A Study on City-University Partnerships for Smart City Technologies

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Abstract

On September 14, 2015, the Obama Administration announced its Smart Cities Initiative, a $160 million investment in a range of research and development activities focused on "Smart Cities." The MetroLab Network, a consortium of partnerships involving cities and their universities, was announced as part of the Initiative. In order to join the Network, university-city partners had to agree to follow a set of rules and procedures to govern their partnership. This research explores the history, governance, goals, and outcomes of two such partnerships: Carnegie Mellon University and Pittsburgh, PA and the University of Chicago, and Chicago, IL. Although these two partnerships work under the same MetroLab Network umbrella, the type and breadth of the activities each university undertook on behalf of their city partner varied greatly. The structure of the partnerships, project selection; deliverables and outcomes; data sharing and data ownership; levels and forms of community engagement; funding; technology transfer; and engagement with and impact of MetroLab were quite different in the two cases. Levels of satisfaction among the city partners, commitments to protect citizens' rights, and the level of control granted to each of the partners varied markedly. These two cases are presented in the context of the history of city-university partnerships, university-community partnerships and the emergence of interest in Smart Cities in the United States. The thesis offers seven recommendations for MetroLab, cities, and universities involved in this type of research moving forward: 1) formalize expectations for every project; 2) Negotiate with funders to prioritize local needs; 3) Mitigate negative impacts of experiments; 4) Develop expertise and allies throughout city government; 5) Seek involvement throughout the university; 6) Engage citizens in the partnership, not just the projects; and 7) Develop revenue sharing agreements for projects that commercialize.

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Introduction and Context
Historical Context

The University and the City

The relationship between each university and its surrounding community has always been important. The siting of a university has often been quite intentional, and in the context of the United States, the locale of choice was often rural. Urban universities were seen as "educational and moral failures," while a rural setting fit with the bucolic and idealistic views of college life (Turner 1984, 101). Nonetheless, some universities were located in cities — or cities grew up around universities. Throughout 20th century America, urbanization resulted in a growing number of universities in cities, such that while only 15 percent of colleges and universities were located in cities in the mid-1920s (Berube 1978, 5); over 50 percent of universities and colleges today are urban.[1] As this evolution took place, the relationship between universities and their urban environs produced a different sort of relationship than that which existed previously. By the late 19th and early 20th centuries, urban universities were expected to engage with urban problems (Hackney 1986), but, the type of research that was of interest to university faculty was a-spatial and often unconcerned with solving local problems (Bender 1988, 8).

Immediately following World War II, with the massive growth in college enrollment fueled by the GI Bill,[2] the teaching mission of universities was reemphasized. At the same time, the

[1] U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), 2017. Retrieved from https://nces.ed.gov/ipeds/datacenter/QueryForm.aspx on April 28, 2019.

[2] Enrollment grew from approximately 1.5 million students in the 1939-1940 school year to approximately 2.4 million in the 1949-1950 school year. Growth continued to balloon in the 1960s through the 1980s due to the attendance of baby boomers. Source: Department of Education, National Center for Education Statistics, Digest of Education Statistics, *Table 301.20. Historical summary of faculty, enrollment, degrees conferred, and finances in degree-granting postsecondary institutions: Selected years, 1869-70 through 2015-16.*

federal government poured money into basic research in the belief that such research could lead to technological change and economic growth (Bush 1945).

During the 1960s, a new mission for universities developed. Social pressure, especially upon urban universities, was beginning to force university administrators to consider public service of various kinds (Berube 1978, 4–5). Peter Szanton (1981, 13) covers much of this history in his book *Not Well Advised*, stating: "[b]y the 1960s, what universities were being asked to do—by mayors, editorialists, foundations, entrepreneurial or socially-conscious faculty, and by their own student bodies—was to take up a position on the urban battlefront." Public urban universities now joined elite private institutions, and both types were expected to educate the masses, develop research relating to the urban condition, and to be good neighbors (Berube 1978, 5). Higher education was being democratized, and students and taxpayers alike had new expectations about who a university served, and what activities it should undertake.

At the same time, and through today, the university has also played the role of urban developer. In many cities, universities and other non-profit institutions are among the largest landholders (see, for example, Pittsburgh: Lord and Belko, 2017). As such, the development of an urban campus, and the surrounding land, has been a key—if contentious—aspect of the pattern of city development (O'Mara 2012). In Chicago, for example, the creation of the University of Illinois at Chicago sparked heated debate regarding the best way of rebuilding blighted areas of the city (Turner 1984, 271–76). Such debates continued as the campus expanded in the 21st century (Perry, Wiewel, and Menendez 2009). In Philadelphia, the role of the University of Pennsylvania and other colleges in creating "University City" and upgrading that neighborhood is another key example (Ehlenz 2016), while students went on strike at Columbia University in 1968 when the university encroached into the Morningside Heights neighborhood in New York City (Kihss 1968).

Such activities were repeated in the mid-2000s due to Columbia's use of the city's eminent domain powers to expand its campus into West Harlem (Hirokawa and Salkin 2010).

As federal funding for city development (such as federal block grants and urban renewal grants) declined, the nature of the university's engagement with the city came under increasing scrutiny. Many observers, both inside and outside academia, argued that applied research should be pursued by university-community partnerships. Faculty would get their research published, while the city would achieve the benefits of university-assisted problem-solving. Organizations such as the Coalition of Urban and Metropolitan Universities, which was created in 1989, represent a mission perceived as unique, serving poor urban areas. While questions continue about the purpose of the urban university (see, for example, Wusten 1998), community-based research emerged, in part, as one general objective that responds to the interests of individual faculty and the city (Ferman and Hill 2004).

Leigh (2017, 426) outlines some of the challenges associated with urban community partnerships. Some universities engage in such efforts as if they are doing charity, and students at elite universities may be "'doing for' rather than 'doing with.'" The literature surrounding university-community partnerships is extensive. Much if it examines where such research partnerships have happened (Maurrasse 2001). Other reviews are more reflective. In "Higher Education Collaboratives for Community Engagement and Improvement, " Pasque et. al (2005) reflect on a series of conferences examining these partnerships, finding that the power imbalance between university researchers and poor urban communities often lead to negative outcomes, at least from the perspective of the communities. Ferman and Hill (2004, 245) speak for community partners and seek to understand their incentives for joining partnerships with universities.

Typically, these organizations are seeking to obtain project-related resources, leverage further resources, gain access to networks, and increase their own legitimacy.

Ferman and Hill (2004) and Pasque et al. (2005) point to structural adjustments that might be made to improve the outcomes for communities while furthering the university's interests. Both sets of authors agree that partners in a collaboration need to individually and jointly assess and set the goals of the partnership prior to engaging in any joint work. Capacity is also a primary concern, regarding the ability for faculty, students, and community members to engage in the work that is agreed upon. They also recommend that operational structures be agreed to, with a formalization of the partnership that allows for clear roles for all involved, and clear pathways for achieving the goals. One surprising recommendation from Ferman and Hill (2004, 253-254), however, is that faculty members avoid engaging with partners that are geographically close to the university, citing concern that such a partnership would bear the burden of the entire university's impact on the community. This recommendation is in stark contradiction with one of the primary goals that universities hope to achieve in engaging in community research projects: appearing to be a good neighbor. Given that trust and strong interpersonal relationships are also a key to success according to the literature, working with community partners that are physically distant seems like a barrier, rather than a key to success.

Into the 21st Century, the concept of universities as anchor institutions became more important to city development strategies. Universities as anchor institutions were viewed as a mixed blessing (Adams 2003), yet many hailed this new lens through which to view universities as an important development (Birch, Perry, and Taylor Jr. 2013). A number of philanthropic foundations have taken a particular interest in universities-as-anchor-institutions, hoping that such a focus will allow cities to achieve economic development through increased cooperation with

"eds and meds" that are unlikely to be highly mobile, employ large numbers of city residents, and create knowledge spill-over effects (Dever et al. 2015; Initiative for a Competitive Inner City (ICIC) 2011; Kleiman et al. 2016). This increased reliance on anchor institutions is important in the current context, as city governments have heeded this call and expect universities to play this role. In mid-sized cities in particular, the local university or medical center may be among the largest employers, land holders, and the chief attractors to the city for new residents. Additionally, by encouraging educational and medical institutions to engage with their local communities, leaders can make up for revenue lost through non-profit land-holding through "in kind" activities, while the institutions can engage in place-based activities that may enhance their own prospects of recruiting and retaining students, faculty, or staff.

University Service to the City

The most poignant antecedent to the current focus on university-city partnerships is clearly the 1950s through 1970s, where a confluence of factors pushed universities into a new role in local knowledge and technology production. Universities' involvement in technology production largely accelerated during World War II and continued throughout the second half of the 20th century. New ideas about management and governance, which also emerged during World War II, spawned new departments of management science and operations research. The theories of these new fields greatly influenced government, which was expected to become more efficient in solving problems, especially at the local scale. Simultaneously, social and fiscal pressures forced both cities and universities to seek new partners and to address new problems (Murphy 1971).

