonardi and Barley, 2008; Leonardi et al., 2012; Neff et al., 2014), "smart" infrastructures - similarly need to be approached as mediated which is to say, as an "ongoing, articulated, and mutually determining relationship" (Lievrouw, 2014, p. 45). From a data-as-mediated perspective, Fiore-Gartland and Neff (2015) present a typology of data valences: "the multidimensional expectations and values that mediate the social and material performance of data, or what data can do and will do within a particular social system" (p. 1470). They argue that data valences are often in conflict, illuminate the nature of relationships between

institutions and communities, and ought to be utilized as a heuristic for the social life of data (p. 1470-71). Fiore-Gartland and Neff (2015) introduce a non-comprehensive list of salient data valences from their fieldwork at the intersection of medical data and health and wellness self-tracking. Many data valences reflect persistent discourses about the stability and neutrality of data that critical data studies have contested. However, from a practice perspective, the persistence of these data valences drives action toward policymaking and organization practice.

Extant research on data care and critical data studies have largely focused on the knowledge work of researchers (Pinel et al., 2020). However, "smart" infrastructures necessitate care that encompasses care for and maintenance of cyber-physical infrastructures. This dissertation will extend previous work on data care and introduce cyber-physical data security as a value in data care work that comes into conflict with open, transparent, and accessible data paradigms. The empirical setting of this study expands beyond a laboratory, a singular organization, or project, and encompasses a complex assemblage of actors with a shared interest in data generated by IoT devices embedded in built environments. This dissertation engages these topics at the scale of infrastructure. Knowledge production is only part of the goal of a "smart" campus. Operability and cyber-physical security of critical infrastructures are paramount to participants of this study. The contextual shift from knowledge production to infrastructure operability of a shared built environment is an important distinction in the study.

Human-Building Interaction

As buildings, campuses, and cities become "smart", a shift is underway in our collective sociotechnical relations that complicates the divide between digital/datatfied environments and the built environments. Shifts in our interaction with built environments necessitate bridging the study of architecture, construction management, and urban design with the methods of human-

computer interaction (Alavi et al., 2016; Verma et al., 2017; Alavi et al., 2019). Alavi et al. (2016) introduce Human-Building Interaction (HBI) as a new paradigm for research poised to attend to the "smart"-ness of spaces. The bridging of these disciplines has resulted in the introduction of the term "user/occupant" (Alavi et al., 2019) to attend to the role of human actors in "smart" spaces as both users of the built environment as technology and occupants of built environments as spaces. Users is the terminology commonly used in HCI research and occupants is commonly used in studies of the built environment. Moving forward I will use the combined "user/occupant" to reference human actors in "smart" built environments.

Two terms introduced alongside the burgeoning field of HBI are particularly provocative in the context of this project: *Awarenessergy* and *Databitation*. An *Awarenessergy* perspective recognizes "comfort and services need energy. Instead of being pushed to be economical, users have the right to know where energy comes from, what it is used for, and to what amount, so as to save it wisely or spend it joyfully." (Alavi et al., 2016, p. 62). Relatedly, *Databitation* refers to a recognition that "In addition to walls and roofs, building users increasingly inhabit data without being naturally sensitive to it. The sheer quantity of these data calls for new interface paradigms." (p. 62). These two perspectives illuminate the sociotechnical aspects of "smart" infrastructuring projects and prompt us to interrogate the various ways users/occupants are engaging with physical infrastructures as well as cyberinfrastructures. Relative power over infrastructural decision-making or transparency in "smart" systems is related to not just data access but also the ability to control aspects of life and illuminate a struggle over rights to access data to inform action. However, as Fiore-Gartland and Neff (2015) argue, data valences often function under the assumption that data can be easily disentangled from context. Alavi et al. (2016) attend to this partially by putting these value and expectation paradigms into conversation

with a building context. The findings of this dissertation will provide empirical evidence for the contradictions and practices that emerge in this conversation between data valences and values and expectations for the built environment in the process of becoming “smart.”

Research Questions and Preview of Argument

This dissertation draws on a feminist approach to care and STS that “engages with care as a way to draw attention to the significance of practices and experiences made invisible or marginalized by dominant, ‘successful’, forms of technoscientific mobilization” (Puig de la Bellacasa, 2015, p. 692). I employ a framework of maintenance as care in analyzing the processes of sociotechnical change. Specifically, I investigate the introduction of “smart” technology into the built environment of the university campus through this framework. In an institutional setting with a wide array of actors, a commensurate array of conceptions of what constitutes successful technology introduction and what role maintenance/care plays in this sociotechnical process must exist. I use the ways in which diverse user/occupant groups in the built environment of the university campus care for these technologies as a heuristic for how these groups relate to the built environment and care for each other. In exploring the differences in diverse actors’ criteria for success in IoT introduction to the built environment of the campus, I illuminate the politics of care in these stakeholder groups.

The overarching question of this project is: **How do user/occupant groups with different subjectivities within an institution define success in the introduction and implementation of “smart” technology infrastructure, and how do these groups care for this emerging technology infrastructure within a shared built environment?** I do not simply examine the relationship between those who take care of these devices and the devices themselves, but more importantly, how this work is related to differing perspectives on

successful sociotechnical change on a infrastructural scale. The definition of success is, therefore, subject to changing spatial, temporal, and social relationships.

In pursuit of an answer to this question, I investigated different user/occupant subjectivities with respect to their definitions of success in the introduction of “smart” technologies, practices of care in response to their introduction and maintenance, and efforts toward convergence in this process. The myriad interests of these publics define and expand the ideas that these subjectivities exercised in relation to work with emergent technologies. These differences, balanced by the power these user/occupant groups have to effect change in the larger institution, are imperative to a fuller understanding of the impacts of rapid “smart” technology introduction. Changes to the infrastructure of the built environment of the university require collaborative efforts in the governance, practice, and maintenance/care of these sociotechnical systems. The overarching question above led to the following three research questions:

RQ1: How do different user/occupant groups on a university campus define success in “smart” infrastructure projects within a shared built environment?

RQ 2: What practices of maintenance/care are involved in “smart” infrastructure projects and how do they differ across user/occupant groups?

RQ3: How does the convergence of sociotechnical systems as a result of “smart” infrastructure projects impact practices of maintenance/care both socially and materially?

In Chapter II I outline my data collection and analysis methods and introduce the analytical tools I used to make sense of my data and present my findings. Chapter III offers a deeper analysis of the field site. This chapter goes beyond a description of the research site and engages in analysis of the organizational structures, value alignments and misalignments, and communicative practices as observed in my fieldwork. This chapter presents my sense-making about the field as

a foundation upon which the problems addressed in subsequent chapters rely. This project is a multi-perspectival analysis and Chapter III serves as an orientation to the configuration of the perspectives that are presented in Chapters IV, V, VI, and VII.

In chapter IV, I describe two distinct and contradictory orientations to sustainability infrastructuring taking place at Cedars University. The prevailing orientation, I argue, is a technosolutionist one that equates more data extraction and more “smart” technology with “greener” and more sustainable infrastructures. Analysis of ethnographic and interview data reveals that this orientation to sustainability contradicts an orientation to sustainability defined by maintenance/care. The chapter introduces two of the major user/occupant groups on campus through an analysis of these groups as infrastructuring publics. This analysis illuminates their distinct orientations to sustainability and the tensions that arise between these orientations. These findings set the stage conceptually and empirically as a meta-analysis of an underlying phenomenon within the current political economic context of the university. The following chapters highlight case studies that illustrate the differences between infrastructuring publics constituted by user/occupant groups across the university in terms of their relationship to new “smart” technology, their values and expectations for data extracted from these technologies, and their orientation care as they relate to “smart” technologies.

In chapter V, care is conceptualized in relation to sustainability staff and researchers at Cedars University. This user/occupant group, I argue, defines care for campus and the “smart” technologies therein as the continued maintenance and expansion of “smart” technology powered sustainability solutions, particularly those aimed at minimizing energy expenditure. Part of this definition of successful infrastructuring, according to these stakeholders, is the continuation of their access to data generated by these systems. “Smart” systems and the data they generate are

valuable in terms of knowledge production as well as for building a business case for more “green” and “smart” investments. Cyber-physical security is secondary to the interest this infrastructuring public has for access and dissemination of environmental data.

In chapter VI, I present the other side of this tension, which centers the maintenance/care sustainability orientation of the combined efforts of Information Technology (IT) and Operations and Maintenance (O&M) groups on campus who have come together to work collaboratively on the cyber-physical security threats posed by increasing “smart” technology systems across campus infrastructures. Sustainability is important to this infrastructuring public in that they are beholden to compliance with energy sustainability initiatives within and beyond the university. However, cyber-physical security takes precedence over knowledge production or the business development case for “green” infrastructure building. The data extracted by “smart” technologies embedded in the built environment are as much a threat to cyber-physical security as a benefit for reporting and compliance needs. As this infrastructuring public generally controls the flow of these data, they can delegate data access through their own “cyber-physical data security valence” which I introduce in this chapter.

In chapter VII, a third orientation to maintenance/care on a “smart” campus is introduced, this time centering the experiences and perceptions of building services staff. This user/occupant group includes workers who have commonly been considered “care” workers and include custodians, window-washers, and facilities repair persons. While the previous chapters positioned distinct infrastructuring publics in relation to their orientations to sustainability vis a vis values and expectations for data generated by “smart” technologies, the infrastructuring public introduced in this chapter is much more concerned with the means by which “smart” technologies may afford them access and physical security to their workplaces. Access controls –

the systems by which individuals gain or are denied entry to campus spaces – are the focus of many building services members infrastructuring interests. While other “smart” technologies certainly impact their workplace, access controls for specific reasons are highlighted as desirable to this user/occupant group. However, as I argue, this infrastructuring public is often overlooked in the “smart” infrastructure investing decisions.

Finally, I conclude the dissertation in Chapter VIII by summarizing the contributions, both practical and theoretical, that are presented in the preceding chapters. Furthermore, I share some reflections on the project after its completion, limitations to the research, and avenues for further research.

II. Methods and Overview of Research Site and Participants

Data Collection

This dissertation is based on the analysis of data gathered at a large research university in the western United States that I refer to as Cedars University. Studying a single university provided the opportunity to deeply integrate myself into a complex institution during a time of rapid sociotechnical, infrastructural, and organizational change. The nexus of increasing “smart” technology introduction to the university’s built environment, the reinvigorated focus on sustainability and data science, and the public health crisis of the COVID-19 pandemic are

reflected in the findings presented in subsequent chapters. Situated within a large city, Cedars University has 40-60,000 enrolled students, and over 500 buildings. The campus includes housing and dining facilities, libraries, research laboratories, museums, and a large medical facility. Like a city, the sociotechnical assemblages which make up a campus involve a diverse array of user/occupant groups whose respective power over the infrastructuring process is unequal. As such, a large university field site like Cedars University offers both a high level of complexity in terms of organizational and sociotechnical relations, but with the benefit of a more contained and centralized scope than a city. As discussed in the previous chapter, the lines between “smart” campus and “smart” city projects are not always distinct.

I focused my research on Cedars University specifically for a few key reasons. First, it has been recognized as a thought-leader in the integration of “smart” technology into the built environment. Many of the organizational and communicative phenomenon explored in the analysis of my research at Cedars University can be applied to other universities and complex, multistakeholder institutions more generally. Second, Cedars University is on the cutting edge of research in engineering and computer science—departments which have developed and continue to design and implement technical components and applications of “smart” technology. This includes work with sensors, network engineering, and cybersecurity. Additionally, Cedars University is a hub for human-computer interaction (HCI) research and other social scientific and humanistic approaches to the study of emergent technology. As will be discussed in greater detail in chapters V and VI, the interdependencies “smart” infrastructuring projects are creating between research and operational stakeholders is of particular importance on a university campus as there is a dual mission to promote knowledge production and discovery as well as maintain operations and security. This dissertation examines the sociotechnical implications of work with

data, and work within increasingly datafied spaces, that engage with questions about power, security, and impact that are important in any setting in which a new technology is being introduced.

This dissertation is concerned with the sociotechnical processes underway in a time of infrastructural change. Therefore, an ethnographic approach was best suited to capture and make sense of the dynamic nature of “smart” infrastructuring process. As articulated by Edwards et al. (2009) in an introduction to infrastructure studies, an ethnographic approach to the study of both the sociotechnical processes and the material implications of changing infrastructures is appropriate for many reasons and requires:

Following, describing, and mapping these bridges among various scales of infrastructure, demand techniques of analysis that penetrate deeply into the work lives of organizations and individuals, rather than uncritically accepting the largest scales of infrastructure as the most important ones. (Edwards et al., 2009, p. 370)

Ethnographic methods enabled me to dig deep into the nature of infrastructure as a dynamic sociotechnical and material process. An ethnographic approach counters the conceptualization of infrastructure as something that is built and passively observable through prescriptive measurement of inputs and outputs. On the contrary, infrastructure studies scholars have conceptualized infrastructure as “growing” and relational (Jackson et al., 2007, Edwards et al., 2009). A commitment to conceptualizing infrastructure in such a way is particularly important as it allows for an interrogation of conflict, breakdown, and (re)formation that make visible functions of power within infrastructure as a sociotechnical system. These dynamics are parsed through a more dynamic conception of infrastructure and a commitment to thick description following the understanding that “ethnography roots these concerns in empirical soil, resisting arguments that threaten to wash away ordinary experience in a flood of abstraction”

(Seaver, 2017, p. 2). This chapter presents a synopsis of the data gathering methods I employed, the analytical frameworks I used to make sense of a large and complex dataset, and the conceptual frameworks that helped me articulate these analyses.

Interview data, which included both ethnographic interviews and key informant interviews, expanded on and deepened knowledge of the field gleaned by participant observations. For some participant groups, participant observation was not possible due to time constraints and COVID-19 limitations. In those cases, interviews represent the key data collection method. Interviews strengthened and broadened the findings of participant observation and fieldnote-taking. The breadth of approaches to data collection served as an effort to “validate interpretations by comparing two or more forms of evidence concerning our research object” (Lindlof & Taylor 2017, p. 358). However, interviewing is not always a suitable approach as different methods, contexts, and interpretations by distinct researchers’ positionality all lead to different findings that are inherently unable to be replicated and critiques of reliability and validity follow. Such arguments posit that interviewing as a method is often misused and ignores the attitudinal fallacy—that people do not do as they say. It offers ethnographic methods like participant observation as a more appropriate approach to questions regarding collective and individual behavior (Jerolmack & Khan, 2014). I follow Seaver’s (2017) work on the enactment of methods in algorithmic ethnography, which has many similarities to the sociotechnical processes of change in my own project context. Rather than see interviews as ancillary to the ethnographic project, Seaver calls on algorithmic ethnographers (and I will expand that to include ethnographers of sociotechnical change generally) to consider interviews *as* fieldwork. Interviews, especially during data collection period contemporaneous with a pandemic, are in many ways an enactment of the daily work practices of those I interviewed. As Seaver (2017)

argues, softening these methodological boundaries does not evade the limitations of approaches for the researcher, but it “broadens her attention, turning the mundane mechanics of arranging and conducting conversations into material for analysis” (p. 8). The changing modalities of work, learning, teaching, and research have impacted many people and thus serve as a further justification for interviews as a data collection method.

I consider interviews as cultural activities (Seaver, 2017). Interview data is critical to a greater understanding of language use, terminology, and understanding of the organizational structures at large as they related to the processes central to my inquiry. These aspects may be missed in observational methods because they are part of systems that do not come up in meetings or day-to-day interactions because they are already *known* by participants in observations. As I approached interviewees, I was prepared with a semi-structured interview protocol to guide a conversation about personal experiences of organizational change, practices, and processes considering “smart” technology implementation. Asking these questions from the participants’ personal and professional point of view, helped contextualize the ways in which these system-wide changes have myriad impacts. Interviews with those who are involved in the participant observations helped to corroborate and expand a richer understanding of the state of the field.

Research Site and Participants

This dissertation project expands on my work as a research assistant on an NSF-funded project titled “SaTC: CORE: Medium: Knowledge Work and Coordination to Improve O&M and IT Collaboration to Keep Our Buildings Smart AND Secure” (NSF #1932769), as part of the Communication, Technology, and Organizational Practice (CTOP) Lab in the Center for Education and Research in Construction in the College of Built Environments at the University

of Washington. For clarity I refer to this project as the CTOP project going forward. The project is led by co-principal investigators Dr. Laura Osburn and Dr. Carrie Sturts Dossick (College of Built Environments), with co-investigators Dr. Jessica Beyer (Jackson School of International Studies, College of Arts & Sciences), and Chuck Benson (Chief Information Security Officer's Office). Working closely with project leadership, I created this dissertation project based on inquiries that both deepen and expand the central questions of the CTOP project.

The CTOP project seeks to identify interactions taking place between local, state, federal, and international policy and formal organizational policies and practices as they relate to and support knowledge work and task coordination between operations and management (O&M) and information technology (IT) organizations' collaborative work around IoT cybersecurity. The research questions addressed by the CTOP project are the following:

1. What are the interactive dynamics between public policies and guidance, organizational policies and procedures, and daily formal and informal work practices that impact collaborative knowledge work and task coordination work with IoT between IT departments and O&M?
2. What confluence of these macro-level policies and procedures and micro-level work practices supports the knowledge work and task coordination required for IoT cybersecurity collaboration that can overcome IT/OT convergence?

The CTOP Lab research team utilizes a qualitative approach; data are collected through observations, expert interviews, and document analysis. The CTOP project makes use of data

from an ethnographic study of Cedars University, interviews with area experts in other North American universities, and case studies from other higher education institutions.

My dissertation both leverages and extends the CTOP project's inquiry by focusing on the interorganizational dynamics of maintenance/care and contrasting perspectives of a broader range of user/occupant groups. Additionally, my analyses employ a distinctive analytical lens. This dissertation leverages the multi-institutional and policy analysis of the CTOP project to examine more deeply the dynamics within a single institution: Cedars University. I focus specifically on the role of maintenance/care practices as they relate to different orientations to sustainability, data values and expectations, and the implications of unequal power in infrastructural investment decision-making. The analyses bring together data collected by the CTOP project as well as data I collected independently. Although the CTOP project is a combination of comparative case studies, expert interviews, policy analysis, and ethnographic study, my own project remains focused on the ethnographic site of Cedars University while leveraging insights from the broader field of the CTOP project where relevant. Although my field site was limited to a single institution, the range of user/occupant groups I studied extends beyond those in the CTOP project. Rather than following the CTOP project's comparative approach across central administrative organizations, I recruited participants beyond IT and O&M. These user/occupant groups included care workers (i.e., custodians, window-washers, facility repair technicians), sustainability staff, students, and researchers. Although distinct from the CTOP project in the ways mentioned, my dissertation data was subsumed under the IRB approval for the CTOP project. As such, this data is available for our larger team to use for analyses and will enrich the research products attributed to the NSF grant. These data and my interpretations and analyses have been shared with the CTOP project as well as inform my

dissertation. I am fortunate to have gained entry to this field through the work of the CTOP research team and the relationships we have cultivated at Cedars University.

Data Collection Procedures

At the time of fieldwork, Cedars University was in the midst of a large-scale construction project for a new Global Health Institute (GHI). Through the noise of an active construction site, the project team gathered to collaborate with university owners on tasks necessary for timely opening of the building. GHI's design highlights energy efficiency including passive solar design elements, rainwater catchments, and smart metering throughout. During phases of construction, commissioning, and move-in I observed in design-build meetings with owners, architects, contractors, and subcontractors on the GHI project.

Simultaneously, I participated in strategic meetings with representatives from central IT and O&M as well as other university departments like engineering, housing and food services, and building services. Participating in these concurrent meetings illuminated different values and expectations for infrastructuring projects and the data being gathered immediately following commissioning, and to be gathered over the course of the building's life. Design and construction meetings were highly action oriented, and conversations rarely strayed from a predetermined list of project to-dos and progress check-ins. It was during IT/O&M led strategic meetings that deeper conversations about campus-wide initiatives took place. Three distinct meetings are considered part of the IT/O&M strategy work. These meetings had a lot of overlap in attendance, though specialists from across campus came and went as foci changed. Meetings considered central to the IT/O&M collaboration focused on network configuration, critical infrastructure systems, and energy meter management. In all three ongoing meetings data care and data

security were an underlying interest. The confluence happening technologically speaking between built and cyber infrastructures were reflected in the conversations happening between IT and O&M. Data management and security—as a form of data care work—was exercised with a particular set of values and expectations which will be explored in Chapters IV and V.

Between October 2019 through February 2020, ethnographic and interview data was primarily collected in person on Cedars University's campus. This included being physically present in meetings in various campus buildings, including administrative buildings and active construction sites. However, in response to COVID-19 related campus closures in March 2020, the project was forced to transition to a virtual ethnography modality. Some of the participants were also required to work from home, which necessitated those meetings and interviews be moved to an online conferencing platform. Some participants were still required to work on campus as their job duties were unable to be done remotely. In those cases, interviews and participant observation were still conducted virtually.

The COVID-19 pandemic and its subsequent shutdown of schools, businesses, and critical infrastructures across the globe have damaged us in ways we will likely continue to learn about for decades. While I do not believe the practice of hierarchizing the comparative suffering of communities, individuals, or infrastructures to be altogether productive, it is worth noting that many of my colleagues in the social sciences were unable to progress on their research agendas, lost funding, or had to leave their posts to attend to care for others. It is also worth noting that the occupational hardship because of increased care labor needs is one that disproportionately affected women in academia (Bender et al., 2022). The ability to continue this work at all is a testament to the resilience of our team.

I do consider us lucky in that the switch to an online-mediated modality was minimally disruptive to the study's progress. I was still able to attend monthly and bimonthly strategy meetings with leaders in O&M and IT at Cedars University as well as monthly and bimonthly meetings with the design-build team for new construction projects. Recruiting for interview participation was slowed considerably due in part to the inability to conduct interviews in person, but also because university personnel at every level have been functioning in crisis mode for two years which coincided with the period for participant recruitment. Understandably, participating in our study was not a high priority for many of the participants we recruited. Still, many generously gave of their time and shared their perspectives.

One particularly challenging participant group to recruit during the pandemic era was custodians. Custodians at Cedars University are being spread thin by deferred maintenance deficits across the institution that have affected facilities and building services widely. This phenomenon will be explored more closely in chapter IV, but in so far as it related to recruiting participants from this group it was determined to be untenable to get clearance to go onto campus and do participant observation as COVID-19 protocols strictly limited what kinds of activities could take place on campus grounds and buildings. As such, interview recruiting became the focus of my efforts after March 2020.

Labor shortages across these organizations meant finding time for an interview with researchers was hard to do for many of my participants. For those working on hourly wages, like custodians, the recruiting would necessitate participation outside of working hours. Therefore, I needed to secure funding to be able to reimburse participants for their time with cash gift cards. I secured research funding from the Department of Communication to fund three, one-hour long interviews and two interview protocol translations. I benefited greatly from consultation with

someone engaged in community organizing work with campus custodians. Based on her advice I recruited custodians with reimbursement for their time. Most of the interviews I conducted for this project were completed via online conferencing platforms (i.e., Zoom). However, many custodians were more comfortable participating in interviews via phone. English is not the first language of many custodians at Cedars University. The interviews were done in English, but to be sure that the questions were clear and could be made available to participants in advance, I hired two consultants to translate the questions into Tagalog and Tigrinya and offered to send translated versions to participants.

Throughout this dissertation details related to the research site, participants, and interviews have been carefully modified to protect the participants and the research site. While research participant protection is always important, the participants in this study share perspectives on tensions in the workplace including frustration with organizational leadership as well as information regarding cybersecurity risk mitigation strategies which necessitates special care. In Table 1, study participants are listed along with the type of participation they had and their department or position at Cedars University. However, Table 1 does not represent everyone who was present in participant observations as meeting attendees regularly fluctuated, instead this represents the most regular attendees.

Table 1. Study Participation Information

Stakeholder Groups	Alias	Participation Type	
		Interview	Participant Observation
Information Security	Lee	X	X
	James	X	X
	Aiden	X	
Information Technology (IT)	Joshua	X	
	Mariam	X	X
	Harris		X
Facilities IT	Brian	X	X
	David	X	X

	Finn	X	X
	Cameron	X	X
	Eric		X
Building Services	Kim	X	
	Louis	X	
	Owen	X	
	Lilian	X	
	Valentina	X	
	Sienna	X	
Facilities Operations	Kenny	X	X
	Franklin	X	X
	Sam		X
	Cohan		X
Capital Projects	Andy	X	X
	Mary		X
	Lisa		X
	Curtis		X
Sustainability	William	X	
	Joe	X	X
Researchers	Jazmin	X	
	Bridget	X	
	Virgil	X	
	Mila	X	
	Salim	X	
	Jarred	X	
	Jun	X	
Students	Monica	X	
	Arham	X	
Design/Build	Bob	X	X
	Terry	X	X
	Ezra		X
	Blake	X	X

Researcher Position

Ethnographic research is inextricably linked to both the act of entering the social world of the research context and the work of writing fieldnotes. As Emerson et al. (2011) explain, ethnographic research consists of “firsthand participation in some initially unfamiliar social world and the production of written accounts of that world that draw upon such participation” (p. 1). The value of fieldnotes as a method for ethnographic data collection is paramount to the

ethnographers' ability to gather insights about the larger phenomena they observe as well as capture key bits of data *in situ*. Participant observation is not simply an act of being a “fly on the wall” passively and inconsequentially observing. The ethnographer's presence has consequences on the field, just as the field has consequences on the ethnographer.