Many believed that universities could help in "two directions: toward more productive technology (computer-controlled traffic signals, high-pressure trash compactors); and toward new planning, policy-making, or management methods" (Szanton 1981, 8). Both of these two

directions constituted a service to the city, insofar as universities were lending their expertise towards technical development and novel managerial methods. This belief was compounded by a desire to develop an "urban science," that could develop solutions that would be translatable across cities (Szanton 1981, 21). Szanton's book is among the few works that focuses on the university as a service provider to local government, and is thus worth a close review.

The federal government and large philanthropic institutions began envisioning ways that universities could be helpful to the city as early as the 1960s. Programs such as the federal Model Cities[3] and the Urban Observatories Program were designed to encourage urban universities to serve urban populations similarly to the way Land Grant colleges served rural America (Diner 2013). These programs, emerging out of the presidency of Lyndon B. Johnson, tasked universities with playing an important part in combatting the urban problems of the 1960s. Szanton differentiated between three types of initiatives at the time: "urban 'centers' or 'institutes' within universities; federally-funded efforts to induce urban innovation; and direct and essentially personal consulting of academics with local officials" (Szanton 1981, 17). Szanton criticized all three as primarily responsive to the interests of the funders and the universities, with "attempting only afterwards—often clumsily— to interest city officials in the results" (Szanton 1981, 19–20).

In late 1968, the Department of Housing and Urban Development (HUD) established an "Urban Technology and Research Office," which was authorized by the *Demonstration Cities and Metropolitan Development Act of 1966* (P.L. 89-754) and reemphasized in the *Housing and Urban Development Act of 1968* (P.L. 90-448) (*Part 4. Department of Housing and Urban Development.*

[3] The Model Cities program, authorized by Congress in the *Demonstration Cities and Metropolitan Development Act of 1966* (P.L.89-754), provided significant funding to cities across the US to study and implement experimental technologies and methods, towards the goal of eliminating urban poverty. For an article reviewing the literature surrounding Model Cities, see Wallace and Weber (2012).

Testimony of Members of Congress and Other Individuals and Organizations. Urban Technology and Research 1969, 432–46). With the new office, new programs were initiated to better utilize research and technology from institutions of higher education, including the Urban Observatory program.

Robert C. Wood, a professor of political science at MIT, suggested in 1962 that political science may be of service to local government. Following his appointment as Under Secretary of Housing and Urban Development in 1965, he worked with the National League of Cities to develop the program that would allow academic institutions across the US to engage in a coordinated research agenda, in close consultation with their local governments (Murphy 1971; *Part 4. Department of Housing and Urban Development. Testimony of Members of Congress and Other Individuals and Organizations. Urban Technology and Research* 1969, 443).

The Urban Observatory program, launched in 1968, sought to "make available to local governments university resources useful for understanding and solving particular urban and metropolitan problems … achieve a coordinated program of continuing urban research…" and "advance generally the capacities of universities to relate their research and training activities to urban concerns and to the conditions of urban living," with guidelines requiring programmatic boards to insure that the work undertaken was relevant and timely to actual municipal decision making" (Szanton 1981, 22–23). Six cities were initially selected, later expanded to 10 (Bengelsdorf 1972; Murphy 1971). A 1972 edition of *Urban Affairs Quarterly* was largely devoted to the analysis of the Urban Observatory program, which, at the time, was expected to expand beyond the 10 cities (Irwin 1972; "Report On the Evaluation of the Urban Observatory Program" 1972; Williams 1972). The authors found that there was great hope associated with the program, though little work had actually been completed and little impact had been made ("Report On the

Evaluation of the Urban Observatory Program" 1972, 49–50); by the time funding for the program ended in 1974, only two of the ten cities were self-sustaining (Szanton 1981, 25).

The National Science Foundation was also involved with local government utilization of research and technology, sponsoring the Urban Consortium for Technology Initiatives (for large cities), the Urban Technology System (for medium-sized cities), and the Community Technology Initiatives Program (for small cities) (Wise et al. 1980, 13–14). The Urban Technology System, administered by Public Technology, Inc., paid for the placement of a Technology Agent (TA) in city agencies to "identify problems that the application of new technology might solve or ameliorate" (Szanton 1981, 34. See also: Barb Jr and Carter 1976; Mercer and Mascenik 1977). The TA would then report back to universities and research associations, providing the bridge between local government needs and non-governmental technical expertise. Szanton found that having a politically savvy TA led to the most successful partnerships, and though university researchers supporting the TA were among the worst performers (as compared to other research entities) those in interdisciplinary centers with strong support from university administration performed well (Szanton 1981, 35–38). A technical assistance program such as this attempted to provide local governments with access to expertise and technology about which they otherwise may have been unaware. However, Szanton's findings indicate that mere technical knowledge was not sufficient to improve governmental operations; rather, TAs needed to understand how the system operated.

Szanton's book traces numerous examples of universities providing assistance to local governments through the three initiatives outlined above. Cities as diverse as New York, Nashville, Pittsburgh, Cincinnati, and Los Angeles received services from their local universities, often with little success. Szanton (1981, 72) created a classification of the types of service that local officials

tended to seek, which either involved problem identification, solution identification, or solution implementation. Szanton then attempted to answer three questions: whether universities can be helpful, whether cities can be helped, and what sorts of changes to future programs might allow universities to help cities, all within this understanding of these three distinct forms of service.

Regarding the first question, Szanton found universities were poorly structured to incentivize faculty to do work that would improve city life. The types of problems that interest faculty members are those that are novel and exciting, while bureaucrats need solutions to everyday problems (Szanton 1981, 140). Moreover, faculty members considered a problem "solved" once they understood it, leaving to others the task of formulating and implementing solutions. The culture of academia in the 1960s through 1970s seemed to Szanton (1981, 59–69) to present a fundamental challenge. On the one hand, you had the issue of the questions faculty considered interesting, the supremacy of traditional departments and disciplines, and dominance of the academic calendar, which often resulted in city agencies and residents wondering where their helpers had gone. On the other hand, city and funding agencies each had their own ideas about the problems that needed attention, concerns about implementation, and a great sense of urgency. Though little has been written about city government-university partnerships since Szanton's book, there are clear parallels presented here to the challenges written about by those who study university-community partnerships (cf. Ferman and Hill, 2004; Leigh, 2017; Pasque et al., 2005).

Szanton found that, of the various types of services cities need, academics may be best suited to help with problem identification, and perhaps proposing possible (but not necessarily politically realistic) solutions. In Szanton's view, professional disciplines, such as engineering, law, and social work, may be better suited to provide support to city officials than disciplines that

were mostly or wholly academic. Szanton attributed this difference to the fact that these disciplines often housed academics who had had professional, client-based work experience. Additionally, faculty in such disciplines had colleagues in industry, lessening the social pressure from the academy to demur from professional service (Szanton 1981, 140–41).

Szanton's attempt to figure out whether cities can be helped generated an even more negative finding. By comparing the experiences of consultants such as RAND and McKinsey with the experiences of universities, he found:

> "It is the limited ability and weak incentives of local officials to seek, absorb, and attempt to apply such ideas in the face of political, bureaucratic, and fiscal limitations that bind them. Improvement in the 'supply' side of the relationship, in short, can be helpful and may be necessary, but it will rarely prove sufficient. More efficient urban services and more effective urban policies require either that the 'consuming' side of the advice relationship gain a far greater capacity to use the advice available, or that the producing side radically expand its role and responsibilities." (Szanton 1981, 70)

In short, Szanton found that if both academics and professional consulting organizations have difficulty providing advice to cities, perhaps it is the fault of city governments, who are constrained by local political dynamics and thus unable to act on advice in the way private clients do (Szanton 1981, 110–13). Szanton did find some success stories, attributing these to "innovation-minded mayors, city managers, department heads, and bureau chiefs," who had the ability and authority to act on the advice they received (Szanton 1981, 126–27). Current studies of local government reform with regards to technology have also found that political leadership is of extreme importance (Goldsmith and Kleiman 2017, 115).

Szanton identified challenges and solutions that are still relevant. He noted that due to the structure of funding, funders tried to push solutions onto local governments, rather than local governments demanding novel solutions and requesting funding for exploration and

implementation. City agencies therefore rarely had reason to use even their limited capacity to ensure that new ideas or strategies would work (Szanton 1981, 34). He recommended that funders should require cities to pay for some portion of the advice they received. In this way, they would have to consider what help and what services they wanted to fund (Szanton 1981, 145). Additionally, Szanton urged that advisors compensate for the inability of cities to take and use their advice by building political support for implementing solutions that might be politically unpalatable (Szanton 1981, 132). Szanton also advised against high-level institutional partnerships, instead suggesting that relationships between bureaucrats and professors would lead to more fruitful relationships than those between mayors and university presidents (Szanton 1981, 43–44, 142).

Since Szanton's book was published, much of the relationship between cities and universities has moved beyond either a research or service function. A series of papers by Dunn and Whorton et al. (1985; 1986; 1987) examined university service to state and local governments, finding that by the mid-1980s, university presidents preferred to establish relationships with businesses, especially given that cities and universities didn't see eye to eye on which questions were most pressing. Importantly, university presidents found it unlikely that programs to support service for state and local governments would grow (Dunn, Gibson, and Whorton 1985, 507).

More recently, Curry (2016, 2015) demonstrates how a university with branch campuses in two cities works differently with the two local governments. Her findings are consistent with Szanton's. She found that in spite of different cultures, institutional leaders (mayors and university presidents) encourage collaboration, though specific roles should be established to best encourage successful collaborations. Szanton and Curry both underscored the importance of understanding the power and history that universities may have within a local community, as employers, land-

owners, and service providers. Importantly, everyone needs to understand the "why" of the relationship prior to undertaking any joint projects (Curry 2016, 66). These observations illustrate some of the tensions between cities and universities likely to exist regardless of the type of projects being undertaken in a city-university framework.

Smart Cities

A key component of university work on behalf of city governments has been a quest towards greater efficiency through the use of novel technologies and better data. This type of work, today falling under the mantle "smart cities," is in fact part of a history of the normative proposition towards technocratic and computationally-enabled government. Goodspeed (2015) rightly links the relationship between the modern term smart cities and the earlier movement of cybernetics. Indeed, Szanton (1981, 25, 47–50) chronicles projects that imagined that universities could help design better street repair procedures and reroute trash collection. These same types of projects exist today under the umbrella of smart cities, with researchers at Carnegie Mellon University using novel technologies to predict where potholes will occur (Bhatt et al. 2017) while faculty at New York University predict better routes for municipal waste collection (Kontokosta et al. 2018).

Among the earliest iterations of using computational power for urban government, large-scale urban models were used more than fifty years ago to help cities plan for their future. Even as early as the 1970s, however, Lee (1973) challenged the usefulness of these models, claiming that they would not be up-to-date or comprehensive. However, 20 years later, Wegener (1994) cataloged numerous contemporary attempts to build computational urban models, claiming that Lee's "requiem for large scale models" was premature. Now, omni-present sensors and ever-increasing computing power mean that university researchers can help city governments generate real time dashboards of city performance and activities.

It has been pointed out that the definition and drive to "smarten-up" cities has been led by corporations and local boosters with profit in mind (Greenfield 2013). Corporations seeking to embed sensors and telecommunications devices throughout the city have sought to define "smart cities" in terms of the data they can help produce, requiring practitioners and theoreticians to grapple with the meaning and politics of a term that has very little clarity on its own (Wiig and Wyly 2016). Goodspeed (2015, 83) synthesizes the corporate definitions as follows:

> "[A] smart city pursues the goals of effective services and efficient city systems through real-time monitoring and control. The city is a system to be optimised [sic] or run efficiently. To do this, the city is instrumented, which means using both sensors for data collection and actuators or control devices that might include city residents themselves."

From Goodspeed, we can see that there are three core components of a smart city. The first is centered on technology and data collection. Almost inevitably, in order to be a smart city, a city must collect novel information through sensors. Green (2019, 98–103) points out that such data collection combines private companies' provision of sensors and other technologies associated with data with expanded knowledge by the state of its citizens. Corporations may offer technology to cities for free, in exchange for data ownership and the use of the public way, or, cities must pay for the novel technologies themselves, hopefully with specific uses in mind. Concerns regarding privacy, data ownership, and data accuracy are all associated pitfalls associated with novel technologies that are used in the smart city.

With data that the sensors collect — and, with data that cities already have — a smart city government can use data analytics to drive better decisions. This is the second core component of a smart city. The first proposition associated with data analytics stems from the use of big data to understand cities in new ways (see, *e.g.,* Glaeser et al. 2016; González et al. 2008; Salesses et al. 2013). The second proposition actually posits that data analytics can lead to improved government

service delivery, from fire inspection (D'Ignazio and Klein 2018, 7–8), social service delivery (Goldsmith and Kleiman 2017, 111–13), to government performance itself (Perez and Rushing 2007).

In order to enable data-driven decision making, data legibility is a prerequisite. Thus, openness is the third and final component of a smart city. For Goldsmith and Kleiman (2017, 18-25), data analytics is primarily enabled by *openness* — open data and open partnerships between cities and non-profits, universities, foundations, and others — in order to make good on the promise of government reforms first proposed in the early 20th century. They argue that, through openness and open data, "cities can raise their trust and legitimacy in the eyes of residents, augment their data with more and better information to make smarter decisions, find new partners to deliver specific services in more efficient ways, and hear about and collaborate on exciting and new approaches to addressing urban challenges" (Goldsmith and Kleiman 2017, 6). However, research has found that though there are numerous benefits to open data, barriers are plentiful and myths abound regarding the usefulness and magnitude of change associated with open data (Janssen, Charalabidis, and Zuiderwijk 2012).

The three components of a smart city — sensors, analytics, and openness — ultimately comprise a technocratic view of how government can work. Such a technocratic orientation has always raised worries. In the contemporary debate, much centers on whether big data is telling us what we need to know, and the risks associated with following it blindly. Where Szanton (1981, 9) noted that the problems of cities were "only partially administrative or aesthetic; they were technical, economic, demographic, social, moral, and all of these together," Goodspeed (2015) uses the understanding of "wicked problems," from Rittel and Webber (1973) as a lens through

which to reframe the modern debate regarding smart city. Both Szanton and Goodspeed ultimately argue that cybernetic or smart cities solutions cannot "solve" many of the problems with cities.

Green (2019:158-163) in *The Smart Enough City* argues that, while technology may offer some solutions, the paradigm must be shifted to focus on technologies for social needs and better policies. This follows Townsend (2013), who also viewed big data and smart cities as inevitable, and urged good governance and restraint when implementing technocratic solutions. Thus, though there may still be some voices arguing strongly against smart cities (see , e.g., Greenfield 2013; Mattern 2017), the contemporary debate has largely moved on to *whether* sensors and other technology are providing the information that is needed, *how* they can be more equitable and accurate, and *who* has access and ownership of the data that are being collected.

Universities and Smart Cities

Though much of the discourse surrounding smart cities has tended to focus on the role of the private corporation and public entities, universities have been brought into the discourse and action of smart cities. Addie (2017) and Leigh (2017) both provide somewhat more cautionary evaluations of the university in smart city projects. Leigh draws comparisons to university-community partnerships, and cautions that university involvement in smart cities retains the same problems associated both with smart cities generally and with university-community partnerships. Leigh (2017, 427–29) imagines a "hyper-local" community engagement, with a commitment to being an anchor institution and bottom-up approaches to engagement. Addie (2017, 1093) notes that "there is nothing inherently progressive about the university as an urban actor," and argues in favor of a new conception of "universities in urban society," with a more theoretical and nuanced utility than "urban universities."

Ardito et al. (2018) write about the role of the university in knowledge management of smart cities, cataloging numerous smart cities projects and identifying the university as a knowledge provider, knowledge gatekeeper, knowledge intermediary, or knowledge evaluator. Thus, universities may play many different roles with regards to smart cities projects, depending on the type of information and technologies at hand.

These highly theoretical critiques and evaluations notwithstanding, the specific activities the university can undertake in smart cities projects are varied. Tanweer and Fiore-Gartland (2017) outline five roles that universities can have under the auspices of "data science for social good," (a strain of university-smart city engagement): expertise, labor, ethics, experimentation, and neutrality. Similarly, Goldsmith and Kleiman (2017, 194) recommend that cities partner with universities, in order to access data analysis and research skills. Harkness (2016) writes specifically about three examples of city-university partnerships for smart cities, bracketing the type of work as "research, development, and deployment." If smart cities are defined by novel technologies, data analysis, and open data, then universities may play a role in each of these three areas.

As was true in the 1960s and 1970s, "university" engagement with cities may not necessarily originate from the university as a whole. Given the distributed nature of academic governance, some city-university partnerships are, in fact, city-faculty partnerships. In the context of this thesis, the main focus will be on projects and partnerships that are sufficiently large and impactful to be considered university-level engagements, though ultimately, all work must be conducted by faculty, staff, and students.

Some universities have followed their private sector counterparts and engaged with cities to deploy and test novel technologies in the urban core. The Array of Things from the University of Chicago (Catlett et al. 2017), Roadbotics and Surtrac at Carnegie Mellon University

("Company" n.d.; Smith et al. 2013), and Benchmark from the Massachusetts Institute of Technology (Giampieri et al. 2017) are all examples of such projects, with the former two spearheaded by the universities studied in this thesis. What is important to note here is that the cautions about the collection and use of sensor technologies remain, even in the case where it is a university, rather than a company, that has developed and is deploying the technologies.