I joined the CTOP lab project during fall quarter of the second year of my PhD program. I had just convened my committee and was beginning to prepare for qualifying exams and considering my dissertation topic. At that point I was still very unfamiliar with much of the technical language being used in the field among participants of the CTOP project. Interviews provided an opportunity to dialogue with participants and unpack technical language, jargon, and concepts. Interviews also helped participants—many of whom we saw regularly in participant observation—become more familiar and comfortable with our presence. Dr. Laura Osburn, co-Principal Investigator on the project, and I did most of the ethnographic data collection for the CTOP project. We are both white women with graduate degrees in social sciences. We were frequently the only women in participant observations and interviews. As Laura and I have both observed in our fieldnotes, our gender and positionality as social science researchers entering the field dominated by men, many of whom were trained in trades, engineering, or IT, made us clear outsiders. I usually felt welcome in these spaces thanks to the relationship-building work Laura and the rest of the team did before I joined the team. As the months turned to years, I became more familiar with the recurring members and got to know their personalities through small talk and humor. We also had the benefit of having on our team a leader in the nascent IoT Risk Mitigation field who was able to make connections to participants on our behalf. Our intention as a team is to report back our findings in the form of industry reports, white papers, and presentations specifically aimed at different participant groups from the ethnography in addition

to academic publications. The findings of this dissertation will be included in those products. As for those participants that were not part of the original scope of the study, but are central to my dissertation project, I intend to create reports and present the findings to these participants as well.

The intersection of infrastructure and care emerge in a wide array of contexts as discussed in the previous chapter. My own fascination with the role of care in a rapidly shifting sociotechnical system, my desire as a researcher to center those workers who are often overlooked regarding technology decision-making, and the need for more nuance in theorizing about what counts as care work in a “smart” infrastructure, led me to propose this dissertation project. My own positionality as a social science researcher with an interest in unweaving the structures and systems that shape the world and trouble or perpetuate power dynamics shaped the design of this project and the forthcoming analysis.

Data Analysis

Analysis Process

The data gathered and analyzed for this dissertation includes interviews with 30 participants across Cedars University. Seven of the interviewees were researchers. Of the researchers two were professors, one was a postdoctoral scholar, and four were PhD students. Two interviewees were undergraduate students working on campus for organizations related to “smart” technology procurement, evaluation, and monitoring. The largest sector of interviewees came from the facilities organization at Cedars University. However, the facilities organization is large and disparate, thus it is perhaps more informative to break this contingent down further. Of those participants in facilities, four represented the internal IT for facilities, three represented the Chief

Information Security Officer's (CISO) office, two represented campus conservation efforts, one represented building project management, and one represented departmental IT. Furthermore, seven participants were from building services on Cedars University's campus. These participants included four managers: one in building access, one in window washing, one in general building services, and one in custodial services. I also interviewed three custodians. In addition to internal Cedars University employees, I interviewed four contractors working on building projects on campus.

Concurrent with my interview data collection, I was a participant observer in various meetings across campus including strategy meetings between representatives from IT, O&M, Network Engineering, Housing and Food Services, Building Services, and Building Project Delivery. These participant observations involved some of the same individuals interviewed however as previously noted, many interviewees only participated in that capacity. Participant observations occurred between January 2019 and May 2021. During this period, I observed 58 hours of meetings comprising over 90,000 words of field notes.

In both interviews and participant observations documents were shared and referenced. When possible, I collected those documents from the author or else tracked them down online or through other communications to collect them for analysis. Examples of these documents include organizational charts, design standards, agendas, drawings, and technical specifics. While participant observation and interviews were the core of my data corpus, documents were useful in the substantiation of findings and as a reference when they became the topic of conversation.

This data corpus is substantive enough to answer the questions I set out to answer in this dissertation and more. Data analysis began before the data collection was completed to ensure saturation. Additionally, many sections of this dissertation's findings have been member checked

by members of the CTOP lab as well as key participants of many of the participant observations and interviews. As Candela (2019) states, member checking, or the qualitative research methods practice of having participants review an early draft of the study's findings, has become a common practice for bolstering the validity claims of research with too little regard for the impact on participants. As such, it is a methodological practice that requires more theoretical engagement (Hallett, 2013). While not all my findings were member checked, I did member check specific chapters or sections with participants and scholars with expertise in the areas investigated.

Tracing sociotechnical changes over time, maintaining a pulse on the shift in the analytic framework through the course of the project, and pragmatically organizing and managing large amounts of data is a challenge. To be more efficient, I made use of a Computer-Assisted Qualitative Data Analysis Software (CAQDAS): Atlas.ti. The major benefit of adopting CAQDAS software for my dissertation project was as a means of indexing and organizing themes and codes for large sets of data (thick description field notes and interview transcripts especially). It is not within the capacity of such a program to replace the interpretive work of the researcher. Atlas.ti was instead used as an organizing and categorizing apparatus to help identify salient themes and trends over a large amount of data, over a long range of time. My key role as the researcher on this project was to do the interpretive analytic work, attending to my own positionality and situated knowledge.

Primary coding of the data focused on topical areas (e.g., innovation, maintenance, labor). Additional codes emerged through the analysis process and provided more nuance to larger themes. From this interpretive coding process, sustainability emerged as a definition of success for infrastructuring publics aligned respectively with innovation or maintenance/care.

Analysis of ethnographic data, including participant observation and in-depth interviews, has been ongoing since shortly after entering the field. As the analysis has progressed, salient themes have emerged. The data were repeatedly returned to, the codes sharpened, and the analysis deepened. The first pass at coding the fieldnotes, interview transcripts, and collected artifacts was done with high level themes in mind. Stories that were introduced in participant observations were substantiated and fleshed out in subsequent interviews. The stories and excerpts included in the findings chapters were selected as part of the interpretive work of this analysis. They reflect ongoing contradictions and tensions and should be read as a representation of a larger set of phenomena. The interview transcript excerpts presented prioritize the voices of maintenance/care workers as part of the critical/interpretive aims of this project to help give voice to user/occupant groups that are generally overlooked.

Analysis Tools

Cultural Historical Activity Theory and Modified Grounded Theory

To analyze the data systematically and interpretively, I employ modified grounded theory and cultural-historical activity theory (CHAT) in ways proposed by Seaman (2008). Based on the work of several scholars in each arena, and bringing a modified version of each approach together, Seaman (2008) provided a framework for using each approach's "complementary ambiguities" (p. 5) together. Engeström (1987) the model of an activity system as a visual representation of an assemblage that brought into conversation the relationships and actions that constitute a communication environment with a balance of attention paid to subjects, objects, tools, and the power relations among the community of the activity (see Figure 1). The subject is whatever individuals or groups engage the object. The object is a multifaceted orientation point or horizon toward which subjects seek to move. It is negotiated, situated, and evolving. Tools

refer to both the common material conception of tools as well as “signs, language, symbols, and abstract constructs such as models and epistemologies” (Foot & Groleau, 2011).

CHAT is an adaptation of activity theory developed by Russian psychologists, L. S. Vygotsky and Leont’ev, and more recently developed by the Finnish school of activity theory led by Engeström (1987) and other interdisciplinary scholars at the Center for Research on Activity, Development and Learning (CRADLE). Largely still centered in European scholarship, the theory has gained a foothold in the organization studies in United States thanks to works from Foot (2001), Canary (2007), and others. CHAT acknowledges the actors, artifacts, social constructions, and histories that comprise them, as living assemblages—rather than blackboxing or flattening the contours of these relations (Engeström, 1987). A CHAT framework is well suited to the analysis of the dynamic processes of change involving humans and objects across time and space to discover rather than assume what is going on. Following the discursive turn in organizational communication, Taylor (1999) argues that “organization emerges in communication” (p. 21). Engeström’s (1999) explication of CHAT expands on the communicative constitution of organizations (CCO) approach to better account for the duality of communication as material and discursive. In the empirical setting of this analysis, both Taylor and Engeström’s arguments are complicated by the duality of activity between those ideating, designing, and constructing new “smart” infrastructure, and those maintaining and caring for existing “not-so-smart” infrastructure as well as taking on the maintenance and care responsibilities of new “smart” infrastructure. Infrastructuring as communicatively constituted presents itself as a series of contradictions at key moments of transition, with material implications (Foot & Groleau, 2011). The processes by which alignment around definitions of sustainability take place and inform action differentially are used as a heuristic for power in this

analysis. Practices of maintenance and care as they articulate with practices privileging innovation and technosolutionism will be examined in relation to sociotechnical interdependencies. The power dynamics of those interdependencies are analyzed closely in Chapter IV.

More specifically looking at activity systems within a cultural and historical context, CHAT is a useful explanatory framework for communication scholarship. CHAT does not assume that activity systems are autonomous. Rather each activity system must be approached with the knowledge that it is a node in a more complex meta-activity system or system of systems (see Figure 2 and Engeström, 2001). Herein lies the importance of cultural and historical situatedness. Multilevel contradictions are the source of changes that are initiated within an activity system. A CHAT approach avoids essentializing analysis that constitutes each component and its meaning and action or by freezing it in time or space.

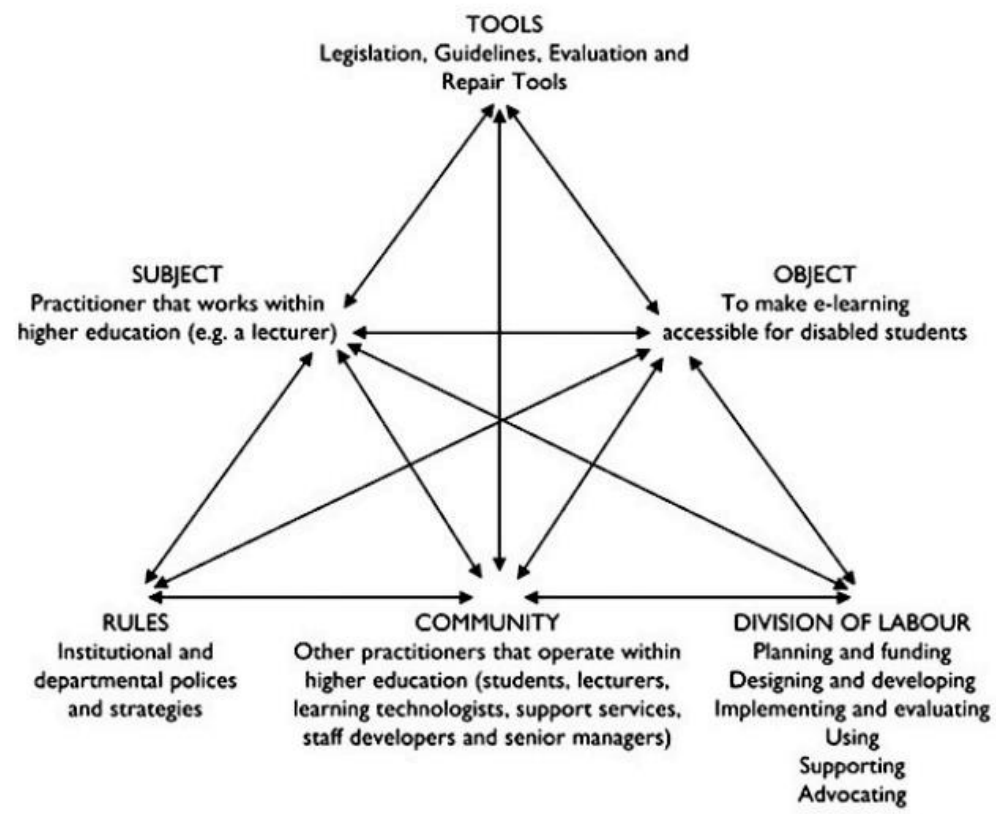


Figure 1. The most basic components of an activity system originally from Engeström (1987)

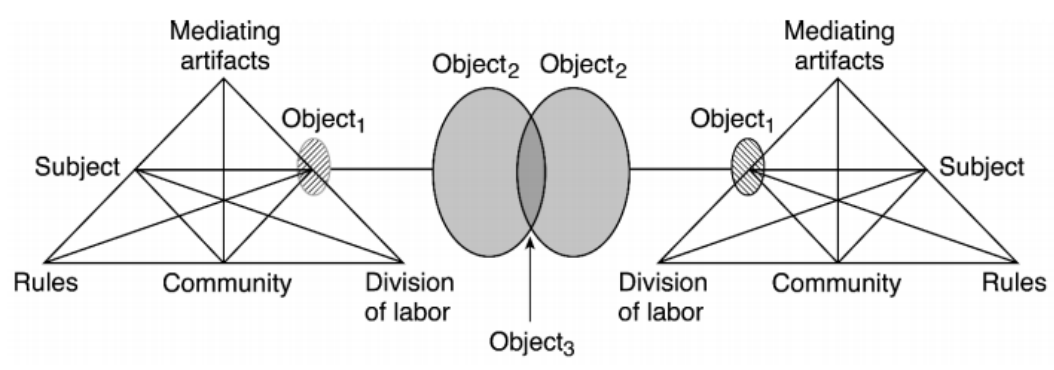


Figure 2. A system of activity systems originally from Engeström (2001)

Employing a scale of multiple activity systems is well-suited to what Engeström and Sannino (2020) term the third generation of CHAT, i.e. one in which “the formation of minimally two activity systems connected by a partially shared object may be regarded as the prime unit of analysis” (p. 2). See Figure 3 for an illustration of activity systems in the third iteration of CHAT.

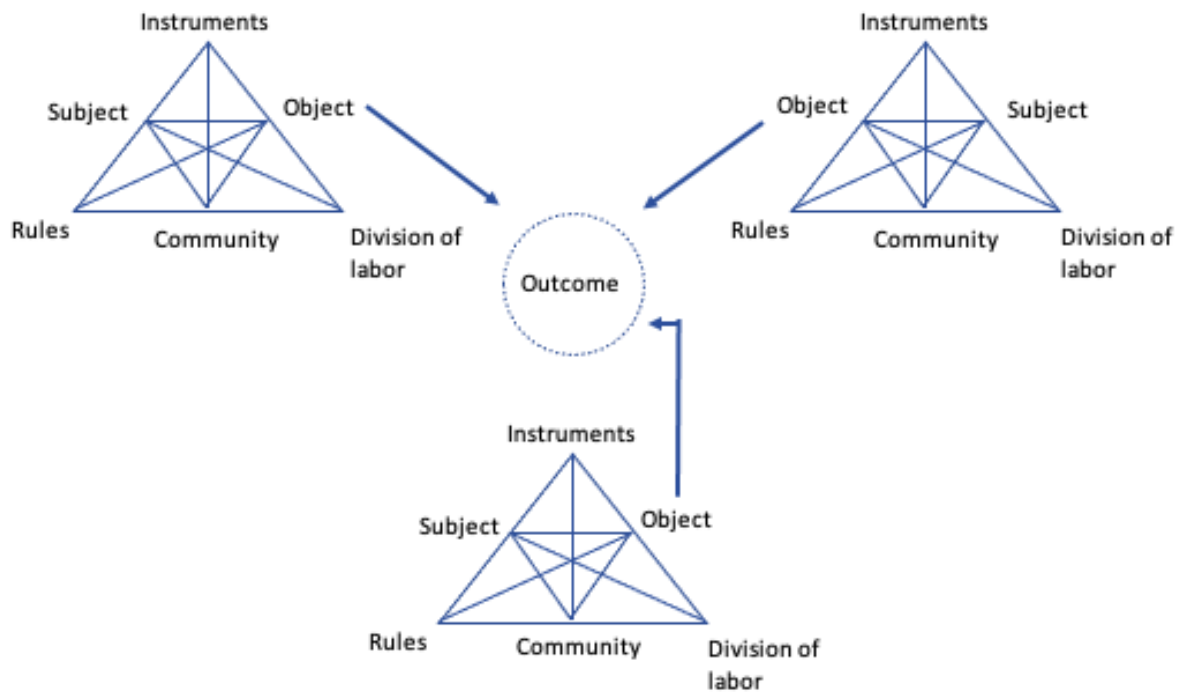


Figure 3. A Third-Generation CHAT System Model

A third-generation CHAT approach allows for the many scales of inquiry to be analyzed from both bird-eye view and up-close. It rejects the assumption that different subjects and communities uniformly intend to collaborate. As it relates to my interest in definitions of success, objects and outcomes similarly need not be in complete alignment.

Returning to Seaman (2008), I attend to this conceptual and analytic space by bringing modified grounded theory into a CHAT approach. Although purist grounded theorists have distinct protocols for gathering and interpreting data, this approach lacks “clear strategies for substantively analyzing how social situations are constituted by culture” (Seaman, 2008, p. 5). Modified grounded theory is distinct from the more purist application of grounded theory as a methodology. Grounded theory aims to privilege *finding out* what is going on rather than *assuming* what is going on and *testing findings* against the existing theory. Grounded theory, as it was conceived by Glaser and Strauss (1967), calls for an openness to theory generation through the research and analysis process. It is a fitting approach to the study of systems in the process of substantial sociotechnical change. However, existing theoretical work on information infrastructure, feminist politics of care, and maintenance and repair, as outlined in the previous chapter, provides important scaffolding for investigating my research questions in this specific context. Therefore, I use a modified grounded theory approach to “develop explanatory theory concerning common social life patterns” (Annells, 1996, as quoted in Seaman, 2008, p. 2) that also incorporates the theoretical scaffolding I established above.

CHAT benefits from the methodological approaches developed by grounded theorists for the collection and interpreting data through emergent coding, memoing, and asides. Boczkowski and Lievrouw (2008) call for STS and communication studies of technology scholarship to “take as their point of departure a still-emerging body of research that takes an environmental

perspective, analyzing technological systems, social structure and relations, and action together” (p. 966). I employ Seaman’s (2008) proposition to bring grounded theory and CHAT together toward a method of analysis that can capture the constructivist importance of context (historical and cultural) and is open to emergent and processual relationships between subjects, instruments/tools, and objects.

While the components of a CHAT analysis include terms such as activity, object, and subject that are commonly used in vernacular speech, when I refer to them in my analysis, I am referring to their meaning in activity theory. This is particularly important to note in regard to Chapter IV. Contradictions are part of the dialectical grounding of CHAT which is to say that contradictions identified and analyzed are systemic, in other words, structural. Contradictions from a CHAT perspective are rooted in intractable structures of capitalism. However, contradictions do not reflect an impasse for action, but rather are the source from which expansive learning is powered. The generative view of contradictions (Engeström, 1993; Foot, 2001; Poole et al., 1985), is an opportunity to investigate the interaction of activity systems as will be explored in Chapter IV. Before diving into an analysis of the generative power of contradictions, I first will introduce the research context and user/occupant groups in more depth in the next chapter. Chapter III is based on my analysis of Cedars University’s organizational structure both as presented through published documentation, as observed in fieldwork, and how I have made sense of the relationships between user/occupant groups through analysis.

III. Visualizing Infrastructuring Publics: Hierarchical Structure, Value Alignments, and Communication Practice

Introduction

This chapter presents more substantively the organizational and communication research context for this dissertation project. To examine closely the power dynamics that inform work with “smart” technology, this chapter first lays out a characterization of the research site. As previously noted, Cedars University is a large and complex institution. Therefore, this chapter does not endeavor to examine closely every stakeholder group of the institution, but rather to go beyond description to contextualize the disparate participant groups of the study in relation to the political economy of deferred maintenance and capital funding as they inform infrastructure investment. This chapter leverages the work of ethnography of work scholars including Suchman (1995; 1996), Goodwin & Goodwin (1996), and Heath & Luff (1996) as taken up by Engeström (1999a) to affect the visibilization of work. This analysis requires an examination beyond linear sequencing of tasks to make sense of work as not just as a series of actions, but as “always also interactions, between people and between people and their artifactual surroundings” (Engeström, 1999a, p. 64). The expansive visibilization of work integrates the linear and socio-spatial aspects

of work with a third and consequential *developmental dimension* which includes what drives people in their work. In the context of this project, the developmental dimension of work is evidenced by the values and expectations that user/occupant groups have for “smart” infrastructure projects, the data that they generate, and the ways in which they interact through work. Following the tradition of CHAT scholars, this chapter offers a multi-perspectival analysis. The point is not to identify a group on which to blame inconsistencies, inefficiencies, or harm. Nor is it meant to blame the political economy of the context, but rather to present its effects and impacts from multiple vantage points to affect more work visibilization.

As I began my analysis efforts, I turned to artifacts like organizational charts to make sense of where—organizationally speaking—my participants sat within the institution and in relationship to each other. It became clear quickly that these artifacts were a helpful starting point, but oversimplified the delineations between organizations, disciplines, and hierarchies which turned out to be much more complex. Rather than stay fixed to the stakeholder groups presented by organizational charts, I instead tracked the value alignments, priorities, and motivations of participants and the communication practices or siloes between them. This process led me to a reconceptualization of my participants, not as representatives of a particular stakeholder faction or professional discipline, but as infrastructuring publics organized by values and goals in relation to infrastructuring projects at Cedars University.

A linear conceptualization of work is traditionally presented by an organization both internally and externally through an organizational chart. However, the organizational chart as an artefact tends to freeze the organization in time, limiting one’s ability to see the ever-changing nature of organizational life. Furthermore, the organizational chart presents a birds-eye-view of the organization in an effort toward neutrality but reflects an ideal hierarchization and clean and

direct chains of command often privileging the perspective of leadership. The reality on the ground is much more fluid. Considering the socio-spatial and developmental dimensions of work necessitates not only a new conceptualization of the organization's hierarchy, but new conceptual categorizations of workers, user/occupants, and stakeholders. In what follows I introduce infrastructuring publics as a more appropriate conceptual categorization for the participants at Cedars University and leverage this approach to complicate the organizational chart and make visible other dimensions of work at Cedars University as it pertains to "smart" infrastructure building and maintenance.

Infrastructuring Publics

Infrastructure studies has maintained that 'infrastructure is fundamentally and always a relation, never a thing' (Star and Ruhleder 1994, p. 253). The move from infrastructure as an object of study to infrastructuring is a recognition that the processes of creating, maintaining, and changing infrastructures are ongoing and uneven. Citing other important scholars in this space including Karasti and Baker (2004); Pipek and Wulf (2009); Twidale and Floyd (2008), Björgvinsson et al. (2010) states:

Infrastructuring can be seen as an ongoing process and should not be seen as being delimited to a design project phase in the development of a free-standing system. Infrastructuring entangles and intertwines potentially controversial '*a priori* infrastructure activities' (like selection, design, development, deployment, and enactment), with 'everyday design activities in actual use' (like mediation, interpretation and articulation), as well as 'design in use' (like adaptation, appropriation, tailoring, re-design and maintenance). (p. 43)

Infrastructuring was first introduced by design scholars to examine the role of design in the creation of infrastructure (DiSalvo, 2009). This work was expanded to participatory design which focused on both the role of the designer, but of the wider community of users as well

(DiSalvo et al., 2011). Infrastructuring is the sociomaterial formation of a public based on John Dewey's pragmatist definition of a public as "a particular configuration of individuals bound by a common cause in confronting a shared issue" (Le Dantec & DiSalvo, 2013, p. 243, citing Dewey, 1954 [1927]). Le Dantec & DiSalvo (2013) explicate infrastructuring not at the scale of the state, as has been the historical conception of a public, but at the scale of an institution or collective. Their definition of infrastructuring as "the work of creating socio-technical resources that intentionally enable adoption and appropriation beyond the initial scope of the design, a process that might include participants not present during the initial design" (Le Dantec & DeSalvo, 2013, p. 247) will help frame the practices examined in this analysis. Despite different orientations to interests including maintenance, care, innovation, and sustainability, which manifest in the contradictions presented in this dissertation, the cumulative efforts toward communication and coordination are considered as part of the infrastructuring process with differing levels of success.