Research is a core function of academe. In modern, non-academic parlance, this would be considered data analysis. Thus, some universities engage in smart city projects through the analysis of data with the goal of greater understanding of urban questions, and perhaps, guiding novel policies. University researchers use their skills to analyze data that local governments have in their possession but do not necessarily know how to *act* upon. Projects such as the routing of trash collection, highlighted earlier (Kontokosta et al. 2018), or analyzing fire risk of commercial buildings (Singh Walia et al. 2018), fall into this category. This type of research clearly follows from the type of work that was undertaken under the Urban Observatory program and other partnerships undertaken by universities and cities that was highlighted by Szanton (1981), yet with bigger and better data than could have been imagined 40 years ago. Within Szanton's framework, one can see how data analysis by university partners can be helpful for cities in problem identification, and may be helpful in solution identification.

A novel role for the university in smart cities projects is that of third party data holder. One of the premier promises of "big data" is the ability to merge disparate data sets leading to new knowledge. However, the merging of data sets requires compatibility among the data, and a willingness of data owners to work together. As such, universities may perform the function of a data repository, appearing as a third-party neutral actor, and perhaps providing privacy protections (Tanweer and Fiore-Gartland 2017). This is the case in Northwest Indiana, for example, where a

professor at Indiana University Northwest houses a data repository and works with local public safety agencies to analyze the information to assist those same agencies (Ferrandino 2018). The use and storage of data may have mutually beneficial aspects for both sides. While the academic is granted access to new sources of data he or she may otherwise be unable to acquire, public actors lower costs and increase (reputational) security by having a "trusted" third party store the data. Both parties can then negotiate for specific products that they want. However, the trustworthiness of the university needs to be ensured through formal mechanisms, and cannot be merely assumed.

There is clearly no singular role for the university within the emerging smart city. As smart cities have primarily been defined by private sector marketing, universities have sought to insert themselves, offering their comparative advantage of place, neutrality, and progressiveness (even if these traits are, in fact, contested) under the banner of "research, development, and deployment" (Barth 2019; Harkness 2016). In part, university interest in smart city technology has been driven by funding interest from the federal government and private philanthropy, who, following the logic of universities as anchor institutions, and perhaps following the playbook from the 1960s, hope to engage universities in the next wave of city technology and research.

Federal Interest in Smart Cities

In recent years, the US federal government has developed a keen interest in smart cities, and, by funding and encouraging research through the Department of Transportation, Department of Energy, National Science Foundation, National Institute for Standards and Technology, and others, has created incentives for universities to engage with their local communities under the umbrella of smart cities research.

In September 2015, the Obama administration announced a "Smart Cities Initiative," with $160 million to support the development of smart cities in various forms throughout the United

States (The White House 2015). Contained within the release, the administration referenced the creation of a new program at the National Science Foundation (NSF), "Smart and Connected Communities," to "bring academic researchers and community stakeholders together to unlock transformational progress on important challenges." The National Institute of Standards and Technology's Global Cities Teams Challenge, which "challenge[s] teams of cities to set Smart City goals and then work with innovators to develop, deploy, and evaluate standards-based Smart City technologies that measurably improve residents' quality of life," received increased support after it was established in 2014. Additionally, the MetroLab Network was announced, a network of 21 cities in partnership with local universities to adopt Smart City Technology (The White House 2015). More details on the MetroLab network will be explored in the following section.

Other top-level announcements from the federal government regarding smart cities contributed to growing interest in the topic. In February 2016, the President's Council of Advisors on Science and Technology (PCAST) released a report entitled *Report to the President: Technology and the Future of Cities*, which called for the creation of a number of new federal initiatives to support the use and development of technology in cities. In that report, PCAST (2016, 23–25) extolled the creation of degrees in urban science and urban analytics, and pointed to universities as possible collaborators on a number of proposed initiatives. In December 2015, the Department of Transportation announced a $40 million "Smart City Challenge," regarding the future of mobility. Ultimately, Columbus, OH was the winner of the challenge ("U.S. Department of Transportation Announces Columbus as Winner of Unprecedented $40 Million Smart City Challenge" 2016), in which the Ohio State University was a key partner.

Concurrently, NSF has conducted a number of workshops regarding its Smart and Connected Communities program. Between December 2015 and December 2017, the Foundation

hosted at least eight workshops on the subject ("NSF's Smart & Connected Communities Effort" n.d.). In addition to Smart and Connected Communities, other NSF programs, such as the Platforms for Advanced Wireless Research or Cyber-Physical Systems, demonstrate the breadth of basic and applied research under the purview of smart cities.

The rapid growth in interest and federal funding for smart cities has led to a plethora of programs supposedly under the same umbrella. An October 2018 report from the Smart Cities and Communities Task Force of the National Science and Technology Council (2018) highlights communities (although it does not define them), universities, local businesses, and the federal government as the necessary partners to successfully develop smart city technologies for local and national impact. It also attempts to outline the multiplicity of federal programs already available to support smart cities, visualized in Figure 1. Figure 1 shows that there is no one federal conception of a smart city; it encompasses everything from novel building materials to personalized medicine, connected vehicles to municipal broadband. Federal smart city programs are also shown to range from basic research in cyber-physical systems to the adoption of information technology and sharing of best practices. In this way, the federal governments funding of smart cities theoretically encompasses nearly anything taking place in the built environment, so long as data and technology are involved.

The approach of the federal government has been crucial in defining the modern smart city-university partnership, just as it was in the past. As the primary funder of university research, its requirements signal to universities what aspects are necessary preconditions to winning funding. For example, in the most recent Smart and Connected Communities funding solicitation, "Letters of Collaboration" from local partners are required from principal investigators requesting funding, indicating the intent that such research not be conducted in a vacuum.

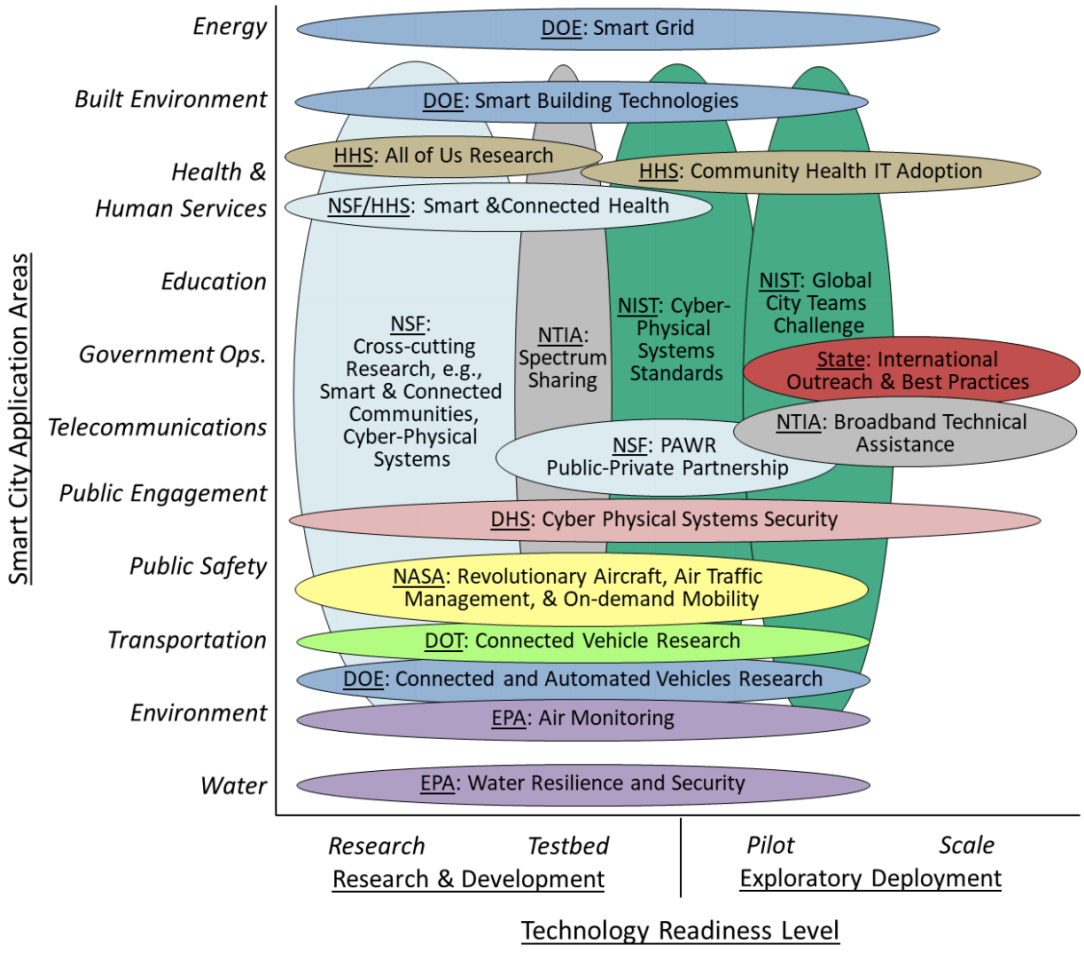

Figure 1 From the National Science and Technology Council (2018, 11).

MetroLab Network

Of the numerous activities announced by the White House on September 14, 2015, the MetroLab Network (MetroLab) seemed the most concrete. Rather than planning for future funding, 21 cities had already pledged to work with their local universities to deploy and test smart cities technologies and solutions. MetroLab was supported with a $1 million grant from the MacArthur Foundation, while individual city-university partners would find various funding streams for their own projects. The following account of the history of MetroLab is partially

informed by its website, in addition to interviews with Ben Levine, the founding and current Executive Director of MetroLab, and Richard Stafford, Distinguished Service Professor of Public Policy in the H. John Heinz III College of Public Policy and Management at Carnegie Mellon University and *Ex Officio* member of the Steering Committee of MetroLab when it was launched.

In many ways, the MetroLab Network grew out of Carnegie Mellon University (CMU). CMU had developed a strong relationship with the City of Pittsburgh through a Smart Cities partnership, having established a transportation research institute called "Traffic21" and later "Metro21," in which the City was a partner. Stafford, who previously held numerous positions in state and local government and in the regional community development organization, saw CMU as an invaluable partner in addressing problems at the local level. As enthusiasm at the federal government grew, it became apparent that a *network* of cities and universities would be an effective mechanism to grow federal support for this type of research and to share research insights. Thus, CMU worked with the White House, the MacArthur Foundation, and others, to bring other cities into a network that was launched in September 2015.

In order to initially join MetroLab, cities and their university partners had to send a letter to President Obama, agreeing to participate in the network and indicating three projects that they would undertake together. Additionally, MetroLab required that the partners sign a Memorandum of Understanding (MOU), with points of contact—or higher-level officials—agreeing to work in concert on the problems. A sample was made available to the partners.[4] In the course of establishing MetroLab, Stafford and Levine outlined "10 Principles for Successful City/County-University Partnerships" abbreviated here:

[4] https://metrolabnetwork.org/wp-content/uploads/2017/07/Generic-MOU-040915.docx. Accessed March 23, 2019.

1. Embrace the idea of the city as a living lab and the university as a research & development resource
2. Formalize a partnership between your city and university with a memorandum of understanding

For Cities

3. Assign a lead point-of-contact at the city
4. Identify problems that need to be solved and opportunities for innovation

For Universities

5. Assign a lead point-of-contact at the university
6. Form a multi-disciplinary network managed by the university point-of-contact.

Executing On Research, Development, And Deployment

7. Find the intersection between city priorities and university expertise. … Identify metrics that will define success on these efforts.
8. Arrange regular, predictable, monthly meetings between the city and university points-of-contact
9. Approach your local business and philanthropic community to support your RD&D efforts
10. Engage local community groups as partners[5]

As one can see, many of these principles are reflective of Szanton's observations about the challenges of city-university partnerships in the 1960s and 1970s. However, the core principle — the formalization of the partnership — is in fact in conflict with Szanton's best practice, which explicitly recommended an organic and informal relationship between university researchers and a city.

On September 14, 2015 the following city partnerships were announced:

- Atlanta, with Georgia State University and Georgia Tech
- Boston, with Boston Area Research Initiative
- Chicago, with the University of Chicago
- Cuyahoga County, with Case Western University
- Dallas, with Texas Research Alliance
- Detroit, with Wayne State University
- Houston, with Rice University
- Madison, with University of Wisconsin-Madison
- Memphis, with University of Memphis

[5] https://metrolabnetwork.org/primer/. Accessed March 23, 2019.

- Minneapolis & St. Paul, with University of Minnesota
- Montgomery County, with University of Maryland and Universities at Shady Grove
- New York City, with New York University
- Philadelphia, with Drexel University and University of Pennsylvania
- Pittsburgh, with Carnegie Mellon University
- Portland, with Portland State University
- Providence, with Brown University, College Unbound, and Rhode Island School of Design
- San Diego, with University of California San Diego
- San Jose, with San Jose State University
- Seattle, with University of Washington
- South Bend, with University of Notre Dame
- Washington, DC, with Howard University, Georgetown University, and George Washington University

In joining MetroLab, the partners agreed to formalize their collaboration with an MOU, appoint a point of contact, and participate in Metrolab's workshops and "knowledge sharing activities." The joint letter also highlighted the human and physical capital that universities had at their disposal to aid cities in meeting local challenges through technology-enabled solutions, putting MetroLab squarely in the smart cities arena. Many of these signatories already had collaborations ongoing; joining MetroLab established formalization of a partnership, rather than the creation of a new collaboration ("Letter from University Presidents and Mayors to President Obama on the Creation of a Metro Lab Network" 2015).

It is within this context — of urban universities, smart cities, and MetroLab network — that this thesis attempts to understand this latest round of university-city partnerships. In the chapters that follow, this thesis will examine two partnerships that were part of MetroLab's launch in 2015 in Chicago and Pittsburgh. The goal is to understand whether these partnerships are distinct in significant ways from the attempts of the 1960s and 1970s. Given the novel technology and concerns that are being raised today about smart cities, it is also important to situate these new

partnerships in the broader discourse regarding the risks associated with smart cities or big data used for city management.

Research Questions and Methodology
Research Questions

The relationship between universities and their host cities will certainly endure in one form or another, yet the current manifestation focusing on technology production and use is a unique expression of this relationship that bears investigation. A significant heterogeneity of work products exist under the heading of "city-university partnerships for smart city technologies," with everything from data storage, data analytics, technology testing, and data generation through novel technologies, all existing under one umbrella.

The goals of universities and cities are not necessarily in alignment. Cities must provide services, and are concerned with providing new services and improving existing services or reducing the cost of delivery. On the other hand, universities are primarily concerned with generating new knowledge and teaching students. Nonetheless, there may be some areas of agreement, especially with regards to political considerations. Both the university and the city may be interested in improving or maintaining the reputation of the city; the university may also be concerned with its own reputation as a good neighbor. The city may be under pressure to appear at the forefront of technological governance and to provide open data to its citizens, that same data and technology that may be of interest to researchers.

There may be negative outcomes associated with the pursuit of these goals. While "open data" in the abstract may be worthy of pursuit, individuals' privacy may be exposed if adequate protections are not put in place. If new technologies are being tested, issues of the ownership of the data and intellectual property resulting from those technologies must be negotiated; privacy is also of concern if those technologies are collecting data about their environment. As such, this thesis attempts to explore how the goals of cities and universities are being pursued through the

new manifestation of their relationship, and whether adequate controls are in place to protect both parties involved, in addition to the citizens who are an assumed third party. In particular, this thesis attempts to answer the question:

> When governments and universities develop these partnerships, do they consider the long-term implications for citizens and the community, or are they thinking merely in terms of short-term political optics?

In order to answer this question, the following sub-questions need to be explored:

1. What are the intended and actual outputs and impacts of these partnerships and projects?
2. How have these partnerships been structured?
3. Who sets the goals of these projects?
4. What projects benefits do these respective partners expect?

Case Selection

Three cases were originally selected for examination: Pittsburgh and Carnegie Mellon University, Chicago and the University of Chicago; and Atlanta and Georgia Institute of Technology. These cases were selected from among the 21 partnerships that were announced on September 14, 2015, as part of the White House's announcement of MetroLab. Pittsburgh and Carnegie Mellon were selected, in part, because of the centrality to Carnegie Mellon in the founding of MetroLab. Chicago and the University of Chicago were selected, in part, because of the significant publicity that the partnership and its projects have received at a national level. Atlanta and Georgia Institute of Technology were selected to provide a contrast to the other cities, as a public university outside of the Midwestern United States. Additionally, all three case studies had made movement towards the type of partnership prior to the September 2015 announcement of MetroLab, providing for the opportunity for a longer track record, greater availability of

materials, and the ability to see the impact of implementation in addition to mere announcements. Additionally, the author knew relevant informants involved in all three cases. These three cases also provided heterogeneous political landscape: Chicago has had one mayor during its entire smart cities partnership with the University of Chicago. Pittsburgh's current manifestation of the partnership has also existed wholly under one Mayor, though earlier iterations of the partnership began with the previous mayor. Chicago will inaugurate a new Mayor in May 2019, while Pittsburgh will not hold another election until 2021, at which point the current mayor is expected to run for a third term. Alternatively, Atlanta underwent a mayoral transition in January 2018.