As Lodato and DiSalvo (2016), reflect, infrastructuring publics draw upon Actor Network Theory and Latour, who himself drew on Dewey. Infrastructuring publics have since been applied to a wide array of contexts and taken up by participatory design scholarship (Karasti and Syrjänen 2004; Björgvinsson et al. 2010; Le Dantec 2012). In studying the infrastructuring of Heathrow Airport, Nold (2018), posits that "participatory design has placed too much emphasis on the way infrastructures create connections between humans, and not enough on the way these infrastructures constrain and reinforce practices" (p. 98). While this dissertation project does not engage in participatory design methods, it evidences the power of connections between humans in infrastructuring projects as situated within contexts of power and the constraints it creates. Nold (2018) recognizes the need to "engage critically with the existing

elements that comprise a controversy, and not only to build new relations” (p. 98) and turns to Latour’s concept of ‘scaling’ to address controversy in his study. I agree with this approach to better attend to the reality of infrastructuring projects as relational and material but find that my own research context and design is better attended to through an examination of contradictions and the subsequent actions precipitated by infrastructuring publics. This break from the usual return to Actor Network Theory makes space for a new bridge between infrastructuring publics and Cultural Historical Activity Theory to be forged in chapter IV.

In the context of a large public university, the number and variety of infrastructuring publics are vast, and consideration of all possible publics is outside the scope of this project. I use infrastructuring publics as a framework for making sense of the interconnectedness of user/occupant groups with a stake in the built infrastructures - including “smart” infrastructures - being impacted by rapid IoT introduction and implementation in a university setting. The key infrastructuring publics that I consider in this project are: 1) staff in central facilities and IT organizations, 2) staff working on a contract with the university, 3) students and researchers working directly with IoT or the data acquired by IoT, and 4) buildings and grounds workers maintaining and caring for the built environment of the campus, and 5) Architecture, engineering, and construction (AEC) contractor teams working on new building projects. Each group has a different position and stake in the university, yet they all share a university-based identity. Exploring the discourses of organization within a university setting, McClellan and Deetz (2012) found that the way different groups talk about the organization “constitutes a relational understanding for what the organization is as well as a way to know the self in relation to the organization” (p. 42). I argue that practices of care in the processes of introduction and maintenance of emerging technologies expand both what ties each infrastructuring public to the

university and what makes these publics distinct, and perhaps in tensions with one another. In the context of sociotechnical change in the building of a “smart” campus, a relational understanding of what success in this process can and should be, paired with evidence for maintenance and care toward these ends, becomes an analytical framework for understanding this process better.

The rationale for engaging diverse infrastructuring publics reflects a central aim of this project: to analyze observed silos of communication in efforts to care for and maintain the critical infrastructures of the university. Cyber-physical security, sustainability, efficiency, and other drivers of “smart” infrastructure projects on campus have been met with a combination of concern and excitement. By including publics outside of the regulatory bodies of central administration, I can ascertain the practices in this process that are important to each group, and the reasons those practices are valued differentially across the groups.

The findings presented here substantiate each layer of relationship between infrastructuring publics. First, their relationship to the administrative structure is presented, and complicated. Next, I present their relative values as it relates to infrastructuring efforts. Third, I present their relative communication (or lack thereof). Taken together these representations tell a story about Cedars University based on my data set, that foregrounds the multi-perspectival analyses to follow in chapters IV-VII.

Complicating the organizational chart

Upon entering the field, the first thing I did was study the organizational charts for Cedars University. The charts were publicly available on the institution’s website. After a few weeks of participant observation and interviews it became clear that these organizational charts offered a

limited and sometimes flawed illustration of the communication, coordination, and collaborative practices really taking place.

Figure 4 shows a pared down version of the organizational chart for the participants of this study at Cedars University. Organizational charts are necessarily simplistic and cannot capture the complexity and nuance of any organization, certainly not one as large and multifaceted as a research university. However, organizational charts can help make sense of aspirational or historical conceptions of organizational structure that are meaningful. In Figure 4 the organizations/departments to which my study participants belong are mapped out as they relate to their administrative location in the university. For the sake of participant confidentiality, the organization names have been changed and made purposely vague. This figure presents an idealized, aspirational, and perhaps historically accurate representation of relationships and communication between stakeholder groups. As the next figures reveal, this is an oversimplification and idealization of institutional relationships and communication.

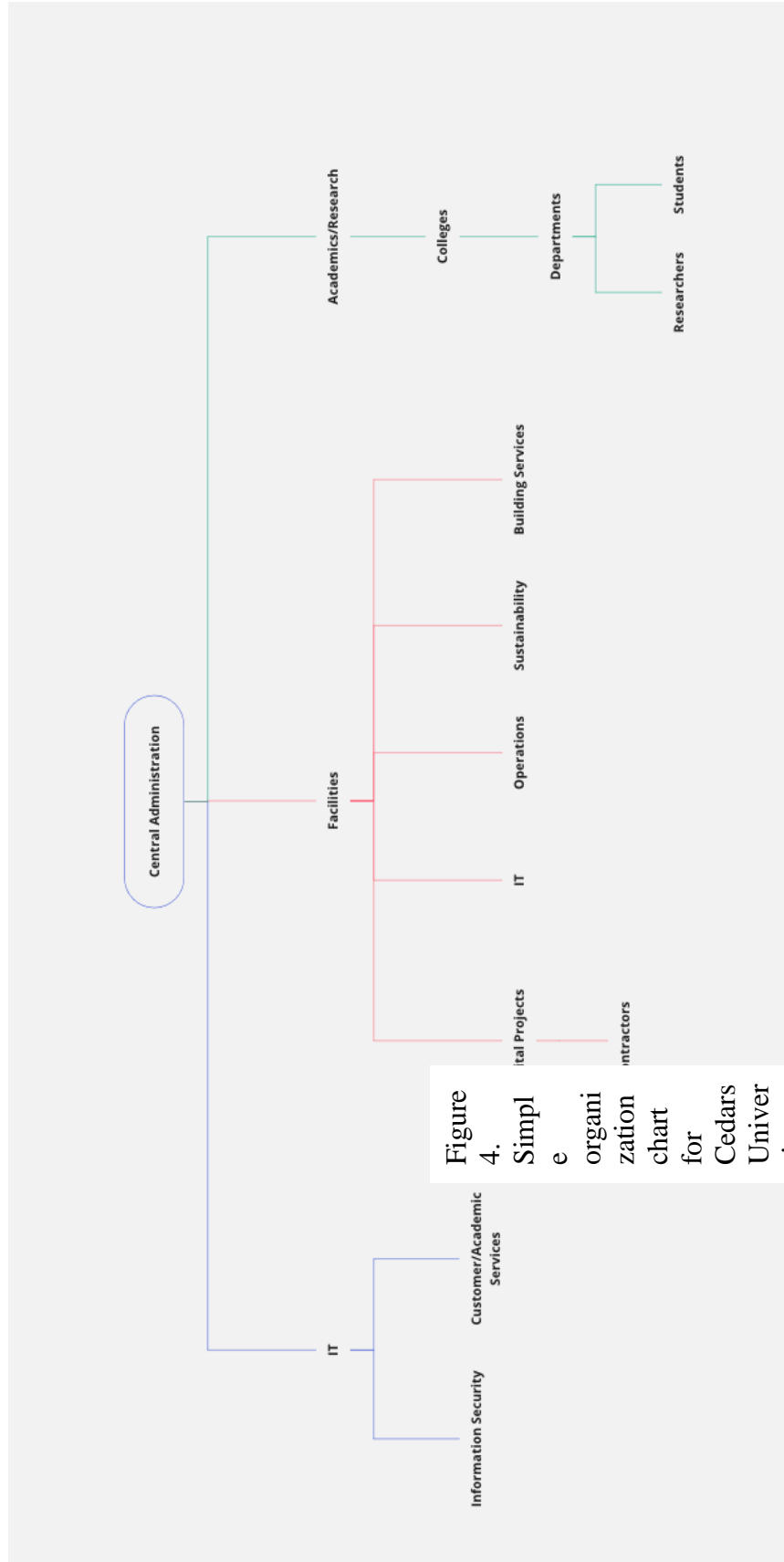


Figure 4. Simple organization chart for Cedars University

Driven by values: Infrastructuring publics and a new organizational configuration

Rather than remain adhered to the administrative presentation of the organization chart in Figure 4, I examined the values that drive participants based on analysis from interviews and participant observation. The administrative organizational chart provided a framework that I held loosely to make sense of the situatedness of each participant in the organization. However, to define their place within the organization and in relation to others I privileged how participants talked about the organization and their work rather than where they sat within it administratively, following McClellan and Deetz (2012), Considering values as drivers of their work, four infrastructuring publics emerged from my analysis. Like infrastructure itself, these publics are relational and constantly being renegotiated, however, they offer a richer understanding of the drivers of participants in their work with “smart” infrastructuring and a greater visibility of work at an institutional level. This analysis does not purport to include all possible driving values for work with “smart” infrastructuring projects, but instead reflects those values that emerged from the data analysis as salient and meaningful in the interactions observed between publics. As presented in Figure 5, three primary work values emerged from the data: “Smart” infrastructuring, environmental and economic sustainability, and infrastructural maintenance.

“Smart” infrastructuring as a work value reflects the values of technosolutionism that privilege “smart” technology introduction as the driver of change to collective relationships to the built and natural environment, work, and social life. Environmental and economic sustainability as a value reflect a dual interest in minimizing the energy resource consumption on campus for environmental and economic benefits, this often—though not necessarily—involves “smart” infrastructuring as a solution. Infrastructural maintenance as a value focuses on the

sustained operability of infrastructures—“smart” and non-“smart”—and places value on maintaining infrastructures that already exist over adding new things.

Introducing infrastructuring publics

With significant values defined, I mapped each of the stakeholder groups represented by my participants onto a diagram to understand where values alignments were taking place. What emerged were at least four infrastructuring publics that allowed me to continue my analysis in subsequent chapters in meaningful ways. These publics were not static and depending on the context of their interactions and the infrastructuring work taking place at a given time their alignments were subject to shifts. The presence of a user/occupant group in a shared public “bubble” in Figure 5 should not be read as evidence for coordination between the groups, but that they share values in regard to “smart” infrastructuring investment and integration.

Communication and coordination activities—or lack thereof—will be examined in the following section. I will introduce each public starting at the bottom left corner of Figure 5 and moving clockwise.

The primary goals of the combined efforts of information security professionals at Cedars University is to maintain the cyber and physical security of the existing and emergent infrastructures on campus. Building services similarly aim to maintain the safety and health of all user/occupants of the built environment infrastructures across campus and integrate new built environments into their scope of work. These two groups emerge as an infrastructural public with a shared value in infrastructural maintenance which includes both the maintenance of the physical and cyberinfrastructures that sustain Cedar University’s operations. However, as explored in the next section (and more deeply in subsequent chapters) this values alignment does not necessarily translate to coordination or communication between these groups.

Moving to the “Smart” Innovation value circle are the Design/build contractors. This user/occupant group works on a project-by-project basis with the university and are driven by the donor/funders desire for state-of-the-art technology. Thus, their goals align most strongly with "smart" innovation as they will not be tasked with maintenance or sustainability. Because they work on project contracts, which end with a project handover to building owners, there is less incentive to prioritize the longevity of systems and the operations of infrastructures beyond the handover date. There are exceptions to this especially regarding warranties that keep contractors involved in the project after the construction is done, but there is generally less incentive to worry about the long-term impact of “smart” innovation decisions as these teams have likely already moved on to the next project before the impact of these systems emerges.

Relatedly, Capital Projects has a dual goal of positioning the university as a leader in new technology in campus buildings and making sure new infrastructure is awarded the highest possible ranks for sustainability metrics (like LEED certifications). This user/occupant group is largely driven by donors who represent the funding for many new construction projects on campus. Researchers, students, and sustainability staff share the dual goals of promoting, funding, and administering sustainability innovations with a particular focus on "smart" or data-rich sustainability approaches. Thus, these user/occupant groups represent an infrastructuring public between “Smart” Innovation and Economic and Environmental Sustainability as indicated in Figure 5.

Finally, Facilities IT and Operations share dual goals of infrastructural maintenance and environmental and economic sustainability. However, these interests are not explicitly "smart" and are much more tied to energy efficiency on a campus-wide scale rather than though "smart"

tech interventions. When "smart" infrastructure interventions are introduced, this public errs on the side of infrastructural maintenance of operations.

It should be noted that this visual representation of infrastructuring publics at Cedars University is not perfect and there are individuals within each group who have personal or professional alignments that deviate from what has been presented in this section.

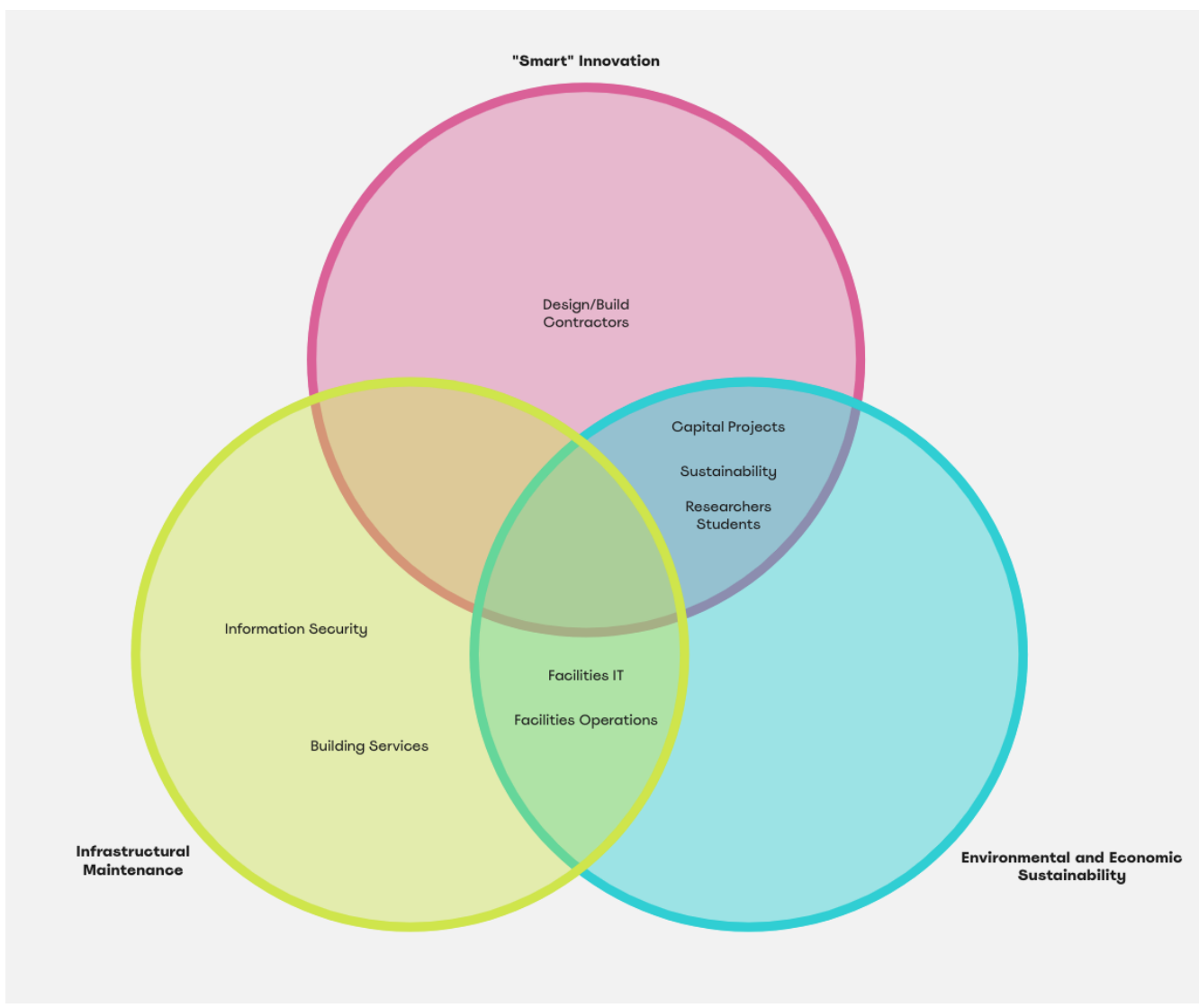


Figure 5. Values driving infrastructuring publics

Alignments and Tensions: Communication, Collaboration, and Values for Infrastructuring Publics at Cedars University

Value alignments and tensions, as represented in Figure 5, can illuminate possibilities or obstacles for communication and collaboration. As previously noted, the traditional organizational chart lacks the nuance or flexibility to respond to changes in communication or collaboration practices, much less shifts in collaboration needs in response to emergent technology. However, as an artefact of aspirational or historical organizational structures, it is a helpful heuristic. In Figure 6, I present the organizational chart with additional layers. The first layer is the green box surrounding those infrastructuring publics whose participation in the study was central to the ethnographic data collection. These are the user/occupant groups who were represented at both strategic administrative meetings as well as design/build project team meetings. Their communication and collaboration were most robust, as indicated by the formation of ongoing meetings between their members. Less robust are the collaborations and communication practices between those user/occupant groups identified outside the green box. These user/occupant groups either emerged as important stakeholders in “smart” infrastructuring projects based on conversations with those within the green box, or through investigation of outside user/occupant groups. As noted in Chapter II, the inclusion of some user/occupant groups was based on my own theoretical purview from a politics of care standpoint.

Reading Figure 5 alongside Figure 6, it is worth noting that there are values alignments that are not operationalized in communication or collaboration. Just because user/occupant groups might have shared values, does not mean they necessarily communicated with each other or collaborated in pursuit of their values in any meaningful way. In these instances, there may be potential for more effective collaboration and communication, in others, value misalignments substantiate siloes. The solid red lines connecting user/occupant groups represent communication

and coordination between respective groups. In the case of Sustainability, analysis of communication and coordination practices made clear that this group was actively working with capital projects, researchers, and students. The role of sustainability—as an organization and an underlying value alignment—pervaded many different user/occupant groups and as such represented a powerful infrastructuring public at Cedars University.

In terms of a lack of communication or coordination, Building Services was of the most siloed group represented in Figure 6. Despite being a faction of the larger facilities organization, Building Services, which included custodians, window washers, access controls, and other departments, was largely left out of high-level strategy meetings regarding “smart” infrastructuring. This lack of coordination had implications for the maintenance and care for Cedars University’s campus as will be explored in Chapter VII. In Chapters IV and V, the values tensions are explored between those infrastructuring publics who aligned with “Smart Innovation” and “Environmental and Economic Sustainability” and those who aligned with “Infrastructural Maintenance” in Figure 5.

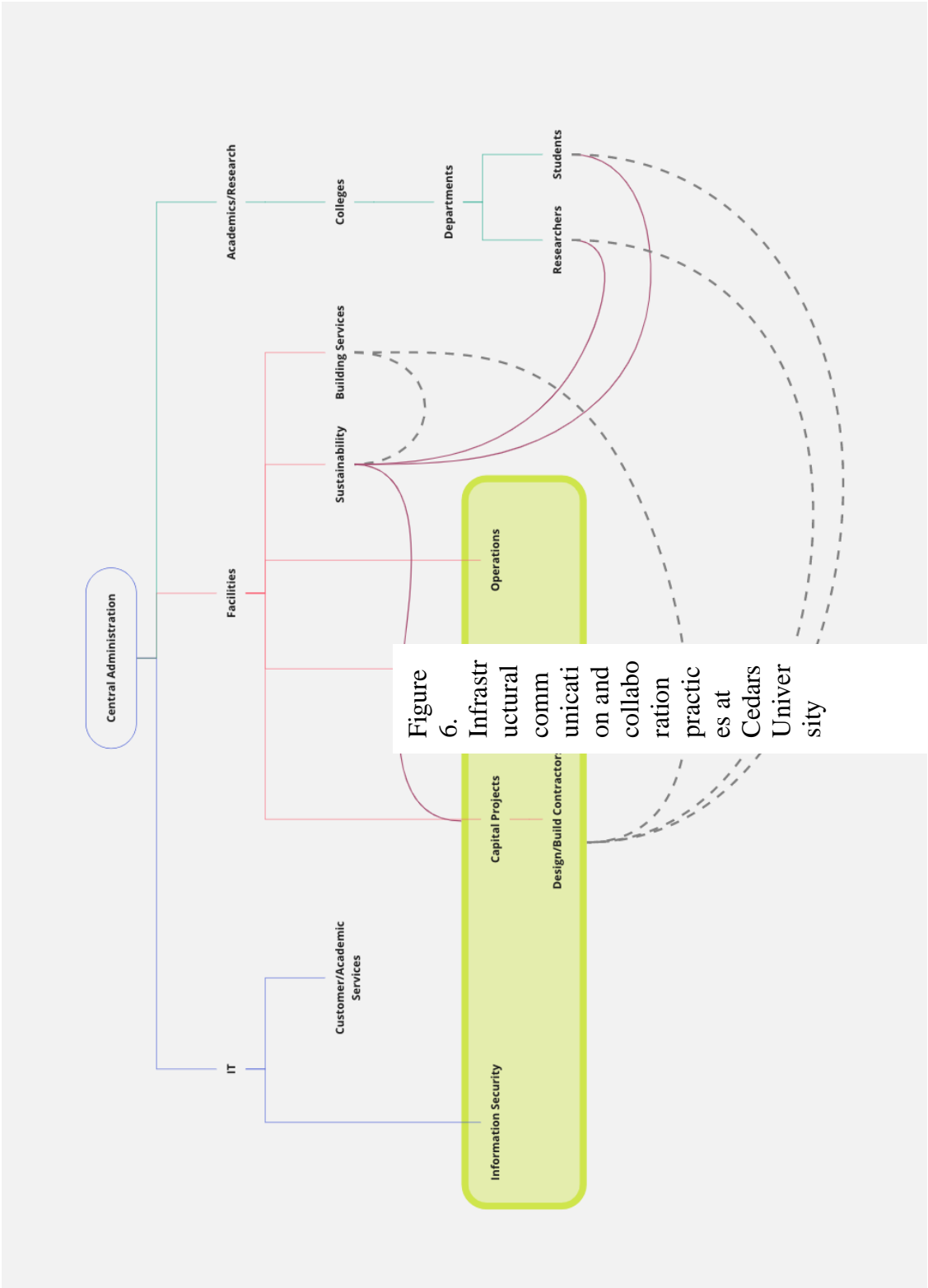


Figure 6. Infrastructural communication and collaboration practices at Cedar University

This chapter serves as a guide for the reader moving forward. In the subsequent chapters, the value alignments, and misalignments between infrastructuring publics are explored more deeply. In the next chapter, I explore the contradictions that have driven action at Cedars University regarding “smart” infrastructuring. These contradictions surface from value alignments among some user/occupant group and misalignments with others. While this chapter provides a contextual foundation for the rest of the dissertation, the next chapter provides analysis that introduces the underlying, action-spurring, contradictions that can be read as the animating forces for chapters V, VI, and VII.

IV. Contradictions in Sustainability: Communication and Practice Among Infrastructuring Publics on a “Smart” Campus

Introduction

The practices of multiple publics that interact during new infrastructure projects constitute infrastructuring. At Cedars University, and many other large public universities in the United States, new infrastructure projects are largely financed by capital funds while the maintenance and care for existing and future infrastructure operates at a deficit. The focus of this chapter is the communication and organizational practices that impact the power that certain infrastructuring publics have over infrastructure decision-making and the underlying political economy that constrains these activities. Through analysis of these practices, the enactment of different definitions of sustainability emerged as an indicator of infrastructuring public alignment across the university. Therefore, sustainability definitions represent the objects—or desired outcomes—driving action for respective publics.

Engeström (1987/1999b) posits that activity systems are the result of four levels of contradictions and corresponding epistemic actions. Action, in CHAT terms, is often individually directed and temporally short, but if action is expanded to activity, it can become part of a larger and longer cycle (Engeström, 1999a). These cycles are considered expansive in that they are not indicative of failure, but rather opportunities for development or growth. While a focus on expansion in this definition can be read as optimistic, it is also a mechanism by which contradictions are unveiled and their impacts are examined.

This analysis employs contradiction as defined in CHAT as the engine of action in an activity system. Contradiction in a CHAT analysis goes beyond colloquial use of the term that

connote paradoxes or conflicting views. Rather, in CHAT, contradictions respond to a view of “human activity and social order as interpenetrated with systemic, irreconcilable contradictions between inherently oppositional forces” (Foot & Groleau, 2011). This definition of contradictions draws upon the dialectical foundation of CHAT which is interested in the “the ascent from the abstract to the concrete” (Foot, 2001, p. 65).

This chapter employs this definition to examine the contradictions that drive action at Cedars University in relation to “smart” infrastructuring projects. In so doing, I argue that the systemic and irreconcilable contradictions between infrastructuring publics are a response underlying political economic realities that have stymied effective communication and collaboration. In the subsequent chapters the reverberations of these contradictions are examined in specific case studies.