However, this mayoral transition required the elimination of Atlanta as a case study. Though the author traveled to Atlanta to conduct interviews with university participants, no current staff at the city of Atlanta responded to multiple attempts for interviews. One former staff person was interviewed from the prior administration, and two others indicated a willingness to be interviewed prior to ultimately reneging. As such, Atlanta was dropped as a case, with no to little comparative information available about the structure, goals, or expected benefits about the partnership from the perspective of either current or former city employees.

Methodology

The primary means of data collection was through semi-structured interviews with officials, staff, and researchers and the cities and universities involved in the partnerships. Though an initial set of interviewees were identified based on public information and prior knowledge about the cases, a "snowball method" was also used to identify other interviewees, as at the end of each interview, the interviewee was asked who else should be consulted about the case at hand.

A number of preliminary, informal, interviews were also conducted with experts in the field, to understand some of the contemporary issues associated with the urban university and its

partnership with its host city. These interviews informed the formulation of some of the questions asked in the case study cities.

In addition to the semi-structured interviews conducted at each case study, a comprehensive review of published academic research, local media, and publicly-facing materials was conducted. To the extent that non-public materials became relevant to the research, such as contracts between the city and university, attempts were made to collect and analyze them as well.

Using the evidence collected from interviews, published materials, and other relevant documents, I construct a representation of the two cases, highlighting in each case the relevant aspects of the partnership, including its history, structure, and specific projects. Following the two chapters on the cases, I analyze the aspects of the partnerships that were successful, and other aspects that justify future adjustment.

Pittsburgh
Introduction

The relationship between the city of Pittsburgh and Carnegie Mellon University (CMU) has been active, in some way, since the university was founded in 1900.[6] In the present context, the relationship between CMU and Pittsburgh is particularly interesting, as it was the founding member of the MetroLab Network. In order to understand the current form of the relationship and projects undertaken by CMU and Pittsburgh, the following individuals were interviewed:

Name	Position
Karen Lightman	Executive Director, Metro21, Carnegie Mellon University
Richard Stafford	Heinz College Distinguished Service Professor of Public Policy, Distinguished Fellow at Metro21, Founding Director of Traffic21, CMU
Santiago Garces	Director, Department of Innovation and Performance (I&P), Pittsburgh
Karina Ricks	Director, Department of Mobility and Infrastructure (DOMI), Pittsburgh
Laura Meixell	Assistant Director of Digital Service, I&P, Pittsburgh
Alex Pazuchanics	Assistant Director of Planning, Policy, and Permitting, DOMI, Pittsburgh
Debra Lam	Former Chief Innovation and Performance Officer, Pittsburgh; Managing Director, Smart Cities and Inclusive Innovation, Georgia Tech
Geoffrey Arnold	Senior Digital Services Analyst, I&P, Pittsburgh

The chapter begins with a brief overview of the antecedents to the current partnership, followed by a history of the various centers at CMU that support this work. A description of the many projects that were raised by interviewees follows, with an in-depth explanation of the Western Pennsylvania Regional Data Center (WPRDC). Further detail of the partnership structure

[6] The present form of Carnegie Mellon University is the result of a merger between the Carnegie Institute of Technology and the Mellon Institute of Industrial Research in 1967.

and governance is then provided, followed by details around three specific projects. This chapter concludes with observations about the future of the partnership.

Antecedents to the Current Partnership

Professor Rick Stafford points to the inclusion of the Mayor on the Board of Trustees of Carnegie Institute from its founding as proof that the university has always been committed to its community (Stafford 2019), and indeed, both the Mayor and City Council President sit *ex officio* on CMU's Board of Trustees.[7] CMU has also been concerned with the economic development of the region, with the President of Carnegie Institute of Technology serving as the founding president of the Allegheny Conference on Community Development (Stafford 2019; "The History of the Allegheny Conference on Community Development" 2016). Pittsburgh is no stranger to city-university partnerships using novel technology; Szanton wrote about the large scale modeling conducted on behalf of Pittsburgh in coordination with The Center for Regional Economic Studies at the University of Pittsburgh, as part of the Community Renewal Program in the early 1960s (Szanton 1981, 52–54).

Some centers at Carnegie Mellon, such as the Remaking Cities Institute (RCI), have engaged the City on various research projects, and, according to its website RCI, "grew out of the Urban Laboratory, a fifth year community and urban design studio in the CMU School of Architecture," which "focused on projects in the Pittsburgh region" ("About the Institute - Remaking Cities Institute - Carnegie Mellon University" n.d.). Founded in 2006, RCI has conducted research on behalf of Pittsburgh, such as conducting an analysis of the impact of Light Emitting Diode (LED) streetlights in 2012 and again in 2015.[8]

[7] See: https://www.cmu.edu/leadership/board/index.html. Accessed April 19, 2019.
[8] See Pittsburgh City contract #51450, November 12, 2014

The "21s" at CMU

The current center leading the relationship between CMU and Pittsburgh is called "Metro21: Smart Cities Institute," an interdisciplinary, university-wide center led by Director Raj Rajkumar and Executive Director Karen Lightman. Metro21, established in 2014, grew out of Traffic21, a center established in 2009 to focus on using technology to address traffic issues in the Pittsburgh region (Stafford 2014, 2019).

As the story is told, Henry Hillman, a local philanthropist, was sitting at a traffic light near CMU when he came to the realization that there must be a better way to address transportation using information and communication technology (Lightman 2019). As such, Hillman approached the president of CMU and offered financial support for the creation of a new center with a focus on deploying novel technologies to address transportation in the Pittsburgh region. After significant engagement between university officials and the Hillman Foundation, a pledge of $600,000 was given to CMU for the creation of a new center, titled Traffic21 (Lightman 2019; Stafford 2014, 2019).

Traffic21 was expected to focus on solving problems related to technology and transportation in the Pittsburgh region; secondary goals included the leveraging of further funding, commercialization, and technology transfer (Stafford 2014, 6–7). In order to do so, Director Stafford approached officials at the city, Allegheny County, Port Authority of Allegheny County,[9] and the Pennsylvania Department of Transportation asking not for money, but "asking for problems" (Stafford 2014, 7). After approaching the government officials and consolidating a list of the various issues at hand, Director Stafford approached CMU faculty, pitching the problems

[9] The public transit agency in the Pittsburgh region.

and soliciting requests for seed funding from the faculty, which resulted in 26 proposals and 12 funded projects, each receiving between $20,000 and $75,000 (Stafford 2014). Of the initial 12 proposals, two were mentioned by city officials in the course of the interviews for this thesis, Surtrac and Roadbotics, to be explained more in detail in the next section.

The initial investment in Traffic21 also spurred pursuit of federal funding by CMU, including two successful applications for University Transportation Centers (UTCs) supported by the US Department of Transportation (USDOT) (Stafford 2014). These UTCs, Technologies for Safe and Efficient Transportation (T-SET), and later, Mobility21, continued to be connected to Traffic21, with Stan Caldwell being brought to the team to serve as director of both Traffic21 and T-SET, and, later, Mobility21. Traffic21 also served to aid the city in its pursuit of federal funding, such as a grant from USDOT to support the development of a new Bus Rapid Transit (BRT) route in Pittsburgh (Stafford 2014).

In July 2014, Traffic21 was built upon to create Metro21, a university-wide institute focused not just on transportation, but on smart cities generally. This coincided with the ascension of Bill Peduto to the mayorship of Pittsburgh in January of that year. In August 2014, Metro21 and Pittsburgh signed a memorandum of understanding (MOU) outlining an intent to work collaboratively,[10] which later became the basis for the MetroLab Network MOU.

Metro21, currently led by Executive Director Karen Lightman, retains many of the characteristics of Traffic21. Its director, Professor Raj Rajkumar, is also the principal investigator and Director of the Mobility21 UTC. Rick Stafford maintains a position as a Distinguished Fellow in Mobility21, though has removed himself from some of the work (Stafford 2019). Traffic21 has

[10] https://www.cmu.edu/metro21/partners/assets/city-carnegiecellon-mou.pdf

also continued as an entity within the university, supporting the Mobility21 UTC and other projects.

Description of the Projects

In the course of conducting the interviews, over ten individual projects that have been funded by Traffic21 or Metro21 were mentioned by either city or university officials. Some projects were mentioned as exemplars, while others were spoken about as sources of failure and frustration. These projects are worthy of some brief mention, while three will receive further detail later in the chapter.

Surtrac

Surtrac, or Scalable Urban TRAffic Control, was among the initial recipients of Traffic21 funding. Surtrac uses artificial intelligence and communication technology to change the timing of traffic lights to increase traffic flow and decrease wait-times (Smith et al. 2013; Stafford 2014).