This chapter will examine communication silos as they emerged through the building process at a large university. These findings are based on ethnographic data gathered during simultaneous building projects and enduring maintenance and care efforts include participant observation of meetings and conversations among and between Architecture, Engineering, and Construction (AEC) teams, Operations & Maintenance (O&M) teams, Information Technology (IT) teams, and Building Services teams. As described in depth in chapter II, participant observations of design-build meetings, strategic campus infrastructure meetings, as well as in-depth interviews with participants across these groups, were analyzed using CHAT. This analysis leverages Foot and Groleau’s (2011) explication of the cycles of expansive learning as defined by contradictions and their corresponding epistemic actions.

The overarching contradiction of a "smart" campus, found at Cedars University, was that design and construction teams, under the guidance of capital campaign leadership and donors,

operated with a cultural and historical appetite for technosolutionist approaches to sustainability. This orientation to sustainability was privileged at the expense of a maintenance and care approach to sustainability, which was championed by O&M, IT, and Building Services. Either side of this contradiction had a distinct approach in their treatment of technology as a tool toward their respective objectives. Technology is used generally in the chapter to refer to a whole host of devices and systems as well as the assemblage of devices and systems with buildings, energy infrastructures, and networks (Osburn, et al., 2021). It is worth noting that the precipitous rise in “smart” technologies is inextricably linked with this primary contradiction. It is not the aim of this chapter to interrogate what “smart” technology and systems are most/least useful toward these aims, but rather to investigate the cultural values that inform technology introduction and integration into an organization, following technocultural theory (Pacey, 1983). When technology and technosolutionism are referenced in the analysis, they encompass the assemblage of networked technologies in “smart” building paradigms as well as the cultural values of innovation that precipitate their design and construction.

Evidence of contradictions in building and maintenance processes, I argue, is the result of power disparities between those participants who defined sustainability through a technosolutionist lens and those who defined sustainability as maintenance and care. Therefore, each contradiction presented through the analysis of the cycles of expansive learning evidence cultural-historical power disparities as communicatively constituted and perpetuated. While some actions were already being taken to counter this pattern, the perpetuation of this dynamic in the activity system at hand was continuing without change to policy and practice. The chapter ends with some design and policy insights and suggestions for future research.

This chapter is a foundation upon which the subsequent chapters are built because it closely examines the irreconcilable contradictions between infrastructuring publics as they formed within the enduring political economic structure of the institution. The primary contradiction permeates activity across multiple infrastructures and as such is examined and defined here in order that the reader can refer to it in reading about specific cases in which this contradiction manifests in practice, presented in Chapters V, VI, and VII. At its core the primary contradiction is a political-economic one (Engeström, 1987). However, it can be observed in the communication of definitions of success as articulated by participants. The definitions of success for a “smart” or “not-so-smart” campus as articulated by distinct infrastructuring publics at once instantiate those publics as distinct and provide a heuristic for the enactment of the primary contradiction. The primary contradiction is in fact, a series of contradictions and epistemic actions which will be analyzed as a cycle of expansive learning following the work of Engeström (1987) and Foot & Groleau (2011).

The Deferred Maintenance Crisis

Primacy is often given to the innovative and aesthetically pleasing aspects of new infrastructure projects over the maintenance and care labor needs. Those leading the charge toward innovation and investment in new infrastructure projects often have more power than those whose objective is the care for and maintenance of new and existing infrastructures across an institution. Despite interventions to reconcile this power disparity and include maintenance/care-centered design insights into new infrastructure projects, technosolutionist innovation toward a particular definition of sustainability and its associated aesthetics are prioritized. These design choices are the result of siloed communication between workers tasked with maintenance/care and those who commission, design, and deliver new infrastructure to the institution. This power disparity,

communicatively constructed, has implications not only for the maintenance and care workforce that is increasingly overburdened and underfunded but also for the institution and the larger community of users as critical facilities fall into disrepair. The eventual disrepair of facilities contradicts the overarching objectives of innovation and sustainability-driven decision-making.

CHAT Contradictions in “Smart” Campus Infrastructuring

Mapping the activity systems emerging from the infrastructuring publics of maintenance/care workers and building teams onto an expansive cycle of learning helped articulate the implications of the cultural and historical context in which these systems are enacted and their possible trajectories. Primary contradictions “stem from the opposition between use value and exchange value in capitalist political economies” (Foot & Groleau, 2011). Thus, the primary contradiction endures even as secondary, tertiary, and quaternary contradictions prompt epistemic actions. In the case of “smart” campus infrastructure projects, the primary contradiction is the result of a political-economic system of the public university that privileges technoscientific innovation over maintenance/care work. As infrastructuring publics move through the cycle, subsequent contradictions harken back to this enduring and intractable contradiction. However, it is not clear that the cycle of learning evidenced in the present analysis is expansive. It instead appears to be divergent in that different orientations to care, emanating from the primary contradiction, have resulted in the emergence of two different campuses. On one hand, infrastructures that align with a technosolutionist orientation to sustainability are compatible with the funding structure of capital funding and therefore get the institutional support needed to move forward. On the other hand, existing infrastructures that no longer fit within this orientation to sustainability and conversely necessitate maintenance/care investment were left to fall into disrepair. The great irony of the contradiction is that even the most cutting-

edge, technologically advanced, and sustainable infrastructures will one day be old and in need of maintenance/care. In fact, this day is in the not-so-distant future as it relates to the maintenance/care of networked systems that are increasingly complex and “buggy and brittle” (Townsend, 2013).

The secondary contradiction, as articulated by Foot and Groleau (2011), “prompts the latent primary contradiction in the activity system to surface and take the form of a specific problem as tension builds between different parts of an activity.” In the case at hand, the secondary contradiction emerges in the celebration of new infrastructure projects as this tension becomes visible to different publics, thus, prompting reactive action on the part of maintenance/care as they try to make sense of the often-unanticipated and enduring impacts of celebrated innovation. The third level of contradiction involves the introduction of another object into the activity system. It is at this level that power relations become visible. The tertiary conflict presented here is prompted by a history of failed attempts by the maintenance/care workers to have their needs met by building teams. Finally, the quaternary contradiction is a reaction to the power relations and epistemic actions of the previous levels. Maintenance/care teams are forced to make choices about what to maintain and care for. In what follows each level of contradictions and their corresponding actions are explored. See Figure 7 for a visual representation of the cycle.

Primary Contradiction: Technosolutionist Sustainability vs. Maintenance/Care Sustainability

Technosolutionist sustainability was privileged over maintenance/care sustainability in the treatment of new and existing infrastructure on Cedars University’s campus. This dynamic emerged from the aforementioned capital funds system that excludes maintenance/care in budgeting for building and construction and the simultaneous deferred maintenance crisis. In

addition to academic and journalistic analysis of this issue, the recurring reminder of this dynamic played into the conversations between O&M, IT, and Building Services teams. David, who works in O&M with a specific focus on IT components in facilities, worked as a liaison between the building teams and the maintenance/care teams. Articulating the primary contradiction, he made clear the tensions between what the maintenance/care teams need and what institutional leadership is willing to give:

If you asked our shop folks, they would say labor is number one. And that's the competing factor because our leadership said, "you can have anything you want, except for more labor." Well, our shops are saying, "the only way we can take care of all these buildings, the old ones and new ones, is if we have more labor." So, you got one saying, "no". One is saying "this is what we need."

This tension was similarly shared by Owen, the Window Washing Team Manager. He and his team faced the labor issues highlighted in the previous excerpt. In Owen's view the institutional privileging of new infrastructure projects went against his own conception of sustainability as maintenance/care:

What it appears like is you're okay to have these buildings fail because you're going to go secure funds to go build a new building on campus instead. And in that process, what you're doing is you're letting a building fail, you're not maintaining it, you're using funds to build a brand new building, which is only adding more work to the maintenance worker.

These two interview excerpts represent a recurring theme in other interviews with maintenance/care-oriented staff as well as exchanges that took place in infrastructure strategy meetings that brought together various collaborations between O&M, IT, and Building Services. The primary contradiction in this cycle of expansive learning was a dichotomy between innovation and maintenance/care that was enacted through financial practices which in turn constrained labor practices. This contradiction was enacted through the *inaction* of institutional

leadership in response to the labor needs of maintenance/care teams. This lack of action set up the subsequent cycle and epistemic actions.

Secondary Contradiction: “It would be like having a house built for you, but you have no say in it.”

The institutional preferences for continual new infrastructure construction even as older infrastructure fell into disrepair constrained the possible activities for both the building teams and the maintenance/care teams moving forward. The lack of power that maintenance/care teams had on the construction of their own workplaces is perhaps not surprising. How many of us have much say in the construction of our workplace? However, what was notable is the ways in which this socio-economic system was substantiated in the communication of what makes a project successful. It is not just a matter of numbers. The strains on labor in maintenance/care for the campus’ built environments would be an issue if new buildings were being constructed with a similar level of technological complexity as the existing infrastructure on campus. However, the labor issues were augmented by the fact that not only are these projects increasing the overall square footage of maintenance/care teams’ responsibility but were more technologically complex due to the integration of networked systems that were touted as “smart” and/or “green.” These words signified to the maintenance/care teams that the new infrastructure project included new networked sensors and systems which required special knowledge, care, and maintenance. The rationale for this type of infrastructure getting prioritized even as existing, and sometimes historically significant buildings went into disrepair, is in line with the market logic of technosolutionism and data extractivism. “Smart” and “green” buildings, and all their rooms, halls, and even bathrooms, become new sites for the extraction of data to be monetized, analyzed, and visualized. On its own this might not be enough to rationalize the added complexity, however, communicated as a means for achieving sustainability goals, it became

much more compelling for the institution, the donors, and the larger community of users/occupants. Many existing buildings were also being retrofitted with some of these same networked systems, however, retrofitting is often more complicated and costly as it requires existing and new infrastructures to be integrated, a laborious and technically complicated process.

Prestige and public relations have a considerable influence, on this, and certainly many other sustainability efforts. Most of the building projects referenced by participants in in-depth interviews and participant observations were ongoing or had been completed in the past five years. “Smart” and “green” design of new buildings on campus resulted in LEED certifications, national architectural awards, and a deluge of positive press for the university, as well as the construction teams and contractors involved in the projects. However, maintenance/care teams who often only learn about the building’s components and the impact on their responsibilities after the handoff, were left scrambling to integrate the building’s needs into their already strained workload. The amalgamation of aesthetic and technosolutionist design decisions resulted in inefficiencies, safety concerns, and disrepair—all of which, in time, will lessen sustainability or environmental impact of the infrastructure. Louis, a Building Services Manager who led a team of over 60 custodians on campus, noted that LEED buildings present maintenance/care staff with operational challenges:

We have to be careful of not damaging it when we clean this stuff, you know. So, new buildings that come online, they're smarter, you know, they're green, you know, they're green-sealed, they're LEED-certified buildings, and all this means is there's a bunch of materials that are, you know, natural or man-made or whatever, you know, and boy, does it take a little more care, you know, versus just good old fashioned linoleum plastic or floor that you can't damage, you know.

The concerns Louis shared highlight the enmeshing of aesthetics in technosolutionist sustainability in the built environment. In addition to flooring materials, Louis noted that lighting

systems, newly made “smart”, can create trouble for custodians who are often in the buildings outside of normal business hours. Noting the impact on her own work as a custodian, Lilian, reached out to her manager in hopes to get educated on the new technologies in the building to which management told her: “You need not be concerned.” The maintenance/care teams have responded to changing infrastructure by forging new relationships with building teams including project managers on new construction and building managers who take over after construction is complete. The secondary contradiction of this cycle emerges as a tension between short term-goals (e.g., certifications and awards) and the long-term viability and operability of Cedars University’s shared build environments which require maintenance and care. This labor cannot be deferred too long because lasting damage to existing and new infrastructures are evident.

Tertiary Contradiction: Maintenance/care team input has mixed results

Maintenance/care teams were not averse to technosolutionist sustainability investments. Custodians were excited by the new systems that use solar energy to power the building and were keen to have more automated access controls implemented on new and older buildings (this particular “smart” technology application is explored more deeply in Chapter VII). O&M teams were eager to make campus more energy efficient using “smart” metering that allows for almost real-time energy usage data. There are many applications of “smart” and “green” technology that aid in efforts toward preventative maintenance (Wong et al., 2018). However, the decision-making for new technology and design for “smartness” or “greenness” is typically siloed from the maintenance/care teams. This was actively being challenged at Cedars University with varying levels of success. Two stories from different “smart”/“green” infrastructure projects illustrate the tertiary contradiction that emerged in the cycle of expansive learning: that

maintenance/care professional input is not routinely implemented into new infrastructure projects.

Owen, the Window Washing Manager, communicated to leadership his need to work with building teams to make sure his team had a voice in the decisions made regarding rope access or swing stations—two methods for window washing on large buildings. His goals were efficiency and safety for his crew. He was pleased to have been able to meet with the project manager for a new LEED-certified building on campus. The project manager told him about the design of the windows that include fins that work to create not only aesthetic appeal to the outside of the building but are integrated into the passive solar elements of the buildings' energy systems. The project manager, as Owen recalls, came to him to ask about his “reach” for cleaning the building. Part of Owen's considerations with safety includes the ergonomics of window washing. Maintenance/care work is often embodied (Grosz, 1994; Wolkowitz, 2006; Fine, 2006; England & Dyck, 2011), and body ergonomics is a sustainability consideration for building services that considers the safety and wellbeing of workers as an important part of holistic sustainability. Owen communicated to the project manager that, based on the average length of the human arm, he and his team could reach a maximum of 18-24 inches to get their hand on the glass. Despite his consultation, at the next meeting, it was announced that the fins would be 32 inches wide therefore requiring Owen and his team to use extension poles, disturbing ergonomics, and potentially impacting the safety of their work. The building had not yet necessitated window washing as it had not yet opened. However, based on another LEED-certified and “smart” building that was two years older on campus, these design decisions can lead to neglect on the part of window washing and other maintenance/care teams. Similar fins on

another building resulted in Owen's team avoiding cleaning the windows altogether. This older building included solar window fins which add another layer of safety concern. As Owen noted:

Through time those fins with the glass exterior are going to get dirty. Which is going to lower the efficiency of how much energy is being produced by a solar fin. So, eventually, we need to go in there and use water around electrical devices to clean and there's no way to shut off a solar panel. Once light hits it its job is to just start producing electricity so there's a question about how to go about cleaning solar fins and solar panels. And how to shut off the power, so that people don't get electrocuted by using water on these devices.

Owen's concerns were not addressed by institutional leadership. As such, he had instructed his team to neglect cleaning the windows and solar fins on this building and prioritize other, more traditionally built buildings.

On the same existing LEED-certified building, Daniel, a Facilities IT team member, shared the story of another aspect of the building that has already gone into disrepair because the technology used is complicated, maintenance teams are not properly trained on it, nor do they have the capacity to take on its repair and maintenance. The building had an adjoining greenhouse used as a laboratory for biological science departments. The greenhouse included a system that used rainwater catchment from the main building's roof to irrigate the plants as well as a retractable greenhouse roof that used networked light and humidity sensors to determine when and how much to open the roof to let in sun and air, saving energy costs. Two years after the acclaimed opening of the building, the greenhouse roof was broken rendering these systems ineffective. As David put it:

Instead of having a manual turn crank that we know the levers will open and close, well someone decided to make it super exotic, and now they're stuck with a building greenhouse it doesn't work at all. Because they wanted to be able to showcase that we're innovating with technology, and how we're cutting edge with our building systems, and everything is – you think it, it'll do it. Instead of the old ways of manually pushing a button every time you need it to work.

The tertiary contradiction in the cycle emerges between the desires of donors, building owners, and vendors and the desires of those who will inevitably be responsible for the maintenance/care for these build environments. Taking these stories into consideration, many participants across the maintenance/care teams communicated the need for coordination and collaboration with building teams. While this communication was seen as key to mitigating the contradictions of maintenance/care sustainability and technosolutionist sustainability orientations, the above stories show that it was not enough to remedy the problem. Despite interventions by maintenance/care teams in design and construction meetings, the needs of this infrastructuring public were often overlooked and innovation teams (AEC, Capital Funds, owner representatives, and vendors) led the design decision-making process. Maintenance/care staff were forced to react to these decisions rather than being given a voice in them.

Quaternary Contradiction: “At some point they are probably just going to be ubiquitous.”

The drive toward technology innovation, which is emboldened by capital funds, led building teams to integrate new technologies which were outpacing the cultural and organizational shifts necessary to their future maintenance/care. There was a sentiment of the inevitability of innovation, along the lines of ubiquitous computing (Weiser, 1993), which furthered the narrative that maintenance/care teams were oppositional to innovation, when in fact they were often celebratory of innovation so long as the innovations did not actively impede their maintenance/care for the built environment.

Andy, a construction manager who worked on the previously referenced building projects, understood the communication struggles faced by the maintenance/care teams. His position rendered him privy to both the perspective of the building teams and the

maintenance/care teams. In his view, discretion is necessary when designing new buildings because some innovative systems can cause more harm than good. The building teams have taken a more cautious approach to introduce some networked systems. Andy shared:

I think the university has probably avoided automated shades, which is not a bad thing. They're a maintenance issue, for sure, but they're just something that's becoming more and more common, and at some point, are probably just going to be ubiquitous. So, it's kind of one of those things.

The ability to stymie new technologies in emergent infrastructure projects was often treated as a losing battle, or more appropriately as a means for holding off, if possible, in hopes that maintenance/care workforces and budgets will eventually allow for proper maintenance/care sustainability practices. Innovation in building projects outpaced the cultural shifts necessary to achieve maintenance/care sustainability. Efforts by leadership in O&M, IT, and Building Services to introduce team members to these meetings early and often showed some promise.

Andy continues:

[Maintenance/care teams'] voice gets filtered through levels of bureaucracy, and what's important kind of gets missed. But I think we've gotten to a point at the university, now, where those guys are back in the room, and we're having those discussions. And it's a really important voice, because at the end of the day, the contractors or all these consultants, we all go away and go to the next job. Those guys have to live with this stuff forever.

Contradictions and subsequent tensions that have endured through previous projects informed new practices of communication and participation by maintenance/care teams in future infrastructure projects. While this strategy showed promise, it fell short of addressing the underlying labor shortages and endemic budgetary crises. However, maintenance/care teams were turning to design standards as a path to substantiating their needs and requirements for future infrastructure projects. One concern with relying too heavily on standards is that, as a means of negotiating power over the design and construction process, standards may not have

enough teeth for capital projects where donor desires for innovation and technosolutionist sustainability metrics continue to trump maintenance/care sustainability needs. The quaternary contradiction is thus between the need for maintenance and care for existing infrastructures on Cedars University’s campus and the drive for new “smart” infrastructures with little recognition of the implications their addition may have to the existing workload of those in maintenance and care roles. See Figure 7 for a visual representation of the cycle of expansive leaning and contradictions.

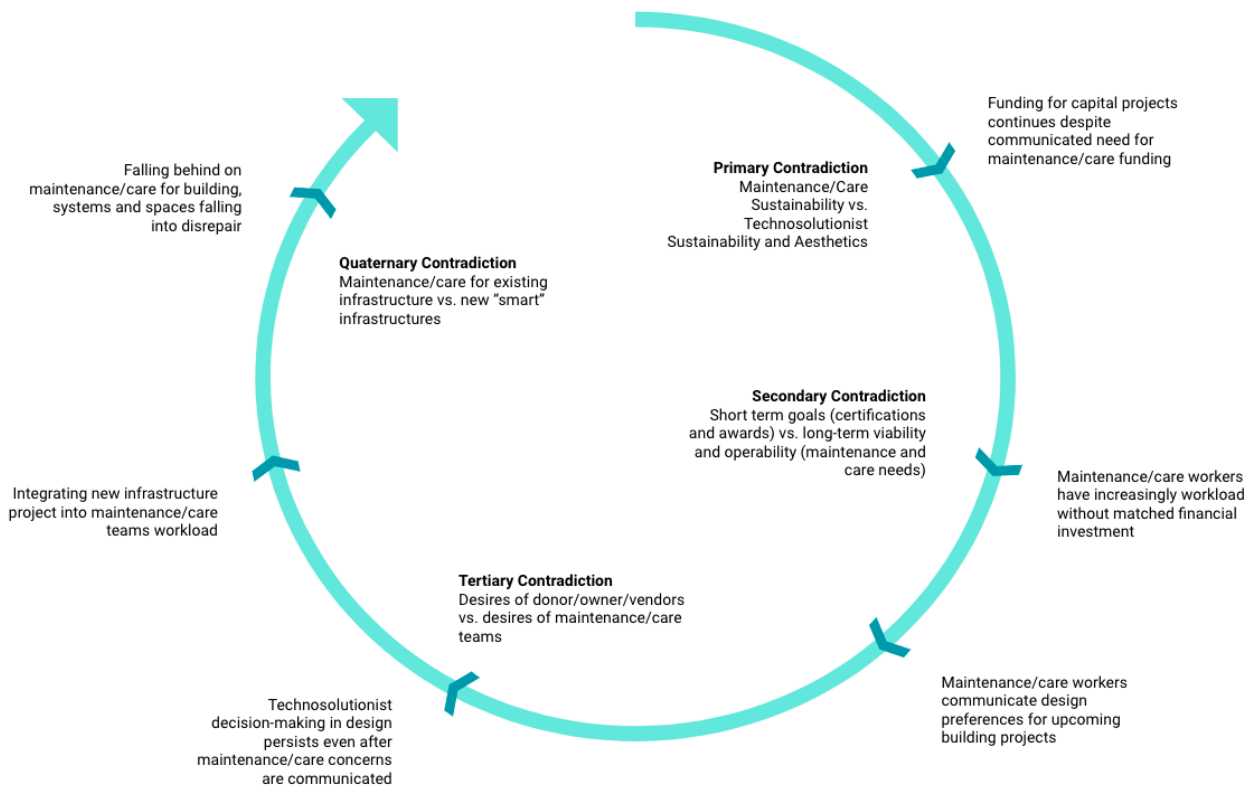


Figure 7: Cycle of expansive learning for “smart” campus infrastructure project

Conclusion

This analysis brings together the stories from participants representing a maintenance/care orientation to sustainability as they responded to recent and current building projects. An enduring contradiction between technosolutionist sustainability and maintenance/care sustainability orientations emerged from these stories and the trends which they illustrated. The subsequent epistemic actions and secondary, tertiary, and quaternary contradictions enabled thinking toward future trajectories. One such trajectory is the future of two distinct campuses. Without increased coordination and collaboration between maintenance/care teams, building teams, and institutional leadership with control over budgetary decisions, the future of infrastructuring on campuses, like Cedars University's, involved a widening divide between new and old infrastructures. The new infrastructures came to be dominated by "smart" systems and increasingly incompatible with legacy systems. Older buildings began to fall into disrepair as newer and more technologically complex buildings demanded outsized labor from maintenance/care teams. In the future, this may result in the instantiation of investment in certain schools and colleges over others, likely reflecting a divestment in humanities and increased investment in STEM fields. However, based on the ethnographic and interview data presented here, it seems more likely that what will happen is that maintenance/care teams will continue to be spread too thin and must partially neglect both new and old infrastructures. This will likely lead to technosolutionist sustainability efforts, like those solar fins referenced earlier, being insufficiently maintained/cared for, and falling short of their promised outcomes.

The contradictions and activities examined above illustrate the need for maintenance/care design considerations early in the design-build process. The integration of this collaboration was

recognized by some of the participants and was in the process of being codified in standards and institutional practice.

In the next three chapters I build on this foundation to examine how these contradictions and the actions they precipitate play out in three cases. Chapter V examines more deeply the definitions of success that drive action to introduce more “smart” technology on campus by sustainability infrastructuring publics. Based on a technosolutionist orientation to sustainability, this public engages in practices of data care based on a particular set of values and expectations for “smart” infrastructure data. Chapter VI explores the relationship a very different public has to the same set of data and their generating devices and systems. The combined efforts of IT and O&M on Cedars University campus act on an orientation to sustainability that is fundamentally based on maintenance/care for the whole network of infrastructures impacted by new “smart” systems. The publics centered in Chapter V and Chapter VI respectively, are based on different definitions of success regarding “smart” infrastructuring which inform their orientation to care for the data and actions in infrastructuring. In Chapter VII, I analyze the perspective of an often-overlooked infrastructuring public—building services—finding that the relationship the personnel of building service has to “smart” infrastructure is determined less by values and expectations for data than by the operability and security of the built environments in which they work.