From a technological standpoint, Surtrac is a clear success. In 2014, it had received over $1.5 million in funding from the Hillman Foundation and local businesses (Stafford 2014), while in 2015, it was spun-off into a company, Rapid Flow, for further commercialization (Snow 2017). Other cities, such as Atlanta, GA; Beverly Hills, CA; and Portland, ME, have all adopted Surtrac's technology (Harry 2019; Snow 2017). Pittsburgh included the development of "Smart Spines" with Surtrac technology as a core component of their proposal to the $40 million USDOT Smart City Challenge (City of Pittsburgh 2017), for which they received $11 million as a finalist city (US Department of Transportation 2017). Alex Pazuchanics, in his previous role as Policy Coordinator for the City of Pittsburgh, praised Surtrac in testimony before the US House Committee on Energy and Commerce in 2017 (Pazuchanics 2017).

However, the project has caused some consternation in the city. Surtrac initially caused frustration from pedestrians and cyclists, since the traffic lights prioritized cars, rather than other street users (Snow 2017; Stafford 2019). There have been times when the project manager was unavailable for months at a time (Stafford 2019). Additionally, the city "does not contract or otherwise manage the pilot program," (Simpson 2017). With no contract or data sharing agreement, Pittsburgh has been left in the dark about the operation of the currently-installed Surtrac traffic lights (Meixell 2019), and though the city hopes "that all commercial and academic participants in Pittsburgh's Smart Cities work will eventually share data to improve collective outcomes," (Simpson 2017), such an agreement is not currently in place. Though the city has reached out requesting data from current Surtrac operations, they have been unsuccessful in receiving responses (Meixell 2019). Though the city — and Rapid Flow — would both like the city to resume operations of the Surtrac traffic lights, city engineers lack the technical capability to understand its operations, while the transition from a pilot to full time use (without having followed procurements requirements) leaves next steps unclear (Ricks 2019).

Road Surface Monitoring

Another project that was initially funded through Traffic21 and continued through today, Road Surfacing Monitoring was meant to investigate whether images taken by cellphone cameras could be used to evaluate road conditions through the use of computer vision. (Stafford 2014; Varadharajan et al. 2014). The project is another academic and commercial success, having attracted nearly $500,000 in federal funding for research and development. After testing, the research was spun off into a company, RoadBotics, and has been used by nearly 100 governments across the world to analyze road conditions ("Company" n.d.), including in South Bend, Indiana

(Garces 2019). The research used to advance RoadBotics is now being adapted to identify landslide-prone areas, a serious Pittsburgh-area issue (Lightman 2019).

Like Surtrac, however, city officials had issues with the project. The city was under the impression that the Traffic21-funded research would replace the existing technological solution for identify road conditions at a lower price. However, at that stage of development, the city was unable to get the data accuracy that it needed, causing it to pay for an existing solution at significant city-cost and wasted staff time (Meixell 2019). Where the city saw an opportunity to reduce a significant cost, the perceived goal of the CMU researchers was to advance technology, leading to serious frustration (Meixell 2019), in spite of later commercial success.

Tiramisu

Another project funded by Traffic21, Tiramisu was a mobile application that provided real-time information to users of Port Authority busses. Though the busses collected significant information through on-board sensors, Port Authority had no ability at the time to provide real-time updates (Stafford 2014, 2019). Tiramisu was successfully launched as a public application in 2011 (Stafford 2014). The research and development for Tiramisu prompted the Port Authority to pursue their own mobile app, making Tiramisu obsolete, but achieving the objective nonetheless (Stafford 2019).

Predictive Analytics

Two projects are based in the use of predictive analytics — machine learning to assess future outcomes. One, led by Wilpen Gorr, uses police information to predict chronic and temporary "hot spots," to which police may wish to deploy additional resources (Arnold 2019a; Fitzpatrick, Gorr, and Neill 2019). A second project, led by a PhD student Michael Madaio, uses

a variety of factors to create a "risk score" for susceptibility to fire for all commercial buildings in the city (Arnold 2019a; Singh Walia et al. 2018).

Both of these projects were praised by city officials (Arnold 2019a; Meixell 2019) for the usefulness they provide to city partners, and by university officials (Lightman 2019; Stafford 2019). These projects will be discussed more later in the chapter.

A third predictive analytics project is currently underway, in which students associated with the CMU group Students Using Data for Social-Good are working with data from propriety sensors the city has acquired and installed in their trashcans, to predict fill-levels and optimize collection routes (Arnold 2019a). However, the utility of that project has yet to be seen, as the city is unsure how to reprogram staff time if more optimal routes are identified (Meixell 2019).

Technical Assistance

While not a project *per se*, city officials raised various occasions in which CMU had provided technical assistance, which they found immensely valuable. When preparing for the USDOT Smart City Challenge, CMU worked with city officials as they spoke with vendors, providing them with assessment of technological feasibility and risk (Meixell 2019). Assistant Director Meixell cited this as the best example of the partnership, giving the city a level of sophistication that it otherwise would have lacked. CMU has also engaged with the city on LED and Smart Streetlights, helping them to identify the specifications that will allow flexibility as the technology develops into the future (Ricks 2019).

Given CMU's expertise with regards to autonomous vehicles, the city also hopes to use them as a neutral third party when engaging with the numerous companies currently testing autonomous vehicle in Pittsburgh; for example, the city would wish to understand what data can

be provided by the companies, and would ask CMU to inform them whether such data collection was technologically possible (Ricks 2019).

Road Paving

Another research project raised by city officials relates to an assessment that CMU conducted on the city's behalf regarding road paving methods. The city, having identified the need to use an evidence-based approach to road paving, engaged CMU to conduct an analysis and develop a work plan for paving Pittsburgh's streets. Director Ricks noted that CMU was a free resource to provide expertise to the city, and that the report developed by CMU researchers has been put in place as the city's official road paving policy, to be used starting in 2019 (Ricks 2019).

311 Data Analysis

One project that was universally agreed upon as a failure, was an attempt to analyze 311 data to understand rat sightings in the city, predict future rat infestations, and help the city with its rat baiting (Stafford 2019; Meixell 2019). While this project had been successfully carried out by a CMU researcher for another city, Pittsburgh does not have a rat baiting program, and thus was uninterested in the research. The researcher tried to pursue this research, frustrating city officials who were uninterested in understanding a problem they had no program in place to address (Stafford 2019).

Cost Assessments

Pittsburgh officials are interested in better understanding the value of the street and the curb — two city owned assets — to price them more appropriately. As such, Metro21 has funded a project to analyze the use and cost of the curb (Lightman 2019), while Assistant Director Pazuchanics is working with students, in a class he is co-teaching, to assess the impact of road

closures during construction (Pazuchanics 2019). The hope is to use the findings of the class to more accurately assess developers for their impact on local traffic for road closures undertaken during construction.

Open Pittsburgh wireless Research Accelerator (OPERA)

OPERA is a proposed research project, having sought funding from the National Science Foundation (NSF) through their Platforms for Advanced Wireless Research (PAWR) program. OPERA would "create a next-generation communication and sensing infrastructure as an open research platform in Pittsburgh" (Carnegie Mellon University 2019). OPERA will also be discussed later in this chapter.

University of Pittsburgh and the Western Pennsylvania Regional Data Center (WPRDC)

Though the City of Pittsburgh repeatedly approached CMU with the request that the university help host and run the city's open data portal, there was no interest to be found at CMU (Meixell 2019).[11] Instead, the University of Pittsburgh hosts the Western Pennsylvania Regional Data Center (WPRDC), the data center for Pittsburgh and Allegheny County (WPRDC 2017). WPRDC is a relatively new open data portal, having been founded in 2015, with a mission to "make community information easier to find and use" (Xiao et al. 2018, 5). WPRDC, as the host of all of the city's open data, provides a vital function to the city, one that Assistant Director Meixell (2019) notes would have to be done in-house or by another provider if not by the University of Pittsburgh.

[11] Assistant Director Meixell also noted that she is a co-founder of WPRDC, and a University of Pittsburgh alumna.

WPRDC also takes significant initiative to be engaged with the community, hosting community events throughout the city to help citizens understand and use the open data. WPRDC regularly hosts office hours that are open to the public. Assistant Director Meixell attributes this engagement to the University of Pittsburgh viewing itself as part of the community, and making community function part of their core academic teaching. She cites the incorporation of WPRDC into classes at the University of Pittsburgh and the work that WPRDC does through "data liberation" teams, which help small municipalities and non-profits understand and use their data, as further proof that the University of Pittsburgh is very aware of and engaged in the community (Meixell 2019).

WPRDC also provides data to the city's "Burgh's Eye View" app, an internal and external mapping and data visualization tool. Burgh's Eye View is used by city agencies, and also has an external-facing map for the general public, which omits sensitive data. In this way, WPRDC also supports the work of various Metro21 projects that draw on open data. Both the predictive policing and the fire-risk analysis draw from WPRDC data, and populate the internal Burgh's Eye View map (Arnold 2019a). Assistant Director Meixell hopes that WPRDC is brought on in future projects with Metro21, such as the proposed OPERA project (Meixell 2019). Thus, though CMU does not host the data portal, and was reportedly disinterested in doing so, it continues to benefit from, and contribute to, the data on the portal, through its other Metro21 projects.