V. Care for Data: Sustaining Data Access for Knowledge Infrastructure

Despite renewed interest in care work, due in part to the widespread suffering and increased visibility of our society's collective reliance on care workers during the COVID-19 pandemic, orientations to care that are in conflict are not often discussed. Care work, the foundation of the social and material infrastructures supporting the continuation of life, is primarily discussed in the context of healthcare, domestic work, and other social service realms (England & Dyck, 2011; Ismail et al., 2018; Kaziunas et al., 2019; Dye, 2021). A feminist political economy of care is analyzed in contrast with capitalist logics, technosolutionist progressivism, and extractivism (Puig de la Bellacasa, 2015; Bhattacharya, 2017). In practice, workers of various disciplines in various workplaces engage in care work that may come into conflict with other practices of care work in the same setting. To stretch the term beyond the traditional bounds of healthcare, domestic work, or social service settings provides insight into the complexity of care as non-innocent (Murphy, 2015). Our orientations to care -- who/what we care about, who/what we care for, and who/what receives that care -- can be in conflict even within a single community, institution, or building.

Applying theories of care to work with data is still a nascent body of scholarship (see Pinel et al., 2021). To date, investigations of data care in the university context have been limited to the role of data care work as it relates to research data paradigms including open-data (Kitchin, 2014), eScience (Baru, 2007), and DSSG (Tanweer et al., 2016). These data paradigms, and the data care work they require, are important to understanding how labor with data functions in a university. However, extant research has largely centered on researchers as data care workers and has yet to attend to the increasing data care work necessitated by a broader

cohort. Growing numbers of “smart” technologies in the built environment are resulting in an expansion of data work into the work of maintenance/care for the built environment.

Environmental and sensor data gathered by “smart” technologies embedded in the built environment is of interest to a diverse set of user/occupant groups. This chapter will explore the data access interests of researchers and administrators working toward institutional sustainability goals. In what follows, the contradictions presented in the previous chapter are analyzed more deeply with special attention to the case of a specific sustainability research effort at Cedars University. Fiore-Gartland and Neff’s (2015) data valence typology is applied to interview and observation data to analyze the values and expectations that drive the extraction of environmental data for the purpose of meeting sustainability goals. Extending their original empirical setting regarding personal data for health and wellness, Fiore-Gartland and Neff’s (2015) typology works well as an explanatory framework for the data practices and discourses in the context of a “smart” campus. However, as evidenced in the previous chapter, there are contradictory practices and discourses with data that merit explanation. This chapter takes up sustainability efforts that hinge on the extraction of a large amount of data – as a function of what has been previously referred to as technosolutionist sustainability -- and examines more deeply the interweaving of sustainability and “smart” infrastructure discourses through tensions emerging from the perspective of sustainability/research stakeholders at Cedars University. Expanding on the data valence typology, I argue that sustainability/research interests in this vein represent an infrastructuring public with a particular definition of care for data. This perspective positions this infrastructuring public in tension with IT and O&M groups on campus who have a very different orientation to data care (which are examined in Chapter V). However, these disparate orientations to data care and the tensions they create are not intractable.

The “Smart” Campus as a Cyber-Physical System

A precipitous rise in Internet of Things (IoT) devices and systems is resulting in increased interdependence between physical infrastructures and cyberinfrastructures. This interdependence is resulting changes to the value of built environments and the nature of work to maintain built environments. Making spaces "smart" - including initiatives for "smart" cities, "smart" campuses, and "smart" homes - has made traditional distinctions between physical infrastructure and cyberinfrastructure increasingly obsolete. Smart initiatives involve changes in sociotechnical systems. Operations of a building, much less a set of buildings, rely on simultaneous and coordinated maintenance of ‘things’, ‘connections between things’, and communication between infrastructuring publics. This is to say, it is no longer enough to define building operability as water coming out of faucets or lights turning off and on reliably. Increasingly, because of complexities in the technical interdependencies of systems, a successful building’s energy infrastructure relies on “smart” technology to record and share usage data reliably and securely. Thus, a cyber-physical perspective better attends to the realities of "smart" infrastructure systems (Lun et al., 2016; Shih et al., 2016).

“Smart” infrastructure initiatives—often identifiable as coordinated efforts to increase use of IoT in infrastructures—are celebrated for their capacity for connectivity and require “a 10,000 foot view of infrastructure planning... matching capacity to demand” (Weiss, 2009, p. 20). While "smart" infrastructures are largely discussed in the context of “smart cities”, as Benson (2019a) has argued, many important implications of “smart city” initiatives are relevant in “smart campus” contexts. “Smart” infrastructures, powered by a network of data generating IoT devices, enable institutional leadership to make use of more data than ever before.

Cyber-physical systems (CPS) are “engineered systems that are built from, and depend upon, seamless integration of computation and physical components” (National Science Foundation, Cyber-Physical Systems Division). “Smart” campus initiatives are an example of a CPS being integrated with IoT, creating infrastructures to sustain built environments across campus. IoT systems get introduced and celebrated because of the data they generate. The work of generating and managing these data are laden with values and expectations that vary across infrastructuring publics.

To make sense of these values and expectations, this chapter leverages scholarship on infrastructure to unpack interdependencies between built, information, and social infrastructures of institutions in a "smart" campus setting. I argue that neither theories of maintenance, repair, and care for complex infrastructures nor theories of data care work alone are sufficient to make sense of the cyber-physical data care work being done on a "smart" campus. Rather, the range of work with data needs to be expanded to attend to the collapsing divide between data care work and care for the physical built environment. This collapse has resulted in new values and expectations for "smart" infrastructure data. However, as this chapter presents, tensions between infrastructuring publics, fueled by disparate data valences, precipitate the introduction of platform delegation. Different values and expectations for data, sustainability, and knowledge production on one hand, and cyber-physical security and compliance on the other, are not easily managed by a single university entity. Despite the recognition of sustainability infrastructuring publics' desire for and claim to data access, the operationalization of this access is beyond what the combined efforts of IT and O&M can take on within their job scope. As such, platform delegation of this work has been proposed as a means for automating secure and regular data access. While I am not under the assumption that this will be a seamless or singular task, it is the

start of a process toward reconciling these two infrastructuring publics divergent orientations to data work.

“Smart” Campus as a “Living Laboratory”

To understand the value of environmental data — and specifically the data extracted from the built environment by “smart” technologies — it is necessary to unpack some of the leading discourses surrounding “smart” infrastructuring projects.

“Smart” infrastructure projects—that is the large scale, coordinated efforts to introduce more connected devices and systems of devices to an institution, city, or community—are often the product of collaborations with universities. Many large research universities, in partnership with tech corporations, are the site for developments in the technical aspects of the tools necessary to connectivity and a stage for the introduction and integration of new systems to an institution’s built environment. Unsurprisingly then, research on “smart” technology implementation has increasingly made use of the “smart” campus context. In an introduction to such partnerships, Abuarqoub et al. (2017) outline the motivations and benefits of “smart” campus projects: (1) Save costs and time; (2) Automate maintenance, (3) Protect the environment, (4) Achieve efficient parking, (5) Student and staff attendance, (6) Occupancy detection and tracking. These motivations and benefits can be seen in more recent work championing the opportunity “smart” campuses create to “automate the process of education” (Zhamanov et al., 2017). According to other advocates, the breadth of what “smart” campus infrastructures are poised to accomplish is impressive and includes the quantification of student engagement in the classroom (Sutjarittham et al., 2018), the ability to turn students into a “smart workforce” (Dong et al., 2020).

To bridge the literatures that approach “smart” campuses largely through the lens of the devices and systems of devices and their features, and those that focus more on the experience of teaching and learning in a new “smart” paradigm, Dong et al. (2020) argue for an economic framework to drive development. In so doing, they evoke sustainability as a goal with a particular economic bottom-line driven interest:

“[On a smart campus] the energy within the campus is to be managed in a more efficient and sustainable way using renewable energy sources, IoT, and AI-based techniques, this would result in a significant saving on energy cost. Compared to traditional face-to-face education, most education activities are expected to be implemented via web-based platforms under the new education paradigms, which provide opportunities for the educational institutions to transform their education businesses from business-to-user to business-to-business mode. Such a transformation not only benefits the education industry but also generates more opportunities for technology companies.” (p. 9)

Conversely, under the assumption that face-to-face education will not be obsolete, Chen et al. (2018) argues the merits of utilizing “smart” technologies to track student “footprints” as part of what they call a DeepGuiding framework. The framework, interestingly poised as a means for “smart campus care”, utilizes existing surveillance technology on campus to help students and visitors navigate both indoor and outdoor spaces. Chen et al. (2018) also claim that their DeepGuiding “outperforms existing face recognition methods and can achieve high recognition accuracy for students not close to surveillance cameras” (p. 43957). A claim that would give anyone concerned with surveillance and privacy pause.

Put this array of applications into the context of a pandemic that led to the closure and then limited mobility and access on many university campuses and a whole new set of applications emerges. In a study exploring how IoT systems might be applied to stop the spread of COVID-19, Haglan et al. (2021) review the most recent applications of IoT to attend to the public health crisis in Figure 8.

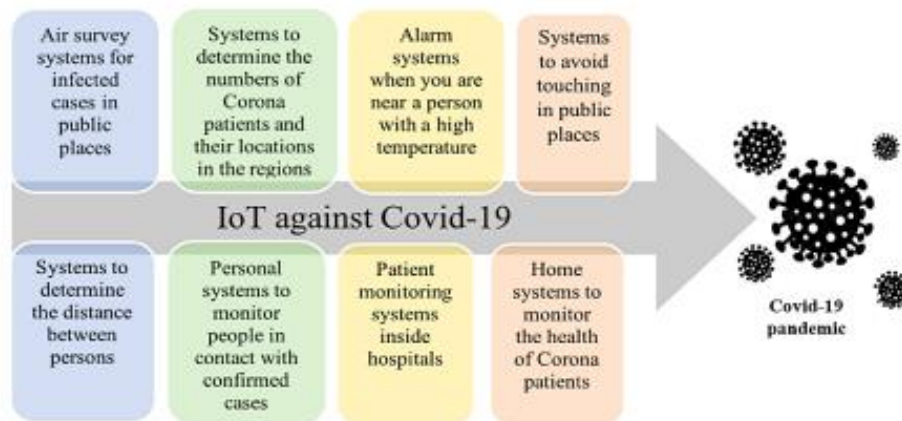


Figure 8: Ideas and frameworks for using IoT against COVID-19 from Haglan et al., 2021, p. 1567.

The campus as a “living laboratory” has emerged in discourses particularly regarding the university campus as a leader in sensing technologies for the goal of achieving energy efficiency and environmental sustainability. As the case explored in this chapter shows, sustainability as defined by energy efficiency and knowledge production from these developments is a key driver in innovations in “smart” technologies within and beyond the campus context. Living laboratory discourses position “smart” campus developments as crucial to “smart” city developments (Benltoufa et al., 2017) and marry learning objectives and sustainability objectives (Mazutti, 2020). As such, data dashboards (Negreiros et al., 2020) are being developed to help make sense of the increasing data extracted from campuses. In the next section, I leverage critical data studies and the data valence framework introduced by Fiore-Gartland & Neff (2015) to examine the values and expectations for “smart” campus data from the perspective of those who champion the expansion of “smart” technology on campus for sustainability goals.

Extending the Data Valence Typology

Exploring the impacts of data requires attention to how data gain meaning. Thanks to the burgeoning field of critical data studies, tendencies to reify data as objective, free of bias, and arbiters of indisputable truth have been challenged (boyd and Crawford, 2012; Dalton and Thatcher, 2014; Kitchin 2014b). Rejection of “raw” data (Gitelman, 2013), while garnering scholarly support in STS and critical data studies worlds, persists in public discourse. Reification of data is better understood as a reflection of values and expectations for data which can help inform efforts to collaborate across disciplinary boundaries to create policies and practices that afford more collaboration for data and sociotechnical systems.

To move away from tendencies to stabilize data as material object, communication scholars have applied the concept of mediation to data to “see data as emerging from communication media, shaped by and embedded into communication practices and materiality” (Fiore and Neff, 2015: 1469). Rejection of stability reframes data as social and creates space to consider what increasing access to data means, to whom, and to examine meaningfully the mutual constitution of data and practice. Following research on the mediation of data and other objects (Leonardi & Barley, 2008; Leonardi et al., 2012; Neff et al., 2014), information infrastructures—and “smart” infrastructures—similarly need to be approached as mediated which is to say, as an “ongoing, articulated, and mutually determining relationship” (Lievrouw, 2014, p. 45). From a data-as-mediated perspective, Fiore-Gartland and Neff (2015) present a typology of data valences, “the multidimensional expectations and values that mediate the social and material performance of data, or what data can do and will do within a particular social system” (p. 1470). The authors argue data valences are often in conflict, illuminate the nature of relationships between institutions and communities, and ought to be utilized as a heuristic for the social life of

data (p. 1470-71). Fiore-Gartland and Neff (2015) introduce a non-comprehensive list of salient data valences from their fieldwork at the intersection of medical data and health and wellness self-tracking. Many data valences reflect persistent discourses about the stability of data that critical data studies have contested. However, from a practice perspective, the persistence of these data valences drive action toward policymaking and organization practice and so continue to be meaningful.

Fiore-Gartland and Neff's (2015) data valences typology is based on analysis of sense-making discourses and practice with self-tracking, health and wellness data, and medical professionals and hobbyists. Despite emerging from a very different empirical setting, their framework offers a foundation upon which I analyze the data valences particular to a "smart" infrastructure.

Self-evidence

Despite the rigorous and illuminating work of critical data studies, the valence of data as self-evident persists. Based on erroneous claims that data are neutral and easily disentangled from their social contexts, this valence champions the role of data for increasing control over almost every aspect of life. In the context of Fiore-Gartland and Neff's (2015) work, this data valence emerged through discourses among individuals gathering health and wellness data and putting them into practice through self-diagnosis.

Actionability

The actionability of data is rooted in an assumption that data can and should inform action and are reliable in doing so well. This data valence emerges in smart device vendor marketing that promises that gathering more data (and allowing for the extraction of this data for use by the institution, vendor, or third parties) will inform action in beneficial ways (Couldry & Mejias,

2019; Sadowski, 2020). The actionability valence assumes that more data equates to more informed decision-making and practice.

Connection

Fiore-Gartland and Neff (2015) introduce the data valence of connection as evidence for the communicative constitution of data based on the conception of data as a “site for conversation” (Taylor and Van Every, 2000). In this view, data open space for deliberation that can be constructive. However, this presents a challenge to the first two data valences in that it requires labor, particularly interpretive sense-making labor for the data to be useful for connection.

Transparency

The data valence of transparency is championed by discourses of open-data and the free flow of information, eschewing top-down control. However, the valence of transparency “can ignore the negotiations people make among different data valences” (Fiore-Gartland & Neff, 2015, p. 1475) particularly when the data are sensitive and necessitate confidentiality or data privacy is an issue.

“Truthiness”

The truthiness valence of data emerges in discourses on the ability for data to represent an objective and measurable reality. As Fiore-Gartland and Neff (2015) put it, “the power of truthiness as a data valence is not necessarily based on the validity of data, but rather on an affective sense of truth ascribed to data in general, or a specific quantified indicator” (p. 1476).

While this valence instantiates some of the other valences, including self-evidence and actionability, it is challenged by the valence of connection which often complicates data expectations and meaning through contextualization and discourse.

Discovery

The discovery valence is based on the expectation that data can unveil truths that were previously hidden. In Fiore-Gartland and Neff’s (2015) study, patients engaged with the discovery valence to make sense of previously misunderstood diagnoses or to create meaningful patterns through self-tracking. The discovery valence, like that of self-evidence, is challenged by expertise (i.e., data science).

To bring their framework to bear on the context of this project—a “smart” campus—different interests, drivers, and governance practices must be considered. Like the self-tracking and health and wellness data space, the governance and ownership of data and knowledge production from data are contested in the context of a “smart” campus. However, unlike Fiore-Gartland and Neff’s study, data gathered by “smart” devices embedded in the built environment have implications on the operability of critical infrastructures relied upon by a diverse set of users/occupants. There are challenges that emerge from the interdependency of the cyber-physical security. Which is to say, the data infrastructures which will be the focus of this chapter are inseparable in any meaningful way from the cyberinfrastructure, physical infrastructure, or social infrastructure of the institution at large. The depth of these interdependencies is explored across the case studies presented in this and the following chapters through a consideration of the multifaceted data care work of the study participants will elucidate some of these connections.

“Smart” Campus Data Valences: A Sustainability Perspective

Case: Student Sustainability Efforts at the New Bio Building

The Bio Building is a state-of-the-art, LEED platinum, “smart” building that opened in 2019 at Cedars University. It is a sprawling building that includes classrooms, laboratories, and a greenhouse. It received what one participant called “the Oscars of architectural awards.” As a

“smart” building project, the Bio Building is home to a huge number of “smart” technologies, many of which are integrated into the building and campus energy infrastructures. Per university design guides, many of these systems had to be approved by leaders in IT and O&M, though as the previous chapter argues, enduring power disparities between those infrastructuring publics who maintain/care for infrastructure and those who innovate/design new infrastructure often privilege the needs of the latter. Buildings—particularly “smart” and “green” buildings—are more than just a space to house facilities for teaching, learning, and research. They are increasingly a site of sustainability research themselves following the discourses of “living laboratories”. From the perspective of sustainability researchers, and administrators at the university seeking to embolden such research, access to data from “smart” infrastructures is imperative. However, data access is much less seamless than some would hope. Security concerns and labor constraints make the sheer demand for data access and growing risk attributed to these infrastructures untenable as it stands.

The appetite for technosolutionist sustainability initiatives on Cedars University’s campus is only growing despite these tensions. One initiative is a student-led organization working to increase sustainability projects across campus using discretionary funds allocated by a student committee. The Bio Building is home to several projects funded by the student sustainability group. These projects not only align with the university’s energy resource conservation goals but align with the university’s ideological position on innovation and knowledge production.

In what follows I examine two projects at the Bio Building: the rooftop solar project and reverse-osmosis (RO) water reuse system to make sense of data valences that inspire these initiatives and their continued maintenance and data care needs. Generally, sustainability and

research staff see these projects as important to the mission of the university as an institution for knowledge production and innovation. The conflicts presented regarding these “smart” sustainability projects illuminate the ways in which data values and expectations vary across infrastructuring publics and their respective relationship to new building projects, cybersecurity, and maintenance of the university’s infrastructures at large. During infrastructure strategy meetings and in conversation with sustainability staff, researchers, and students, different data values and expectations are analyzed in conversations regarding specific devices, data compliance needs, and data access requests.

Innovation is a pillar of the university’s commitment to sustainability and knowledge production. Access to data is necessary for the continuation of such efforts as it functions as a currency for presenting the efficacy of such projects to leadership and the larger community to ensure continued institutional support. William is a staff member and PhD student at Cedars University. He directs the student-led sustainability fund. The fund takes a participatory approach to sustainability on campus and centers on the vision and desires of students. It is operationally supported by the campus sustainability office. Many of the more technologically advanced sustainability efforts on campus are thanks, in large part, to the allocation of funds through the program William manages. As such, he offers a particular perspective on projects like the Bio Building’s solar panels and RO water reuse systems and subsequent struggles over data collection which have precipitated delegation initiatives that have been a recurring discussion among IT/O&M team participants (and will be explored in the following chapter).

William is aware of the primary contradiction between new infrastructure investment and maintenance/care for existing infrastructure on campus. He prefaces his argument for data access with:

I think that, you know, some of the pushback is around who's going to pay, who's going to pay for it. The ongoing maintenance component you know...the university's deferred maintenance backlog is over \$2 billion or \$1.5 billion. So, there's a ton of competing interests in terms of what gets prioritized within the physical infrastructure on campus.

William is keenly aware of the deferred maintenance crisis and how it is pinching the capacity of the teams that are increasingly tasked with maintenance and care for the cyber-physical security of the university. However, from the perspective of sustainability and research teams, sustainability efforts that include data extraction are a necessary innovation towards the university's stated mission. Security concerns and labor limitations on the part of the IT/O&M teams are seen as standing in the way of efforts to make the campus more sustainable and a leader in sustainability innovation in the built environment. Despite the communication of the labor strain and security concerns from the perspective of the IT/O&M team, data access controls from the cyber-physical security perspective can be read as stifling the sustainability office and researchers' access to data and ability to achieve their goals. In discussing this tension with William, he expresses a comprehension of this underlying contradiction and tensions that arise from it but is not convinced that the labor burden of data access requests is substantial enough to deem it impossible. While this tension has resulted in conflicts between sustainability and research teams that align with a data transparency valence, and the IT/O&M teams that prioritize security, it is understood at a deeper level by both infrastructuring publics to be a structural issue at the institutional level.

An example of these tensions comes from the Bio Building's reuse model for reverse osmosis (RO) water system. Many of the labs in the Bio Building require RO water, but the process of treating water in this way is extremely wasteful. The student sustainability organization financially supported the installation of a system to recycle the wastewater from the

RO process and repurpose it in the building's greywater system. To measure the amount of water saved by the system, a meter needed to be commissioned. Meter commissioning is the responsibility of O&M, although "smart" meters like this one also involve collaboration with IT as they need to be added to the network per university design standards. The meter data readings of water savings are beneficial to both IT/O&M teams, as they are mandated to report energy usage to local and state authorities, and the student sustainability fund that uses the data to present the efficacy of their work and make it available for researchers. It should be a win-win. However, data access becomes a pain point as the IT/O&M team is reluctant to provide real-time data to the student group and the student group feels that they deserve access to the data because of their critical role in funding the system.

The tension is one that permeates many more sustainability projects across campus. Data access is in many ways the currency with which researchers and student groups trade their support for new "smart" infrastructure projects. The data care work that these systems necessitate is often taken for granted and not well-understood in its scope and impact. Thus, the IT/O&M team, with a core interest in maintaining cyber-physical security, is often positioned in opposition to technosolutionist sustainability efforts and the ongoing data access that they promise. Like the data from the RO wastewater project, data on energy saving from the Bio Building's solar project is framed not just as a matter of curiosity for the researchers and students involved, but as an asset to the success of the university at large. As William shares:

"We are sure that we can collect really concise information, quantitative information, from [the rooftop solar project]. And that was a big part of the reason that those projects I think have been successful and we're able to communicate the value in a way that people understand or want to hear or prioritize. So I think overall projects centered around 'smart' technologies, I think have in a lot of ways been the easiest to justify and the most lauded."

However, as with the RO wastewater project, working with IT and O&M to install “smart” technologies for sustainability by the book (i.e., following design guides and standards), has posed some challenges. Other projects on campus have gone about the installation of “smart” technologies on their own and the IT/O&M teams have only found out about them when something goes wrong, or they need help with a repair. This is a worst-case scenario for IT/O&M in terms of cyber-physical security risk management. However, working within the bounds of design guides and standards also makes for some inefficiencies for those who want access to the data beyond this team. Discussions about the data access needs of the sustainability research stakeholders in IT/O&M meetings have a very different perspective. In a conversation about the student-managed solar array on the Bio Building, an O&M team member suggests that there be more dialogue with the student group to communicate why there is risk associated with “smart” technology like this. Despite efforts to get this language into the design guides, it is largely understood that this type of risk will continue to increase on campus through similar initiatives. For those systems that IT/O&M do have control of data management, namely the energy systems like the metering for the RO wastewater measurement, there is less of a concern with data security as they have control of the data pathways through metering infrastructure. The tension with this, and similar, systems is providing data access.

The Bio Building projects including the RO metering system and solar panels are used as a case study to make sense of the data valences driving sustainability and knowledge production interests in “smart” infrastructuring on campus. Table 2 adapts a table originally created by Fiore-Gartland and Neff (2015) to recontextualize their data valences in health and wellness to those of a “smart” and sustainable campus.

Table 2. Sustainability Data Valences in Discourses, Practices, and Challenges

Data Valence	Discourses	Practices	Challenges
Self-evidence	Usage knowledge informs behavior	Energy usage data helps building occupants conserve	Risk of misinterpretation, “raw” data doesn’t exist, and interpretive work is not visible
Actionability	Data → Knowledge → Action	Data used as evidence for more investment in similar infrastructure	Data management is itself not sustainable in the current economics of the university
Connection	Data as site for conversation	Currency upon which sustainability efforts gain legitimacy and institutional support	Requires data management on a continual basis
Transparency	Right to access and share data	Dashboard building and reporting	Data analysis requires sense-making (time and labor)
Truthiness	Data represent reality	Policymaking and infrastructure-building to increase data extraction	Lacks consideration of limits of objectivity
Discovery	Data reveal new opportunities	Presentation of data to students, faculty, and staff as a reflection of themselves	Lacks consideration of the environmental impact of processing/storing large amounts of data

From the perspective of sustainability and knowledge production infrastructuring publics on Cedars University’s campus, “smart” data access from meters and sensors in the built environment have a great deal of value. As part of a datafied paradigm for knowledge production, “smart” technologies have data expectations as well which hinge on access to students, researchers, and staff. The following data valences are explored in the order in which they appear in the above table and not ranked by importance or other factors. The self-evidence

valence emerges in the context of the Bio Building and William's groups efforts there as a value for access to energy usage data and an expectation that building occupants can understand their personal and collective energy usage. Access to this data has translated into a data dashboard that is displayed on a screen in the entrance to the building's lobby. The data comes directly from the metering and sensing technologies that William's group has helped fund but is filtered back to the building manager by way of O&M groups. The expectation that this data be made available to building occupants and visitors is predicated on the belief that knowledge of energy usage will mitigate energy waste and encourage more conservative behaviors. However, as this data is filtered through O&M groups, it is not as "raw" and "real time" as it portends. The continuation of discourses of "raw" and "real time" data perpetuates the invisibility of the data care work these initiatives necessitate.

Actionability of data in the Bio Building is important to the future investments of sustainability groups, William's included, would like to make in the future. The actionability valence emerges through the need to present efficacy of current "smart" infrastructure projects through data. However, as has been discussed, the management of this data is bottlenecked by maintenance funds and labor constraints with trickle down effects on those working to increase "smart" and sustainable projects on campus.

Building off self-evidence, data is the currency and the language with which sustainability leaders base their efficacy and present their success to university administration and students who – in the case of William's group – decide where discretionary funds are allocated. This data is also critical to continued administrative support and as a means for advocating their worthiness of limited maintenance labor and resources. This creates a dilemma

in that data is the site for conversation and the means for presenting worthiness of investment, but that data itself necessitates data care labor.

The transparency valence is predicated on the ability for sustainability stakeholders to gain access to data at which point the data must be presented – in the case of the Bio Building – through dashboards and reports. However, once again, labor and time are in short supply making the work of sense-making for this data impossible if the data is unable to be accessed. Building off this, truthiness similarly requires ample time and effort to analyze data, if they can be accessed. Furthermore, truthiness necessitates communication of data to the appropriate stakeholders to effect policy or organizational practice.

Finally, the discovery valence is one of the most important in the context of “smart” campus sustainability efforts. This is where sustainability goals and knowledge production goals come together to reveal new opportunities for teaching, learning, and investment in campus infrastructure. In this way, data access for “smart” sustainable projects is required in order that the project can become a site for knowledge production for students, faculty, and staff. However, in the context of this case study, there was little acknowledgement of the impact data gathering, analysis, or storing were having on the environment itself. While outside the scope of this project, it is important to consider emerging research examining the environmental impact of our collective reliance, values, and expectations for data (Pacek, 2020; Velkova, 2016; Hogan, 2015).

VI. Care as Cyber-Physical Security: Data Security for Operations Infrastructure

Extending from the previous chapter, this chapter similarly centers the communicative mediation work with data, however, to extend the data valences framework to the context of environmental data from “smart” infrastructure, one must consider the ways in which data valences are intimately connected to care for the built environment. That is to say that building asset data access, in the empirical setting of this research, is under the control and governance of O&M and IT professionals insofar as they install, configure, maintain, and repair the smart devices that collect valued data. Caring for this data is only one facet of their work which includes, and privileges, the maintenance of critical infrastructure operability. This operability, I argue, is increasingly being defined by not only the delivery of energy assets, but the subsequent delivery of accurate data readings.

Because of their embeddedness in the built environment of the university, the data extracted by these “smart” systems require maintenance and security by the combined efforts of IT and O&M teams. This chapter attends to this gap by analyzing the work of IT and O&M collaboration as an infrastructuring public interested in the maintenance and security of the cyber-physical infrastructure of the university. I introduce the concept of *cyber-physical data security* as a novel data valence and a catalyst for specific data care work that has important implications for data security and access practices at a university in the process of becoming “smart.” The aim of this chapter is to bring into conversation values and expectations for data as they relate to distinct infrastructuring publics through an examination of different, and sometimes contradictory, practices of data care work. The addition of the cyber-physical data security valence illuminated tensions between infrastructuring publics who espouse a data

transparency valence with an interest in sustainability as examined in the previous chapter. Insights from emerging practices of data care work through platform delegation help make sense of future articulations between divergent infrastructuring publics as they grapple with data valences in conflict. This chapter will introduce a novel data valence that emerged in the context of a "smart" infrastructure among those tasked with maintenance, management, and security of its data. The cyber-physical data security valence is then substantiated through empirical evidence in its application to the work of maintaining building operation data and is presented as a kind of data care work. Approaching cyber-physical data work as a form of care work makes it possible to interrogate values and expectations driving this work and their respective benefits and shortcomings.

This chapter is guided by the following questions: How do IT and O&M define success for data care as it pertains to “smart” technology on the university campus and how might tensions emerge with other infrastructuring publics? How do differing definitions of success translate to data valences? How do differing data valences emerge in tension through conflicting approaches to data care work?

Bridging Cyber-Physical Systems with Data Valences

Much like infrastructures of a "smart" campus are cyber-physical, so too is the labor this infrastructure necessitates. It is no longer sufficient to consider the work of managing data emerging from "smart" technologies embedded in built environments as separable from the work of maintaining, repairing, and caring for built environments themselves. That is to say, “resolving an issue often takes both data analysis and a wrench” (Benson, 2019b).

Building operations data, which is generated by IoT systems, is increasingly important to the operation of buildings’ critical infrastructures including water, electricity, heating,

ventilation, and air conditioning (HVAC) systems, door access systems, lighting control systems, and energy management systems. Data collected by these systems are used to monitor buildings for operational issues, maintain physical security (i.e., prevent trespassing or theft), maintain cybersecurity (i.e., prevent cyberattack), report to internal and external entities for compliance requirements, and provide information for research. An analysis of data care work as part of the process of a university campus becoming "smart" requires the bridging of conceptual frameworks between cyber-physical systems and Fiore-Gartland and Neff's (2015) data valence typology. This conceptual contribution will expand extant research on data work, values, and expectations. Following an introduction of the cyber-physical data security valence in relation to extant research, the concept will be explored empirically to elucidate its merit. The conceptual and empirical work presented here expand our scholarly and practical repertoire of sense-making as our relations to, and generation of, data continue to expand.

"Smart" campus initiatives are sometimes aimed at transforming campus through organized campaigns. In other cases, "smart" campuses unfold one new building, or retrofitting project, at a time. The patchwork nature of the latter approach produces challenges for O&M and IT teams on campus. Underlying the mechanical, informational, and technical challenges "smart" campus initiatives pose for both organizations independently, is a concurrent reckoning with increasing coordination and collaboration needs (Osburn et al., 2021). Historically siloed, O&M and IT are increasingly needing to work together as "smart" infrastructures collapse boundaries between physical and cyber infrastructure of a campus. Physical infrastructures, traditionally under the purview of O&M, are now networked through tens of thousands of IoT devices and systems of devices, a number that is rapidly growing. Operability and security of physical infrastructures is now codependent with cybersecurity of shared networks and servers, which

have previously been under the purview of IT. While organizational distinctions persist, in part evidenced by institutional organization charts, many O&M and IT professionals have spearheaded collaborative working groups to address emergent cyber-physical infrastructure needs. Successful collaboration and coordination between O&M and IT are vital to cyber-physical security of a "smart" campus. Study participants include a collaborative group of IT and O&M professionals that are considered an infrastructuring public with a shared goal of maintaining and caring for data in an effort towards greater cyber-physical security for the university.

The energy sector has garnered much excitement in the world of "smart" infrastructure. Energy-related building systems are increasingly networked with IoT devices or systems of devices as part of an effort to increase efficiency, affordability, and data collection potential. Initiatives for making energy infrastructures "smart" are often closely linked to sustainability efforts. At a technical level, a plethora of IoT devices have emerged to make "smart" infrastructures possible. However, IoT devices and systems are notoriously vulnerable to cyberattack and the sheer number of IoT devices can collectively result in weaknesses for the entire infrastructure (Benson, 2019a; Kimani et al., 2019).

At Cedars University, the O&M and IT professionals have gathered to address their shared concerns for continued operability of campus built environments recognizing this operability is inextricably linked to security of not just physical infrastructure (i.e. door locks and HVAC systems), but cybersecurity of networks increasingly controls functioning of IoT systems (i.e. the networks and servers upon which "smart" door locks and "smart" HVAC systems rely). Collapse of the cyber-physical infrastructure divide is not without its own assumptions. The rise

in cyber-physical infrastructure projects, through proliferation of “smart” technology, is the result of values and expectations for data they generate.

The focus of this chapter is on a novel data valence emerging from a cross-disciplinary team of O&M and IT professionals and is analyzed comparatively with infrastructuring publics that closely mirror what extant research has told us about research goals and data access. Read alongside the previous chapter, tensions in data values and expectations are illuminated. In response to these tensions, the O&M and IT team at Cedars University has begun a process for delegating data care work. That project will be introduced briefly at the end of the chapter with some ideas for future research and practice though the project is so new that no definitive claims can be made about its success at this time.

The Growing Task of Caring for Cyber-physical Systems and Their Data

Increasing extraction of data from built environments through sensors, meters, and other IoT systems results in increasing interest in access to data. “Smart” campus infrastructures complicate data values and expectations resulting in increased data care work. IoT systems increasingly integrated into building operations systems are increasing coordination responsibilities.

Cyber-physical data care work being done at Cedars University offers empirical evidence of a cyber-physical data security valence. A new orientation to data care emerged from a shared concern among a cohort of O&M and IT professionals working collaboratively on campus. The combined efforts of IT and O&M is experiencing an increase in one-off requests for maintenance and repair to “smart” infrastructure systems and one-off data access requests from building coordinators, researchers, and students. Increased labor demand has strained the workforce and has resulted in demand for an enterprise solution for meter data management. In the deliberations

about how to better manage data care labor and the potential benefits and shortcomings of the introduction of a new data management platform, O&M and IT groups have grappled with various data valences. Data presented in the findings here are not the meter datasets, but observations and insights gleaned from ongoing sense-making conversations during negotiation of data access and implementation of a new data management platform. Conflict in data valences arises as participants negotiate their own values and expectations for data against those of contractors, vendors, researchers, students, and others. Evidence for a cyber-physical data security valence is presented through two stories highlighting the role the O&M and IT groups' data care orientation played in the configuration of a data management platform reflecting distinct values and expectations for data.

Campus wide and building specific “smart” campus projects are a recurring topic in O&M and IT group meetings as they continue to be included in new building designs as well as introduced to older infrastructures. The benefits to efficiency, financial sustainability, and environmental sustainability are clear to all participants, but the weighing of these benefits with the cyber-physical security risk and increase maintenance labor they might pose is not.

The problem is as much cultural as it is technical. Data access, and governance thereof, is a concern for cybersecurity. More devices simultaneously mean more data access and more cyber-physical security vulnerability. However, this caution does not necessarily impact the appetite for “smart” technologies for other infrastructuring publics on campus—including sustainability and research teams as discussed in the previous chapter. However, from the perspective of O&M and IT teams their projects are often seen as an additional burden both to their maintenance labors and a cyber-physical security risk.

This conflict first emerged in participant observation of strategic infrastructure meetings regarding the management of metering systems across campus, which are increasingly networked with “smart” systems. Additional interviews with sustainability staff and researchers illuminated the conflict to reveal a central data care conflict in the institution and evidence an additional data valence at play in “smart” infrastructures.

Case #1: The BYOD Problem

At the time of fieldwork, Cedars University was in the midst of a large-scale construction project for a new Global Health Institute (GHI). I was introduced to the project team in a construction trailer located just behind the new building site. Through the noise of an active construction site, the project team gathered to collaborate with university owners on tasks necessary for timely opening of the building. GHI’s design highlights energy efficiency including passive solar design elements, rainwater catchments, and smart metering throughout. I observed the phases of construction, commissioning, and move-in during design-build meetings with owners, architects, contractors, and subcontractors on the GHI project.

Simultaneously, I participated in on-going meetings with representatives from central IT and O&M as well as other university departments like engineering, housing and food services, and building services. Participating in these concurrent meetings illuminated different values and expectations for data being gathered immediately following commissioning, and to be gathered over the course of the building's life. Design and construction meetings were highly action oriented, and conversations rarely strayed from a predetermined list of project to-dos and progress check-ins. It was during O&M and IT team meetings that deeper conversations about strategy took place and where data care and data security were an underlying interest. The confluence happening technologically speaking between built and cyber infrastructures were

reflected in the conversations happening between IT and O&M. Data management and security—as a form of data care work—was exercised with a particular set of values and expectations.

As a "smart" building project, the GHI is home to a huge number of "smart" devices and systems of devices. Many of which make up the energy infrastructure for the building including "smart" water meters, occupancy and lighting sensors, and renewable energy systems. Use of Raspberry Pis by subcontractors on the project became a topic of concern among the O&M and IT teams. Raspberry Pis are single board computers, often used for sensing due to their low cost, modularity, and convenient network connectivity. The use of such devices by subcontractors garnered concern and became known among the O&M and IT teams as a “BYOD (Bring Your Own Device) Problem” (see Garba et al. 2015 for a history of BYOD practices and policies). The BYOD situation at GHI resulted in conflict regarding data pathways. While O&M and IT teams are interested in, and incentivized by, long-term, campus-scale sustainability efforts, the design-build team is concerned with, and incentivized by, accreditations like LEED certifications. LEED (Leadership in Energy and Environmental Design), a widely recognized accreditation from the U.S. Green Building Council, was suspected by the Infrastructure Team to be driving BYOD practices on the GHI project.

More devices mean more vulnerabilities. Among the O&M and IT teams, there is a shared experience of entertaining numerous vendor pitches in which sometimes young companies promise to use their AI or data visualization models to help institutions extract more data from the built environment. The O&M and IT teams are cautious about such vendors. There is an ongoing discussion about the quality of vendors as it relates to their willingness to work

with the O&M and IT teams and to provide important cybersecurity information as well as clear and consistent data pathways.

As one participant from O&M put it: “We need to have our own data foundation in place, and we can push some data to [vendors] but without them collecting or owning this data.” Reluctance to take on more vendors and subcontractors, each with their own devices and data pathways, is more than just a matter of data ownership and control. It is a security concern. There is an underlying security interest in the ownership and control of data movement. The BYOD problem is a priority for the O&M and IT teams because, as one participant explained, “these devices are bringing data out and back which makes me nervous when these devices start showing up on our network in our building and we don’t know what they are doing.” The concern is not just the sharing of data, but ownership and collection of data. The O&M and IT teams have their own compliance and security uses for data in addition to operational needs. They are willing to share some of these data, but only insofar as they can be assured the O&M and IT teams—as representatives of the university—maintain control over data including control over what data is being collected from built environments.

Approaching this conflict with a strong transparency data valence, one might see the O&M and IT teams’ actions to limit the data access as overzealous. While data transparency may be a virtue in some settings, in a cyber-physical infrastructure like a “smart” campus, there is a reason to maintain a tight grip on data pathways. The O&M and IT teams—those at the forefront of efforts to maintain operability, cybersecurity, and physical security of “smart” campus systems—instead privilege a cyber-physical data security valence. The cyber-physical data security valence is the result of an orientation to care, not just for data, but to maintain building operations, compliance reporting, and mitigate cyberattacks. The relationship between care, and

the labor it requires, and the cyber-physical data security valence introduced here is not (just) about caring about the wellbeing of the campus and its occupants. A care perspective allows us to understand values, expectations, and concerns animating data security practices observed. Data security, in a cyber-physical infrastructure is intimately tied up in maintenance, repair, and care for actual devices, spaces, and environments in which data are generated. Recognizing the role of care in data security, O&M and IT participants in the following passage discuss the need to recognize care work as it relates to data security:

“It’s a question of labor, the more we get out there, the more labor support is needed.” Greg and others continue to reiterate the concern with labor and staffing throughout this conversation... James agrees that there is a data security concern that centers on the need for these new meters to have firmware updates which necessitates technicians “who can put hands on this equipment and know what they are doing” (excerpt from fieldnotes).

Management of access to data, and maintenance of cyber-physical security of campus, has brought about some progress. After spearheading the research necessary, members of the O&M and IT teams were able to find a data management platform for industrial operations. A leader in O&M presented a proposal to organizational leaders and it has since been approved. Despite progress, this process has challenged some commonly held data values and expectations and garnered a fresh round of negotiations over data access and security. This time with students and researchers at Cedars University.

Case #2: Data Care Delegation for Secure Sustainability and Knowledge Production

“Smart” meters, like the one discussed in the previous chapter with the RO wastewater system, are part of a campus-wide effort to better measure and report on energy usage. The push for “smart” metering programs is the result of compliance needs—mandated by local and state policy—as well as programmatic needs like that of student sustainability groups. With labor

capacity strained, the compliance needs for metering supersede those of student-led sustainability projects.

To continue providing access to data in a way that is secure and scalable, the O&M and IT teams have made the decision to delegate the data care work to a central data management platform. Management of access to data, and maintenance of cyber-physical security of campus, has brought about some progress. After spearheading the research necessary, members of the O&M and IT teams were able to find a data management platform for industrial operations. A leader in O&M presented a proposal to organizational leaders and it has since been approved. A series of meetings immediately following successful procurement and installation of a new central data management platform centered on conversations about access and publication of data. Data security management and platform governance negotiations take up a lot of airtime in meetings with the O&M and IT teams. The impending platform launch fast-tracked conversations regarding energy data management including data dashboards and data access outside of the O&M and IT teams. A looming concern is cost, and labor limitations faced by their respective organizations. The question of who will take on data access management responsibilities lingers. Firstly, this focus is prompted by a desire to avoid the need for more platform licenses or other infrastructure after the launch that would require additional funding. Secondly, is a desire to leverage student and faculty interest in data while simultaneously tempering expectations for access. Leveraging research interests may in part come from a normative goal of data access for education purposes, but primarily – at least to O&M and IT teams – the intent is to leverage specific funding sources to make space for a “sandbox” for students and faculty to run reports and analytics controlled from a data security standpoint but are also able to be easily adopted by the production side if they prove useful. The academic

license side is limited in its capacities and access. The access is granted, and protocols are determined by the production license side which will be under leadership of the O&M and IT teams.

Different licenses and the access they provide or withhold from particular users/occupants, are primary mechanisms for control over energy data. The data management platform's affordances for access controls by way of different licenses, administrative and academic, is being utilized as a delegation of work previously handed-off to the O&M and IT teams in a one-off manner. Adoption of a centralized platform to lighten this labor aligns with Ribes et al. (2013) definition of delegation as "a means by which organizations are using technologies to avoid the need for human gatekeepers or extra administrative work" (p. 4). "Smart" systems are introduced for myriad reasons, one is promises of seamless data collection and distribution. However, concurrent concerns of data management labor and cybersecurity threats have coalesced, so O&M and IT teams have identified the need to automate delegation of data access as part of their growing data care responsibilities. Automated delegation will eventually produce data sharing dashboards to better control what data are available to whom.

Delegation of data access, through social and material-technical infrastructures, is illustrative of an orientation to care with consequences for the larger sociotechnical system. Accessibility and protection of "smart" technology generated data is creating new interdependencies between researchers, building management, IT, and O&M. Taking up Michele Murphy's (2015) call to "unsettle" care, this case makes clear a conflict has arisen between the data valence of self-evidence and cyber-physical data.

In an exchange regarding the need for delegation of data access control, an O&M participant, who is leading training and building out the data management platform for the

university, expressed accessibility and self-evidence as a liability rather than an asset. Balancing needs of researchers and students to access building systems data with the need to protect servers to maintain building operability and compliance reporting needs, the participant explained to the rest of the group:

As long as [researchers and students] aren't reaching in and touching the production server data – we have security and control over the production data – if that happens the risk is that a student could run a query that brings the server to its knees.

Ensuing conversation illustrated the dual concerns of this group as a cyber-physical data security valence. Protecting data is important for the threat to servers and cloud services and therefore continued access to critical data for building operability and compliance. However, in addition to these concerns which can be categorized as physical security, O&M and IT teams are simultaneously concerned with privacy and security of data. As one participant adds to this conversation moments later:

We will need to carve out a process for what we are going to make available – at some point we will need to review what data is okay and what is not okay because there could be privacy or security implications on some of this data.

Expanding more on what is at stake another participant added concerns about a particular animal research facility that has been under public scrutiny and has been flagged by the university as particularly at risk for cyberattack. Similarly, some “smart” systems are networked with the local public electric utility’s substation. Threat of a “fun political act” bringing the substation down was also floated as a potential risk of lax data access control protocols.

An explicit connection is made between security concerns O&M and IT teams must manage as a convergence of not just data security and information infrastructures that sustain data pathways, but also physical security of energy infrastructures with far-reaching implications

for the university and beyond. Thus, cyber *and* physical security are being considered in ways that inform data care practices of the cross-disciplinary cohort O&M and IT teams and are informing the emergent delegation practices.

A New Data Valence: Cyber-Physical Data Security

The cyber-physical paradigm shift allows for a more comprehensive view of data valences at play in "smart" campus infrastructure projects. Necessity for cyber-physical data security values and expectations to be considered jointly is illuminated by introducing a cyber-physical data security valence and applying it to the empirical setting of this study. By nature of the "smart" campus assemblage, which is physical, digital, and social, the work of maintaining cyber-physical security necessitates care for the physical security of built environments and cybersecurity of networks as they become increasingly interconnected and codependent. Previous work has introduced data values, expectations, and their impacts. Critical data studies, while helpful in attending to the cyberinfrastructure components of a "smart" campus, has yet to attend to the physical security considerations particular to "smart" campus contexts. Values and expectations are attended to through a care framework. Addressing cyber *and* physical security are increasingly of concern in the era of "smart" infrastructures requiring data care work done with a cyber-physical data security valence.

Making sense of the convergence of cyber-physical infrastructures, related to the precipitous rise of data extracted by "smart" technologies embedded in built environments, necessitates introduction of a new data valence. This paper builds on Fiore-Gartland and Neff's (2015) data valences to introduce the cyber-physical data security valence in order to make sense of values and expectations among those tasked with maintaining a safe, secure, and operational "smart" infrastructure. I argue that the cyber-physical data security valence is enacted through

data care work. While previous studies about data care work, and maintenance of data in institutional settings, have evidenced the importance of this work in research settings particularly, this chapter responds to a need for a more comprehensive understanding of data care work in a "smart" campus setting. Further research should examine ways in which other data valences emerge in "smart" infrastructure settings, including but not limited to other data valences introduced by Fiore-Gartland and Neff (2015). Future research should also look to additional user/occupant groups to offer comparative perspectives on the same data infrastructure discussions including researchers, students, departmental staff, and vendors.

This chapter leverages and expands on Fiore-Gartland and Neff (2015) to introduce the data valence: cyber-physical data security. This valence, like those originally presented, are constituted by discourses and practices and present challenges when making sense of data to inform action. The novel data valence presented here is of particular importance to the infrastructuring publics whose values align on the importance of cybersecurity and physical security, as part of a larger goal of continued operability of critical infrastructures for the institution. The precipitous rise in “smart” technology in the critical infrastructure systems at Cedars University—and other institutions—has necessitated a new conceptualization of what it means to secure systems and keep them operating. These systems are cyber-physical in the sense that they require a dual consideration of security risks. Moreover, their introduction into the workflows and systems for which this infrastructuring public are responsible, has created a new relationship to their work with data. Thus, data take on values and expectations that were not yet reflected in the existing data valence typology, thus the introduction of cyber-physical data security. See Table 3 for an updated typology including cyber-physical data security. This addition to Fiore-Gartland and Neff (2015) original typology may not be applicable to all data

settings and will necessitate additional theorizing as “smart” technology is innovated and applied to new and novel contexts.

Table 3. Sustainability Data Valences in Discourses, Practices, and Challenges with Addition of Novel Data Valence “Cyber-Physical Data Security”

Data Valence	Discourses	Practices	Challenges
Self-evidence	Usage knowledge informs behavior	Energy usage data helps building occupants conserve	Risk of misinterpretation, “raw” data doesn’t exist, and interpretive work is not visible
Actionability	Data → Knowledge → Action	Data used as evidence for more investment in similar infrastructure	Data management is itself not sustainable in the current economics of the university
Connection	Data as site for conversation	Currency upon which sustainability efforts gain legitimacy and institutional support	Requires data management on a continual basis
Transparency	Right to access and share data	Dashboard building and reporting	Data analysis requires sense-making (time and labor)
Truthiness	Data represent reality	Policymaking and infrastructure-building to increase data extraction	Lacks consideration of limits of objectivity
Discovery	Data reveal new opportunities	Presentation of data to students, faculty, and staff as a reflection of themselves	Lacks consideration of the environmental impact of processing/storing large amounts of data
Cyber-Physical Data Security	Data present cybersecurity and physical security risks	Data access and sharing necessitates special care	Security can result in withholding of access to interested parties, conflicting with other valences

In the next chapter, sociotechnical relations with the “smart”-ification of the built environment are explored as they impact a different infrastructuring public: care/maintenance teams. Focus on this public represents a distinct, and less direct, relationship to the data extracted from the built environment by “smart” technologies. While the previous chapters have focused on user/occupants that value this extracted data for various uses, the care/maintenance publics presented in the next chapter are less interested in the data extracted from the built environment by these “smart” technologies and more so by the implications their introduction into the workplace have on their work practices.

VII. Care for Campus: Values and Expectations for “Smart” Campus Infrastructuring for Care/Maintenance Publics

I purposefully sought out participation from those who maintain and care for critical infrastructures at Cedars University because investigations into the sociotechnical impacts of “smart” infrastructures have largely left out the perspectives and experiences of those who maintain/care for them. This trend is shifting, however, due in large part to the work of critical infrastructure studies and feminist STS work. Following in these traditions this chapter centers the perspectives of maintenance/care workers as they navigate a dynamic workplace in the process of becoming “smart” through the expansion of IoT devices and systems in the built environment. As I began this investigation, I was steeped in theories of care which inspired my pursuit of participants beyond institutional leadership. Questions about infrastructuring work and sociotechnical system-building ought to engage with stakeholders beyond the decision-making and power-wielding designers and members of executive leadership, but instead center those who are maintaining and caring for the spaces that are being impacted by new technology paradigms.

Informed by emergent literature on the impacts of “smart” technologies on privacy and surveillance (Ball & Wilson, 2000; Hjalmarsson, 2009; Berridge et al., 2019), I designed this project anticipating these themes would emerge among my participants’ own experiences and in their concerns with emergent technologies. I was entirely surprised, however, to instead hear from many participants in maintenance and care roles that they were not very concerned with their own privacy or possible workplace surveillance in relation to the expansion of certain “smart” technologies. Instead, two other categories of concern emerged: First, among those who

maintain the operability and security of the networks that sustain critical infrastructures on campus, cyber-physical security was of utmost concern. This perspective is examined deeply in the previous chapter. Another faction of maintenance/care workers on campus are Building Services—the department of custodial services, window washers, waste management, graffiti removal, and building access services. Participants from Building Services were less concerned with their personal privacy or workplace surveillance and were more concerned with the security of the built environment with an emphasis on the physical security of campus spaces. However, cybersecurity, much less the enmeshedness of cyber-physical security, was not acknowledged as a concern by most Building Services participants.

These two interests are increasingly inextricable as explored in the previous chapter and introduced in what I have called the cyber-physical data security valence. Particular “smart” technologies on campus are perceived by custodians and their managers as beneficial to custodians particularly despite evidence that such technologies may be harmful to workers. This perception is based on the understanding that these technologies can increase security and efficiency. These perceptions and attitudes not only vary individually but are related to specific devices and applications of those devices, such as “smart” access controls (i.e., card access door systems). Therefore, in this chapter, I focus on the perceptions and attitudes of maintenance/care workers (i.e., custodians, window washers, and maintenance/care worker team managers) toward “smart” access controls.

This chapter examines the case of “smart” access controls on campus as a new frontier for “smart” technology that has been deployed unevenly across Cedars University’s campus. Access controls are the technologies by which occupants of a built environment gain access to spaces and institutional leadership can control who does/does not have access to campus spaces.

Access is controlled by the institution via these technologies. Access controls are not necessarily “smart” —keys are access controls, as are keypad/password combinations. However, increasingly, universities are opting into “smart” systems that promise more control by using personal identification proxies like ID cards for access to campus spaces. The unequal distribution of “smart” access controls follows a similar pattern to much of the infrastructuring on Cedars University’s campus and many other North America universities that is examined in Chapter IV: the political economic context of deferred maintenance and capital projects. Many of the “smart” access control systems on campus are in new buildings for which this technology was part of the construction design. As previously discussed, these projects are largely donor-funded and skew toward STEM department facilities. Meanwhile, older buildings await routine maintenance and are only retrofitted with “smart” access controls when departments can fund them. This results in an uneven distribution of “smart” access controls across campus buildings, but within those buildings as well, since departmental funding discretion has in some instances been used to fund “smart” access control system installation on inside doors, where they are less desirable to custodians and other care/maintenance workers on campus.

Ethics of Care

I start by examining ethics of care that inform the work of maintaining and caring for a “smart” campus. I approached this analysis through a sociotechnical systems lens which means I am interested in the mutually constitutive relationship between social actors and technological artifacts and consider actors in the system as more-than-human. This is to say that technology is socially constructed, and the social world is mediated through technology. From this perspective, the care and maintenance work that is the focus of this project encompasses the work of care and maintenance for a sociotechnical system and includes care and maintenance of and for the social

ties that allow for coordination and sometimes result in tensions, the physical infrastructures which are always in a process of transformation and breakdown, and the information systems that are increasingly understood as creating value for these systems while simultaneously increasing risk.

The previous chapters' cases, as well as the case highlighted in this chapter, present orientations to care that can be in conflict. This is part of a project to examine care as “non-innocent” (Murphy, 2015). It is also indicative of the intractable contradictions between infrastructuring publics that are working within the political economy of a “smart” campus. The value and expectations for “smart” systems varies greatly depending on your positionality within the organization and in relation to the systems. As argued in the two previous cases, the extraction of data from the built environment is not only the primary driver for increasing introduction of “smart” technology to campus infrastructure but is part of a political economy which allows for older infrastructures to fall into disrepair. However, the contradictions between “smart” data as an asset for knowledge production, compliance, or other business use cases, there is an infrastructuring public that is less interested in the data extracted from “smart” systems and more interested in their ability to increase efficiency of operations on campus. The care/maintenance workers who are introduced in this chapter are part of that larger public. Their relationship to “smart” systems is much less concerned with access to the data they produce and much more about the ways in which they improve or complicate their workflows, movement through the built environment, and safety on the job.

Moving away from technosolutionist thinking that guided some of the publics previously highlighted, requires looking beyond the marketing-driven hype that claims “smart” innovations will give us the data to solve many social, security, environmental, or economic problems. Much

like the care/maintenance publics highlighted in the previous chapter, this chapter highlights another care/maintenance public that is also interested in security, but of a different kind. The previous chapter highlighted IT and O&M professionals working in opposition to technosolutionist efforts to make data freely available. In that way, that public engaged in data care of a certain type. The care/maintenance examined in this chapter, however, is more closely related to care work in the definition from feminist politics of care studies in that it centers the work of those caring for the social and material wellbeing of the campus and its community through caring practices. To make sense of the importance, but routine invisibilization of this work, it is helpful to turn to an ethics of care.

Ethics of care were championed by feminist scholars making sense of the value of social reproductive labor. Emblematic of this scholarly tradition is an investigation of unpaid domestic labor, the commodification and institutionalization of domestic labors (Fraser, 2014; Bhattacharya, 2017), and more recently the digitalization and datafication of social reproduction labor (Berridge et al., 2019). Social reproduction is the labor that sustains life and a capitalist system. In the context of “smart” infrastructure, it emerges in tensions in the building of new infrastructure on campus between logics of care/maintenance and technosolutionism with marked power disparities between their representative infrastructuring publics as argued in Chapter IV. Furthermore, an ethics of care extends beyond those labors traditionally considered social reproduction to attend to a growing threat to the cyber-physical security of the institution and occupants of the built environment, which ought to be considered as a type of care work that is sometimes in tension with other data paradigms, as argued in Chapter VI. This chapter builds on the that argument to engage more directly with the work of maintenance/care infrastructuring publics on a “smart” campus to make sense of the role care plays in sociotechnical relationships

between more-than-human actors, including maintenance/care workers, their bodies, and the built environment.

Myriad “smart” systems populate the built environment of the campus. As part of IoT, specific “smart” technologies, like “smart” access controls, ought to be considered as part of a larger sociotechnical system. As articulated in previous chapters, the “smart” campus as a sociotechnical system can be understood as a product of technocapitalism, data extraction, and technosolutionist sustainability paradigms. Chapter IV introduces persistent contradictions between orientations to sustainability that are technosolutionist and those that are maintenance/care oriented. The following case manifests those contradictions.

Case: “Smart” Access Controls

“Smart” access control systems include a whole host of networked devices aimed at controlling access to spaces. Popular examples include “smart” home security systems like Ring, SimpliSafe, or Vivint. Home systems are often cloud-based and smart-phone controlled, allowing homeowners to access cameras and microphones at their door or else capture data on exit and entrance occurrences from various access points in their home. Much of the scholarly investigations of this emerging entanglement has focused on the home and city (Al-Turjman et al., 2019; Kozubaev et al., 2019; Lopez-Neira et al., 2019; Bridges, 2021). However, institutional or enterprise access control systems pose many of the same threats. Enterprise systems are similarly being “smart”-ified. University campuses, like Cedars University, often have more than one system functioning across their campus. Adding still to the complexity of these systems, many “smart” access controls are networked with other security systems like CCTV cameras and controlled centrally by a single institutional body. Given the reach of a large university campus,

this network encompasses not only a large geographic area, but accounts for the extraction of an enormous amount of data from a diverse set of user/occupant groups.

Approaching “smart” access controls as a sociotechnical system from the perspective of care workers, necessitates asking the questions: what/who are “smart” access controls for? In what follows I will briefly introduce my findings from interviews with custodians and other building services workers at Cedars University.

The infrastructuring publics whose perspectives guided the analysis of the previous two chapters require intimate knowledge of network configuration and security, metering infrastructures, or other “smart” systems. Dissimilarly, many building services and custodians specifically interact with “smart” technologies as users/occupants rather than architects and maintainers. However, care workers like custodians are the first and most regular users/occupants of “smart” buildings and systems and offer an important perspective on who “smart” infrastructure investments center. Like other users/occupants of the built environments of a campus, custodians enter the building via doors, turn on and off lights, run the water in sinks, and flush toilets. There are also a lot of ways in which custodians interact differently with the built environment than other occupant groups. Most notably, custodians engage in labor with the built environment directly through cleaning procedures. To avoid disruption to teaching, learning, and research endeavors at the university, custodians often start their shift before sunrise—around 5 am. Custodians at Cedars University, reflecting national trends, are predominantly immigrant women of color for whom English is not their first language. This brings into question a host of specific security and personal safety concerns related to immigration status, race, and gender.

When asked generally about their familiarity with the term “smart” campus, or “smart” technologies, most custodians are unaware of any campus wide effort to integrate more IoT devices and systems into the built environment even as other members of their organization are part of strategizing what it means to become a “smart” campus. However, after unpacking this terminology further and providing examples, these user/occupant groups are aware of changes to their workplace through the introduction of automated lights, card access controls, solar panels, rainwater recycling systems, and other “smart” technology applications. Generally, the introduction of “smart” technologies into their workplace are regarded as interesting but not directly impacting their work daily. Frustration with malfunctioning lighting systems and card readers are shared, but generally their biggest frustrations are with increasingly large buildings with fewer custodians to clean than they had previously had for an area of similar size. This indicates that the primary contradiction defining infrastructuring at Cedars University is one between deferred maintenance and capital projects in which new buildings are increasingly the labor need for care/maintenance publics through square footage and complexity, and not addressing the persisting maintenance needs for older infrastructure. This contradiction defines the experience of care/maintenance publics at Cedars University and obfuscates the experience of “smart” technology—the effects of which are a secondary issue.

When asked about what kind of “smart” technologies they would like to see more of on campus, every participant from building services mentioned a desire for more automated access controls and a frustration with the trend that older buildings were slower to get automated access controls than new buildings. In the case of Cedars University, many older buildings still require physical keys for access control, however, new building projects and retrofitting efforts are making card access more and more common. “Smart” access controls are increasingly the norm

in new building projects like the ones explored in previous chapters. However, when it comes to retrofitting older buildings, “smart” access control investments are at the discretion of department budgets leaving many of these buildings without a cohesive access control strategy and resulting in a patchwork of updates that may not be of benefit to maintenance/care workers who specifically call for “smart” access controls on the exterior doors of buildings.

Two arguments animate this desire for more “smart” access controls: efficiency and security. One argument for the continued introduction of “smart” access controls across campus is that keys were inefficient and wasted valuable time and resources. It is generally understood that the biggest obstacle to increasing the use of “smart” access controls - namely “smart” proxy card readers on doors - is budgetary constraints. As custodial team manager, Louis, shared:

Boy, we've tried to ask for old buildings to be retro-ed with [“smart” access controls]... Boy, we love it and we can't say enough about it, newer buildings, some of them, if they can, if it's in the budget they'll get all the exterior doors put on this proxy card or [“smart” access controls]. The ones that can't afford it, or if the budget was somehow made or whatever they'll get like a couple of doors, that will be [“smart” access controls]...I mean I don't know if you ever, you know, done opening doors with a key, I mean, we're talking when I used to do it it's like 40-50 doors a day. I mean your fingers get cracked, you know, you get blood. It hurts. Imagine turning... and these doors are not like brand new nice greased, you know, oil slick, you know, turn it opens up. We're talking about old big doors, you know, I mean with old you know brass locks and your finger gets cracked you know, it starts to hurt your thumb and, you know, you do this all day long, 50-60 times and that's just not easy. I mean 50-60 times. Classrooms, you know, offices, locking your custodial closet door, going to another sort of closet, and plus the weight that the keys. The weight of the keys itself, I mean. And heaven forbid if you lose the set of keys.”

Similarly, the window washing team manager, Owen, shares his own opinion on the utility of “smart” access controls:

And because of security reasons, not all people have access to keys, my group goes to every single building at any given time to do the work but dependent upon the building will determine whether or not I actually have the keys or not. If I don't have the keys, then I have to ask my manager, if my manager doesn't have the keys then I gotta to talk to the building coordinator. The building coordinator doesn't have the keys, and I got to talk to someone else so just to have a physical key and the difficulty

in time associated with dealing with that, also seems like a waste if every door was a ["smart" access control] door, you can easily allow access to particular workers to particular rooms just by putting in some sort of email request.

In addition to these general efficiency benefits, "smart" access controls have seen a lot of celebration considering new COVID-19 related restrictions on campus. When Cedars University's campus closed to most occupants in March 2020, it became clear that programming and managing access on a building-by-building or room-by-room basis was far more efficient and practical than tedious key exchanges in response to constantly shifting guidance. Renewed limitations to access on campus were being put back in place and proxy card access was still required for many campus buildings. It remains to be seen how this context may bolster the funding of more "smart" access control systems on campus in the future, but it will likely increase the rate of adoption.

The argument for efficiency is related to the second argument for more "smart" access controls: the security of workers. Custodial workers and their managers desire more "smart" access controls because they access campus buildings in the early hours of the morning. As custodial team manager, Kim, shared:

"Our staff is starting, you know, early in the morning, 5am. Yeah and some building has two custodians working in there, but some building it's just one. So when they walking in and then who knows right? So somebody might be in the building somewhere hiding, spend the night there, and then our guys go in 5am and then it's just very surprised, you know?"

Desire among care workers for the expansion of "smart" access control systems was a desire to increase worker safety when entering buildings by increasing surveillance potential. There was a credible fear for many custodians, many of whom were women, most of whom were immigrant women of color for whom English was not their first language, that fiddling with keys in the early hours of the morning trying to enter a building on a public university campus posed risks to

their immediate safety. In addition to “smart” access controls, many arguments for the expansion of these systems also invoked an interest in security camera footage. Despite being distinct systems that do not always coexist in a particular location, they are often considered related conceptually as part of an effort toward greater access control and surveillance. They were also technically integrated in the case of Cedars University in that the database management and system maintenance for many “smart” access control systems and security camera footage were controlled by the same vendor and were administered in the same office on campus. As such, data from both systems could be read together to create a more comprehensive surveillance assemblage. While knowledge of this shared vendor relationship may not have been known to many of the participants, the conceptual linkages between the systems were. In speaking about her interest in protecting custodians from unhoused persons on campus in the early mornings, Kim, the custodial team manager quoted above, cited both “smart” access controls and security cameras as important deterrents for this phenomenon. Lilian, a custodial worker, reiterated the connection between ridding the campus of “undesirable” occupants, read as unhoused persons, and her desire for more “smart” access controls:

“It keeps the riff raff out. It keeps people out that shouldn't be in the building, you know, so I mean there's a lot of theft on campus and this would, you know, really help with that.”

Referring to a recent break-in on campus, Franklin, the building access controls manager for campus, contextualized how these systems might help identify a perpetrator of theft and illustrates the technical interdependencies and organizational coordination of these systems on a “smart” campus.

“We had a break in one of our new buildings, [omitted]. So, I'm running reports. We're trying to find out how did the person get into the building? They've trashed a few rooms and things like that. So, I'll use reports and event monitor to try and

troubleshoot that to figure out... to help the police run down and find out what's going on, how they got into the building and who's the likely culprit. Because we didn't find any evidence of damage to a door. So, either had a key, they tailgated, or they you know, put a trashcan in the doorway and came back later on, or put a piece of duct tape over the latch and come back later on. So, we'll run reports and find out how they got into the building. So, in this particular case, you know, it was just transactional data, it's a reader event. So, you know what I mean, "was the door open or closed?" And then I gave them a report of cardholder records and its name, [Cedars University] card badge ID, and then the time and date of their record."

Franklin, as the manager of access controls, had a much more in-depth knowledge of the architecture of "smart" access systems, the possibilities for triangulating access data, and what level of personal data can be surmised from these systems. Additionally, he was part of coordination efforts between other offices on campus like security and campus police to put the capacities other participants have cited into action.

Franklin, as an administrator of "smart" access control systems at Cedars University has a very different orientation to these systems than do the other participants highlighted in this chapter. Returning to Chapter III, Figure 5 highlights the value alignments that constitute infrastructuring publics. The custodians, window-washers, and their managers whose perspectives are highlighted in this chapter constitute a care/maintenance infrastructure public. This public is defined in relation to other publics for its value for the functionality of systems, "smart" or otherwise, and as I argue here, particularly for the efficiency and safety of workers. This contrasts with other infrastructuring publics, like that which I ascribe Franklin to, which are interested in data extracted from the build environment as valuable for the "smart" system business use case and more broadly as a means for understanding behaviors of other user/occupant groups. While Franklin, as he clearly states in the above quote, shares the value of safety with many of those in the care/maintenance public, his relationship to "smart" infrastructure is not as a daily user/occupant and as a manager of the system connectivity and data pathways.

Reading care/maintenance publics and cyber-physical security publics together, there are some shared values and expectations for “smart” infrastructuring. However, the relationship to data extracted from the built environment is different across these groups. For the care/maintenance publics, that data is only useful insofar as it can drive the implementation of more “smart” technology development as improve safety and efficiency on the job. For the cyber-physical security oriented publics the data itself has value at an enterprise level. This relationship to data reconfigured their conceptions of privacy and security.

When it comes to “smart” technologies, one of the most pressing issues is cyber-physical security as examined in Chapter IV. Cyber-physical security is an effort to maintain operations of the system, material security, and personnel security simultaneously as each of these layers of security are increasingly interconnected by the complexity of networked systems. However, definitions of security vary across infrastructuring groups. In the case of administrators of a “smart” enterprise system, security is defined at the scale of the institution as is the risk of harm. When asked generally about data security and privacy concerns in relation to the growing number of “smart” technology on campus, another director-level staff responded:

“So we’re not concerned about personal identifiable data that could be compromised through the process, but we are very much concerned about the corporate data reputation of the [Cedars University] and the associated audit and the risks that it creates.”

This response should be read in conjunction with the scope of work that this individual is tasked with, namely, managing energy usage and data compliance with municipal, state, and federal policies. When it comes to security and privacy, those with power over the architecture of “smart” systems are often thinking about security and privacy at a fundamentally different scale in comparison to individuals in a maintenance/care role like custodians. In the above quote, in

the case of access controls, “bad actors” are conceived of as a threat to the physical security of -- for example -- a laboratory, its equipment, and valuable data as well as a threat to the individuals for whom the laboratory is a workplace. The material harm that threatens campus spaces and their occupants is the impetus for investment in “smart” access controls that promise to deliver better security. Additionally, and in line with other “smart” systems, “smart” access controls provide institutional leadership granular data on occupants coming and going, break-ins, malfunctions in the system, and generally a greater sense of control from afar. These affordances are augmented by connections to other “smart” systems like security cameras.

While neither the care/maintenance nor cyber-physical security publics mentioned above report being deeply concerned with personal privacy in relation to “smart” technology on campus, it is still an important implication of this technology. The shared values these publics have for safety are inextricably linked to a particular definition of security with relation to privacy through the data used to enforce it. In the next section, I examine orientations to safety that promote more “smart” technology to trouble some of the technosolutionist assumptions wrapped up in that argumentation.

Troubling the “Smart” Spaces as Safe Spaces

Privacy concerns vary based on the type of data being extracted by “smart” technologies. For “smart” home technology users, devices that connect to a larger network are usually less concerning than those that collect personally identifiable information like video footage, audio recordings, or geographic location (Naeini et al. 2017; Mare et al., 2020). There is a great deal of uncertainty when it comes to the perceived threat of data extraction and its uses by corporations among users (Zheng et al., 2018) which in time leads to users accepting the technologies despite these concerns (Worthy et al., 2016; Zeng & Roesner, 2019). There have been many critiques

about the privacy issues related to the increasing deployment of “smart” technologies in urban settings which have been called “overlapping infrastructures of urban surveillance” (Guariglia, 2021). Others have traced endemic surveillance and privacy infringement in urban space to the economics of platform capitalism (Srnicek, 2017) and platform urbanism (Barns, 2020). Despite this criticism, others believe design and policy changes in response to privacy concerns with “smart” technology are necessary to the continuation of what they see as societally beneficial systems (Al-Turjman et al., 2019).

Access control using surveillance systems has disproportionately impacted unhoused persons and led to the criminalization of poverty. Spatial control of this type is often a state-sanctioned and police-powered campaign to “sanitize” space (Amster, 2003). Despite applications aiming to deploy algorithms to help “solve” homelessness by connecting unhoused persons to available services (Khayyakhoshnevis et al., 2020), this approach sidesteps the historical trajectory of many spatial technologies which are rooted in carceral geographies and enmeshed with military and police institutions (Jefferson, 2020). Furthermore, assertions that “smart” cities -- and “smart” infrastructures generally -- can improve civic participation make invisible those who are differently positioned to the state (i.e. the unhoused, criminalized, and racially minoritized). The assumption that all users of a “smart” infrastructure are equitably able to access the social capital benefits of the infrastructure -- or even want to -- is questioned (Calzada & Cobo, 2015). The expansion of a “smart” infrastructure often overlooks the lagging access to seemingly taken-for-granted technologies like outlets for charging devices or internet access (Lanz et al., 2021).

Yet another layer to the privacy and surveillance questions gets added when workers in “smart” spaces are considered. The questions surrounding worker surveillance have been newly

invigorated by the profound changes to workplace relations in the shutdowns due to COVID-19. Shortly after the world began to reckon with the magnitude of this shift, I was invited to speak at Microsoft Research's "New Future of Work" Conference. Microsoft, itself a giant in the industry of "smart" technologies and workplace productivity systems, invited computer scientists, social scientists, and designers to engage in discourse about emerging technology practices in the workplace with the lens of futurism. Futurism, in the context of technological innovation, often falls into technosolutionism and remains committed "hard-nosed entrepreneurs designing for the market" (Polak, 2010). This approach is challenged by a growing movement of "tinkerers" sometimes referred to as the "appropriate technology" movement (Schumacher, 1973). Appropriate technology ideals have been foundational to participatory work in computer science and information scholarship through the implementation of makers-spaces for the development of information and communication technologies (ICTs) (Hentschel, 2017). Similarly, "right to repair" movements have emerged in the seams between technology developers and vendors and the needs of users from personal devices (Jackson et al., 2014) to industrial agriculture (Wanstreet, 2020). However, much of the "New Future of Work" Conference centered on the interactions between colleagues and supervisors in a new, primarily virtual, modality. This purview is limited.

While certainly, the impact of large swaths of workers functioning in a virtual workplace has never been such an important research agenda, there is a tendency to overlook those whose work continues to be place-bound. One such group is building services as the maintainers and caretakers of the built environment. With the knowledge that some in the workforce would need to return to in-person modalities, especially as pandemic time turned from months to years, technologies were deployed to assist in health safety protocols. On universities campuses, this

includes testing, contact tracing, and temperature screening. While much of the news coverage has focused on the student experience upon returning to campuses, less has been said about the state of work on campuses, much of which did not stop when the students and faculty left. One such workforce is the maintenance/care workers who have been the focus of this study. The deployment of “smart” technologies and the network of protocols in response to COVID-19 have made this labor more visible in a particular way. This aligns with critical infrastructure studies that have shown processes that make invisible work visible demonstrate the paradox of labor visibility as theorized by Star and Strauss (1999): that making work visible can both mitigate labor exploitation while also providing opportunities for new forms of exploitation. I argue that COVID-19 protocols have rapidly changed the critical infrastructure of university campuses due to the implementation of large numbers of IoT devices, met with the even more rapidly changing health accountability measures, and should give us pause in the consideration of why and how certain aspects of labor are becoming visible (Snider, 2020). This argumentation stems from a large body of research that has shown how care work is highly surveilled (Berridge et al. 2019, Hjalmarsson, 2009; Ball & Wilson, 2000).

The question of surveillance and privacy in the introduction of “smart” technology to the built environments as workplaces has myriad implications. In the context of the constellation of scholarship above, spatial control for the sake of worker security emerged as a particularly compelling reason for an uptick in “smart” surveillance systems like cameras, access controls, and more, despite inadequate evidence that these systems are taking into account these workers’ own perspectives in the design and implementation of them.

Conclusion

Despite concerns for personal privacy and worker surveillance not being articulated by the participants in this study, these concerns are inextricably linked when one considers the uneven distribution of “smart” access controls on Cedars University’s campus. Despite arguments that the proliferation of these systems can increase physical security for workers, their deployment at the exterior doors of campus buildings new and old is lagging. Following the trends examined in Chapter IV and V, new “smart” and “green” buildings are where most of these developments take place. This lag is yet another reflection of the political economic situation of the deferred maintenance and labor shortage problem among maintenance/care teams on campus.

The interests of maintenance/care teams to feel safe at their workplaces, especially being that they may be some of the only people using campus regularly during early morning hours, should be more central in the consideration of who “smart” infrastructures are being developed for. As has been argued in previous chapters, maintenance/care orientations to sustainability—which I argue are underrepresented in leadership and infrastructure decision-making on campus—are critical to achieving long-term sustainability in both environmental and economic terms. Taking seriously the needs of maintenance/care workers in the design and implementation of “smart” infrastructures is critical to their appropriateness and efficacy. However, as has been briefly mentioned above, the perspectives of maintenance/care workers need to also be questioned in relation to carceral logics that inform understandings of safety. While there is credible concern for worker safety on campus, the assumption that more surveillance via “smart” technology can mitigate harm must be challenged. Further research should apply feminist carceral geography critiques to this phenomenon to flesh out some of these questions.

VIII. Conclusions

Summary and Contributions

The questions that animated this dissertation project emerged from ongoing fieldwork that has evidenced a gap in our collective understanding of the ways in which different publics of a university campus specifically, and built environments generally, understand the goals of new technology introduction and implementation. Practices of care are relational and responsive to technology and organizational changes. The shape this change takes is informed by power. Alignment around a shared definition of success was a heuristic for power in this process and illuminated opportunities for alignment and misalignment in the values driving various groups to engage with “smart” infrastructuring projects and the data extracted from them. A better understanding of the politics of care in relation to sociotechnical change on university campuses can inform policymakers, administrative staff, and advocates within and beyond this institutional context. Although this dissertation does not explicitly speak to new policy aims, it illuminates the tensions that exist in these sociotechnical activity systems and informs future decision-making as it relates to the inclusion of stakeholders in processes of policymaking, governance, and organization.

Chapter III built upon published organizational charts for Cedars University. These charts were not a perfect representation of the communication and coordination practices between the study’s participants, but rather an aspirational and simplistic rendering of the organization. Despite their inherent shortcomings, organizational charts are a helpful foundation from which I could begin a more nuanced analysis of these participants as part of a whole. From that point, I introduced infrastructuring publics as a framework for making sense of the organizing power of

values among participants working within the large project of a “smart” campus. Analysis of the values and expectations of the diverse set of participants led me to identify three converging value alignments: “smart” innovation, environmental and economic sustainability, and infrastructural maintenance. I grouped participants into eight distinct stakeholder groups: Information Security, Building Services, Facilities IT, Facilities Operations, Capital Projects, Sustainability, Researchers/Students, and Design/Build Contractors. These groupings are loosely based on the departments and organizations designated by the institution, with additions that leverage my own perceptions of delineations between subgroups that emerged in observations and interviews. These designations are not reflected in such detail in the organization’s own charts. In many cases, these stakeholder groups are lumped together under the banner of “Facilities”, “Research”, or “IT” but this designation is often too simplistic, as became clear during my research. Of course, there is always more nuance that can be added to such visualizations and based on interview data and participant observation it became clear that differences emerged even within these eight stakeholder groups down to an individual level. However, for the sake of making sense of the complexity of the institution, I used my role as an interpretive researcher to delineate important groupings.

From this exercise of visualizing the value alignments and misalignments between infrastructuring publics, observed patterns of communication and coordination became clearer. I observed coordination between infrastructuring publics aligned in their shared values of environmental and economic sustainability which included researchers and sustainability stakeholders. This alignment was explored in more depth in Chapter IV and V.

Small fissures formed between those who value data as an asset for knowledge production and those who value its protection and security as a means of avoiding vulnerability.

The tension that arises between these publics is not too great to render them incompatible for better coordination. In fact, over the course of the fieldwork, plans were being put in place to introduce a data management platform to delegate some of the coordination work necessary to appease both the need for data access and the need for data security. These findings were presented in Chapter VI.

Lastly, the final findings chapter (Chapter VII) presented yet another orientation to “smart” infrastructuring that is much more rooted in the impact of “smartification” on the quotidian practice of caring for and maintaining a campus—and therefore the campus community. Alignment with the value of infrastructural maintenance was observed between information security and building services, although, as discussed in Chapter III these stakeholder groups do not actively work in coordination. I argue that this lack of consideration of building services in “smart” infrastructure design has implications for workers in those departments in terms of their safety and security as well as implications for the long-term sustainability of the university.

Building on the findings presented in regard to the research questions that guided this study, the central argument of this dissertation is that it is insufficient and unsustainable in economic, environmental, and social terms to overlook the insights of those who maintain and care for our shared built environments. These important insights can be gleaned from examining the work practices of these workers to identify frictions that arise as built infrastructures become home to more “smart” things. The increasing complexity of the technology systems that make up infrastructures that are critical to Cedars University’s operations is driven by a high valuation of the data that “smart” systems extract from the environment. Those who not only value this data, but have expectations for its gathering and access, are also often in alignment with those who

dictate the investment, design, and construction of these infrastructures. This view is data-centric in that it prioritizes those publics for whom data extracted from the built environment by “smart” systems share similar values and expectations.

This research has shed light on the process of unequal infrastructural investment at Cedars University—a trend that is shared across many research institutions. Investment in infrastructures and the built environment tell a story about what institutional leadership prioritizes. The process of creating a “smart” campus has been anything but even. In fact, what has emerged is the bifurcation of the original campus into two campuses sharing the original geographical space: the new “smart” campus and the old campus. The new “smart” campus is a site for continual innovation and outside funding. The old campus is a site upon which the deferred maintenance crisis is visible and felt by those responsible for maintenance/care work. Within and between both campuses one can find maintenance/care workers whose ranks have been thinned even as the scale and complexity of their responsibilities continues to grow.

In the following sections I summarize the contributions of this dissertation both theoretically and practically. The contributions include implications for future sociotechnical system studies, conceptualizing data care work, and “smart” infrastructure investment. I end this chapter with some reflections on the research process, limitations of the study, and ideas for future work.

Implications of the framework for future sociotechnical system studies

This dissertation takes seriously the work of care. It examines the built, information, and organizational infrastructures that sustain people, which are often only made visible in moments of disrepair or breakdown. The rise of the “smart” campus cannot be claimed as a success or failure simply. It is more appropriately attended to as a moment in which these infrastructures

might be parsed and made sense with. My findings contribute to an ongoing scholarly effort to bring into conversation, and extend, theories of sociotechnical systems as laden with values and expectations. Furthermore, these values and expectations are instructive in the failure or success of collaboration and communication. This kind of inquiry requires a weaving together of many disciplines. While maintenance, care, and repair activities show up in quotidian practices of participants, they are also part of my own research practice. Thus, they represent more than just a theory, but an epistemological and methodological posture from which I approached the field. Following Mattern (2018), “to fill in the gaps in this literature, to draw connection among different disciplines, is an act of repair or, simply, of taking care—connecting threads, mending holes, amplifying quiet voices” (Introduction section). I applied such care in the context of studying the sociotechnical processes of change that accompany “smart” infrastructuring projects. Doing so enabled me to contribute theoretical knowledge to the study of maintenance and care and expand understanding of our relationships to data, the built environment, and the social world as increasingly mediated through “smart” things. The project challenges much of the productivist logic that pervades the university institution—and our society more generally. Making this conceptual space is both necessary for a deeper understanding of how people work with technology and for the normative project of equity in work with technology.

Implications of the findings for conceptualizing data care work

In Chapter VI, I focused on the value alignment between facilities IT and facilities operations to maintain the cyber-physical security of Cedars University and examine the conflict between this infrastructuring public and the sustainability and research public highlighted in Chapter IV. Despite sharing a value of environmental and economic sustainability, their respective alignment to “smart” innovation for the sustainability/research public and infrastructural maintenance for

the facilities operation's public causes tensions in their approach to managing data extracted from the built environment. In Chapter V I applied the theoretical framing of data valences to the context of data extracted from the built environment for research and sustainability publics. The data valences framework introduced by Fiore-Gartland and Neff (2015), mapped onto my own analysis of the values and expectations for data according to this public. This framework is then leveraged in Chapter VI to understand where misalignments start to occur between the facilities and operations public and the research/sustainability public. The most important difference, I argue, is that the facilities and operations public are more concerned with data security and protection than they are of open access of data for knowledge production. The latter becomes secondary to their interest in and demand for cyber-physical data security. This novel data valence is presented as an addition to the original data valences (Fiore-Gartland & Neff, 2015) that are particular to custodians of the network infrastructure of a "smart" campus. As built environments of many types become increasingly networked with "smart" things, this valence will continue to emerge among those tasked with data care work with a cyber-physical security focus. This novel data valence speaks to a burgeoning exploration in STS studies to make sense of the variety of work that can be considered data care work. While previous studies have focused on the work of cleaning, storing, and creating access pathways to data for research needs (Pinel et al., 2020), this purview is limited. Such knowledge production efforts, highlighted in Chapter V, are only one part of the data care work taking place. I argue that to really attend to the maintenance/care needs of increasingly networked infrastructure, scholars, practitioners, and designers broadly must consider this orientation to work with data that is simultaneously concerned with cybersecurity and physical security as built environments become more vulnerable to cyberattacks.

This is not the only tension that arises from the process of building a “smart” campus. While the data-centric publics on Cedars University’s campus had small fissures that formed in their values and expectations for shared data, those who engage in maintenance/care labor for the buildings and grounds are less interested in access or security of data extracted therein. Rather, these sociotechnical changes have material implications for their work processes in an immediate sense and represent a divestment from their labor in the long term. In the short term, “smart” building design, which highlights “smart” systems throughout can be an impediment to safe and efficient work.

Despite renewed interest in care work, feminist STS scholarship has only just begun to discuss orientations to data care work that are in conflict. Care work, the foundation of our social and material infrastructures supporting the continuation of life, is primarily discussed in the context of healthcare, domestic work, and other social service realms. A feminist political economy of care is analyzed in contrast with capitalist logics, technosolutionist progressivism, and extractivism (Puig de la Bellacasa, 2015; Bhattacharya, 2017).

In practice, workers of various disciplines in various workplaces may perceive their work as a type of care work and that perception may be valid while also coming into conflict with more traditional conceptualizations of care work. To stretch the term beyond the traditional bounds of healthcare, domestic work, or social service settings may provide insight into the complexity of care as non-innocent (Murphy, 2015). That is to say that our orientations to care—who/what we care about, who/what we care for, and who/what receives that care—can be in conflict even within a single community, institution, or building. This dissertation attends to competing orientations to care in “smart” infrastructuring as a necessary step toward attending to

epistemological and ideological conflicts that arise within increasingly networked natural and built environments.

Such networked environments are the result of an increasing number of “smart” technologies and Internet of Things (IoT) systems being embedded into the shared spaces of life. Making sense of care work in these settings requires grappling with values that different publics have for the devices/systems, data, and the built environments from which data is extracted. These values inform orientations to care work and though they are not always in alignment, they necessitate coordination. Like traditional conceptions of care work in health and safety orientations, care in “smart” spaces is part of a system of commodification and as such must reckon with challenges of scale both temporal and spatial. This prompts us to apply a politics of care framework to ecological challenges and sustainability efforts, including but not limited to the repair and maintenance demands of our energy infrastructures. Furthermore, as we see these infrastructures increasingly embedded with sensors of various types, scholars and practitioners are prompted to attend to questions of privacy, surveillance, and cybersecurity within a politics of care framework.

A key conclusion of this dissertation is that we should consider cybersecurity as a particular orientation to care work. Cybersecurity is a field fraught with representation issues. Only 21% of cybersecurity professionals are women in North America ((ISC)² Cybersecurity Workforce Study, 2020). The focus of the field also needs expanding. Cybersecurity is not just the work of network engineering, but the work of collaborating, maintaining, and communicating across complex sociotechnical systems. A network is only as strong as the social and information infrastructures that maintain it. Considering a politics of care in cybersecurity brings us closer to

what the re:Configure Network introduces as “feminist cybersecurity” (re:Configure Network, 2021).

As we strive toward climate resiliency within the bounds of extractive capitalism, we see fissures forming between technosolutionist approaches to sustainability (i.e., demand for more networked devices to make infrastructures “smart” and “green”) and cybersecurity concerns that increasingly threaten our collective and personal privacy (Atlam & Wills, 2020), physical safety (Nawir et al., 2016), and the very infrastructures these vulnerable technologies were introduced to improve (Palleti, 2021).

This conflict is illustrated in Chapters IV, V, and VI, in which I explicated these tensions in the context of a “smart” building projects. These cases should be expanded and applied to other “smart” infrastructuring projects that espouse an underlying desire for sustainability. This is likely a phenomenon underway on university campuses, cities, and corporations globally. Under the pressure to make buildings more energy efficient—a necessity in that nearly 40% of global carbon emissions come from buildings and construction activities (UN Environment, 2017)—industry leaders largely turn to technological innovations as a solution. Building and construction teams, as well as institutional leaders, are inundated with vendor pitches promising their networked sensors, IoT systems, and cloud-based computing solutions are the answer to both strains on energy infrastructures and the climate crisis. This orientation to care straddles both the institutional/municipal scale in that it responds to increasingly stringent top-down policies and codes urging efficiency across energy infrastructures. On the other hand, in many ways it also is a genuine orientation to care on an ecological scale, reflecting an effort to look beyond the building and beyond the lifetime of its current occupants. A technosolutionist approach to “green” building makes use of networked technologies to access and analyze energy

usage. The demand for data and data visualization, and the preference for always-available, real-time data, is its own ecological crisis. Increased sensing in the built and natural environment necessitates data centers that use an incredible amount of energy and are often conveniently out of sight for those leading the charge on “smart” building projects (Hogan, 2015). The resource consumption of having real-time, always available data needs to be framed in comparison to more visually obvious resource expenditures.

Already we see some rifts in orientations to care through sustainability efforts that are enmeshed with technosolutionism. Unfortunately, the complications do not end there. As more and more “smart” technologies and IoT systems become intricately tied up in our built and natural environments—in the name of sustainability or otherwise—there is an increase in cybersecurity risk and privacy infringement. The two are intimately related (van de Poel, 2020). For those for whom privacy and security are a central concern, approaches to sustainability that necessitate more and more sensing and networked devices are not necessarily welcome, and for good reason. Many of these technologies are lacking in adequate security protocols as vendors push ‘off-the-shelf’ solutions, utilize vulnerable devices, or require public internet connectivity (Beyer et al., 2020). Technosolutionist thinking challenged by a sociotechnical systems approach unveils what is missed when social infrastructures are not considered in innovation efforts. As the CTOP study has found, often the growth in networked devices on campus is outpacing the ability to maintain the security and operability of these devices with impacts on legacy systems and critical infrastructures (Beyer et al., 2020).

Yet another orientation to care brings us back to our feminist political economy roots of care theory. The impacts of “smart” technology failure, privacy infringement, and potential surveillance harms fall disproportionately on those in traditional care work roles. In the context

of a “smart” building on a university campus, one that has likely been closed to most occupants since early 2020 due to the COVID-19 pandemic, those who remain are those who clean, sanitize, repair, and maintain the buildings and grounds. The weight of our conflicting orientations to care, however genuine, will fall, as they often do, on the care worker despite these workers having a disproportionate amount of power in the decision-making process of what makes their workplace “smart.” These workers, who include custodians, window washers, and repair technicians, are not often considered as users/occupants of a “smart” space during design yet are critical to the continued functioning of these spaces. Time and again we are privy to the unintelligence of “smart” technologies powered by algorithms that do not consider vulnerable care workers and discriminate based on race and gender (Buolamwini & Gebru, 2018) with heightened security threats to immigrant populations (Guberek et al., 2018).

The conflict it appears is as much a social one as a technical one. Considering this, I contend that a politics of care approach is necessary to both create a shared language about the complexities of increasingly networked built and natural environments within extractive capitalism, but also to inspire more collaboration between communities with different orientations to care. I believe this dialogue can have fruitful outcomes for systems design and policymaking regarding energy infrastructures, sustainability, privacy, and security. Making sense of care in conflict will necessitate ethical design (Baldini et al., 2018) and design justice frameworks (Costanza-Chock, 2020) being brought to bear on the complexities of caring for increasingly networked built and natural environments.

Implications for “smart” infrastructural investment

In addition to expanding our understanding of data care work and the implications of “smart” infrastructuring on a broader conception of users/occupants, this dissertation provides insight

beyond the theoretical. Practitioners in cybersecurity, sustainability, research, maintenance/care work, and beyond will likely recognize some of the challenges presented in the cases from Chapters V-VII and certainly the foundational tensions introduced in Chapter IV. As with many multi-perspectival studies, the aim is not to vilify or blame any groups for failures that have occurred, but rather to offer a prism through which practitioners can see the situation differently from the standpoint of another.

Each case presented in Chapters V, VI, and VII highlight the definitions of success, values, and expectations that different publics have for “smart” infrastructuring on Cedars University’s campus. Chapters V and VI provide a clear narrative for how the research/sustainability publics and facilities operations publics must work to align their data valences to meet both of their data needs. The data care work this requires is two-fold. On the one hand, research/sustainability publics are championing access to data extracted from the built environment as a product of a living laboratory framing for the campus. They see the value of a “smart” campus as an opportunity to gain valuable data access for various knowledge production goals. This valence comes into tension with the emergent data valence of cyber-physical data security that is introduced in Chapter VI through analysis of the values and expectations that facilities operations publics have for “smart” infrastructuring. The story of Chapter V and VI concludes with the introduction of a data management platform, governed by facilities operations leadership, but with the goal to provide data access to research/sustainability publics safely and securely. Future research should pick up from this point in the story to make sense of the process of implementing a data management platform for the delegation of data care work and how successful this delegation is. Of particular importance would be investigating the effects of

putting the management of this platform in the hands of a particular user/occupant group, and how that affects communication and coordination practices moving forward.

Chapter VII offers a more critical analysis of the implications of “smart” campus building efforts. With a normative goal to make visible the work of maintenance/care professionals who are not often visible in the decision-making and design phases of “smart” infrastructuring, this chapter provides insight for leadership in any institution in the process of becoming “smart.” Chapter VII tells the story of maintenance/care workers who are dealing with the complications of “smart” technology and the pinch on their labor because of divestment from maintenance/care across the institution. One example was “smart” solar fins that were not designed with window-washing ergonomics in mind. Similar systems pose safety issues in that these same window-washing teams were not trained on safe cleaning protocols for devices that are always “plugged in.” Similarly, custodians, who are being asked to cover more square footage and more complicated workspaces, are similarly unaware of how “smart” designs may impact their work practices and only are aware of the interruptions these systems may introduce upon discovery in situ, rather than through adequate training or information sharing. These tensions are evidenced by the desire of maintenance/care workers to have more investment in “smart” access controls, but with the knowledge that based on the current political-economic structure of the university, this investment will likely privilege new buildings receiving capital funds.

Chapter VII briefly introduces an additional tension that arose with the investment in “smart” access controls—surveillance. While this concern was not widely shared by participants, it is an ongoing conversation in the literature on “smart” infrastructures. Future research should investigate how conceptions of safety surrounding “smart” access controls are an example of “carceral creep” and challenge the association between spatial control and personal safety.

Additionally, future work should ask how partnerships between researchers and administrators might be leveraged to mitigate harm in the effort to increase campus safety.

Reflections

As I began my dissertation fieldwork in October 2019, seemingly everything around me was becoming “smart.” The classrooms I was teaching and learning in were “smart” classrooms. The devices crowding the corners of my home were “smart.” Even the pockets of my jeans were often occupied by “smart” things. Up until joining the Communication, Technology, and Organizational Practice lab and the Cyber-BE Lab at the University of Washington College of Built Environments, I was only familiar with the concept as it applied to wearable technologies, like smartwatches, and home technologies, like app-controlled security systems. I quickly became aware that “smart” technologies were finding their way into almost every industry and corner of life.

I certainly was impacted by my time in the field and gained a great deal of knowledge about the operational, cyber, and physical security considerations that are being complicated by increasing “smart” devices and systems of devices. I also learned a great deal about the social, political, and economic workings of a large research university. At the time of joining the CTOP lab team, I was involved as a volunteer in a Seattle-based non-profit called Casa Latina. Casa Latina is a worker center in Seattle’s Central District committed to advocacy for workers’ rights, particularly day laborers and domestic workers. As I began planning my dissertation proposal, I was inspired by STS, feminist geography, and labor studies scholarship. I was intrigued by the nexus of “smart” home technologies as they related to the caring labors of domestic workers and what perceptions of privacy and surveillance might accompany these devices. However, as 2019 ended and 2020 began it became clear that gaining entry to this field site was untenable. My

work with Casa Latina came to a standstill as programming was paused or moved remote and many domestic workers found themselves out of work. The project would necessitate participant observation of domestic workers in their workplaces – which usually private homes. In the early days of the COVID-19 pandemic lockdowns, that was not a feasible plan for my dissertation in the time I had available to complete my degree.

However, the more familiar I became with Cedars University the more I began to see similar dynamics between technology innovation and maintenance and care work. I recognized the opportunity to expand the stakeholders invited to participate in the CTOP study and apply my own theoretical and analytical frameworks to this research setting. Despite the challenges of conducting an ethnographic project during a pandemic and the unforeseen changes that had to be made to my original plans, I was able to formulate important questions about the intersection of work and technology that are both particular to a research university setting, but also include insights which can be applied beyond it as well.

Limitations and Future Work

Being embedded in a single institution has benefits and limitations for research. A benefit, that has been leveraged in this project, is the ability to make sense of similar phenomena (i.e., infrastructure projects) from multiple perspectives. This would be challenging to accomplish in a comparative study where so many factors could interfere with the ability to understand how a project might impact other users/occupants. For this reason, embedding myself in an ethnographic field site at Cedars University provided a robust set of cases to draw on for my analysis, but also offered enough overlap between them to provide rich comparative insights.

The other side of this approach is the limitation of generalizing these findings to applications beyond Cedars University. For this reason, my findings reflect a recognition that the social, political, spatial, and temporal aspects of this research ought to be considered in reading through the conclusions presented. One benefit that I enjoyed while conducting this ethnographic work alongside the CTOP project is that, as part of the research team and simultaneous with the analysis presented in this dissertation, I was also interviewing IT and O&M professionals from various universities across North America. These interviews were done as part of an effort to gather insights beyond Cedars University and to compile information about strategies for overcoming challenges in the coordination and communication practices for IoT cybersecurity risk mitigation. This context offered some validation of the challenges I was seeing at Cedars University.

Future research should investigate the efficacy of changes to design standards as a means for negotiating power in the infrastructuring process between technosolutionist sustainability orientations and maintenance/care sustainability orientations. Moving forward in the process, maintenance/care team representatives should continue to be involved in the design and construction process. Often networked systems and other technology innovations are decided on early in the process so their representation early in the process is critical. Furthermore, training on new building systems should expand to all levels of the maintenance/care teams. If custodians and window washers do not feel empowered to do their jobs effectively in “smart” and “green” spaces, then those spaces will inevitably not live up to their long-term sustainability goals.

Future interventions

CHAT enables the identification of implications for change. The work of CHAT scholars usually entails the practice of intervention in the field site. Interventions are one of the pragmatist

pillars of this analytical framework but are also one of the challenges that those who employ it face. Intervention necessitates a higher degree of buy-in from the subjects of the study as it requires them to participate more actively in the research process. It also usually requires more time in the field to develop a nuanced understanding for the sake of intervention design and implementation. Additionally, and in the context of my dissertation project, there are constraints concerning human subjects research, time, and resources that made the design and implementation of an intervention unfeasible. Despite not engaging with the intervention phase of a CHAT methodology, the findings of my dissertation provide insights into implications for change, make sense of a complex and dynamic set of processes, the illumination of which uncovers new paths toward a shared imagination of the future.

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