Metro21 & Innovation and Performance: The Partnership

Partnership Structure: Formal Agreements

Metro21, founded in July 2014, and the Department of Innovation and Performance, created in January 2014[12], form the backbone of the CMU-Pittsburgh relationship. The MOU, signed in August 2014, serves as a formal "document of intent" to work together jointly on projects (Pazuchanics 2019). The MOU[13] later served as the basis for the MetroLab MOU, to which it is nearly identical. The MOU obliges both the city and the university to designate formal points of contact and to meet "on a regular basis" to jointly decide upon projects, concur on a plan for the projects, monitor progress, and coordinate for third-party financial support. Additionally, both the city and the university are tasked with identifying possible projects and bringing them to the other partner. The MOU between Metro21 and Pittsburgh is nearly identical to the MOU between Metro21 and Allegheny County; the MOU with the Allegheny County Airport Authority (signed four years after the MOU with the city) stipulates that individual projects require separate project agreements, and also includes a disclaimer regarding intellectual property, stating that terms and conditions would be stipulated in such project agreements.

The MOU allows the city and university to channel projects through it, meaning that some projects can go through the MOU (Meixell 2019), rather than requiring a separate contract. In fact, for projects for which the city does not contribute money, city officials did not identify contracts as a mechanism that has been used (Arnold 2019a; Meixell 2019; Pazuchanics 2019; Ricks 2019), with one exception: students. When city projects are undertaken either by the student group,

[12] The Department of Innovation and Performance was the Department of City Information Systems prior to the administration of Bill Peduto.
[13] https://www.cmu.edu/metro21/partners/assets/city-carnegiecellon-mou.pdf

Students Using Data Science for Social-Good, or when they are incorporated into CMU coursework, formal check-ins and deliverables are agreed upon (Arnold 2019a; Pazuchanics 2019).

Projects are now moving towards a "project charter," which would outline some of the requirements and expectations of the project (Meixell 2019). Most projects currently begin with an agreed upon problem statement (Arnold 2019a; Lightman 2019); otherwise, verbal agreements dictate future deliverables and work structure (Arnold 2019a).

Partnership Structure: City Structure

The main structure for smart cities projects at the city of Pittsburgh has been through the Department of Innovation and Performance (I&P), which includes core information technology capabilities. The department houses the Analytics and Strategy team for the city (Pazuchanics 2017), and the current Assistant Director, Laura Meixell, has been in that department since its founding in 2014. The Department has seen three directors in five years, first under the stewardship of Chief Debra Lam, then Director Lee Haller, and currently Director Santiago Garces, who assumed the position in January 2019. Former Chief Lam notes that there is some difference in responsibility associated with her role, as Chief, and the role of Directors Haller and Garces (Lam 2019). Indeed, when Director Haller assumed his position in 2017, he made it publicly known that there would be some reshuffling, with I&P focusing more on internal city processes, with a larger focus on technology budgeting and procurement (Wood 2017). Nonetheless, I&P retains both a mission with regards to open data and one for data analytics, positioning them uniquely to understand open data and to use it in analyses (Arnold 2019a). Assistant Director Meixell stated that, while her job description does not include any specific responsibilities regarding coordination with CMU researchers, it is part of her job duties (2019).

In addition to I&P, the Department of Mobility and Infrastructure (DOMI) was launched in early 2017 to incorporate many of the transportation-related goals that were included in Pittsburgh USDOT Smart Cities Challenge proposal. DOMI thus also took on the responsibility of coordinating some research projects with Metro21. Its inaugural, and current, director is Karina Ricks, while Assistant Director Pazuchanics — who had been employed by the city since 2014 — moved to DOMI in mid-2017.

Assistant Director Pazuchanics believes that the ability for the city to engage with CMU researchers is due, in part, to the "professionalization" of city government, with more employees at the city having college and graduate degrees (Pazuchanics 2019). Tellingly, all non-Director-level employees interviewed for this research had graduated from Carnegie Mellon University or the University of Pittsburgh. The relationship between the universities' graduates and the ability for CMU to work with the city was made explicit by Director Stafford, who noted that the former mayor's Chief of Staff had his CMU diploma proudly displayed in his office, while the current mayor's Chief of Staff, Dan Gilman, also graduated from CMU (Stafford 2019).

Given that interpersonal relationships are a defining feature of the partnership at this point, Assistant Director Pazuchanics is unsure as to how the partnership would progress in his absence, or in the absence of Assistant Director Meixell, and Chief Resilience Officer Grant Ervin (Pazuchanics 2019). On the other hand, Assistant Director Meixell is "sure they would find somebody" to replace her, and is more concerned about the personnel in place at CMU (Meixell 2019).

Partnership Structure: University Structure

The university structure has mainly been consolidated through Metro21, with Executive Director Karen Lightman serving as gatekeeper for faculty members interested in working with

city agencies (Lightman 2019). As noted earlier, there remain links between Metro21, Traffic21, and Mobility21, with Professor Raj Rajkumar serving as Director of both Metro21 and Mobility21, and Stan Caldwell serving as Executive Director of both Traffic21 and Mobility21.

Metro21 serves primarily as gatekeeper and purse-holder. Metro21 issues requests for proposals (RFPs) to faculty members, clears research projects with city officials, and ensures that projects have both a public partner and a research interest (Lightman 2019). Faculty members who receive Metro21 funding are held to a set of requirements regarding project reports, to keep city officials informed. In return, Metro21 is the main point of contact for city officials, as they seek check-ins on projects, or seek to bring new projects to the university.

Executive Director Lightman notes that most faculty members are unable to work with the city without the aid that Metro21 provides them in coordinating their research. The perception at the city is that Executive Director Lightman, who has been at CMU since August 2017, had to spend much of her first year at CMU herding cats, as CMU's decentralized structure made finding the faculty and understanding the existing structure difficult (Pazuchanics 2019) Though Professor Rick Stafford remains a Distinguished Fellow with Metro21, he has largely removed himself from its operations (Stafford 2019), and Assistant Director Meixell recalls that, under his leadership, the city had broad check-ins with CMU, while that has not continued (Meixell 2019).

While Assistant Director Meixell sees herself as replaceable, she believes that, without Executive Director Lightman or Professor Stafford, the continuation of the relationship would be very difficult (Meixell 2019). The relationships that the city has with the university are largely "institutional," meaning through the leadership of Metro21, rather than with many specific faculty members (Meixell 2019). Given Professor Stafford's lengthy career in public and public-serving positions, he knew many of the existing players at the outset of Traffic21, including the head of

the Port Authority and Pennsylvania Department of Transportation (Stafford 2019). While he didn't know the technical aspects of the CMU research projects, the Hillman Foundation saw his knowledge of policy as invaluable to leading the institute (Stafford 2014).

Partnership Structure: Project Selection

The initial Traffic21 project selection was detailed earlier. Under Metro21, Assistant Director Meixell recalls 90 minute meetings where researchers gave pitches of their ideas to city officials for seven minutes, who were given the ability to ask a question of the researchers (Meixell 2019). Many of the projects that were pitched by CMU were identified as being outside the scope of the concern of municipal government (Meixell 2019), while this initial process was identified by another city official as a "shotgun approach" to allow fast failure (Pazuchanics 2019).

The more recent process on the CMU side has been through an RFP sent to university researchers. Proposals were then distributed to city partners, with CMU asking city officials to identify which projects they would be interested in, what seemed to be missing, and what would meet long-term and short-term interests of the city (Lightman 2019).

Assistant Director Pazuchanics states that the best projects are often those that are requested by city officials (Pazuchanics 2019), and the MOU allows city officials to bring ideas for projects to Metro21 leadership. In some cases, researchers who know of the right people at the city will come to them, who will in turn refer those researchers to Metro21 for funding, provided city interest (Meixell 2019; Pazuchanics 2019). Alternatively, city officials may approach Metro21 with an idea, and Executive Director Karen Lightman will then seek out researchers at CMU who may be interested in the project (Meixell 2019; Ricks 2019). However, CMU researchers do not necessarily express a willingness to engage on projects that are not directly of interest to them, which is seen in contrast to researchers at the University of Pittsburgh (Meixell 2019).

Some projects that are proposed by university researchers may not have a direct operational benefit to the city, but Director Ricks believes that: "they are doing some great service to us. If this city can help them solve a problem that maybe we don't perceive of here but their learnings can help another community someplace else? That's good enough too," (Ricks 2019). Director Ricks recognizes that, at times, Pittsburgh may have gotten "too giddy" about working on CMU projects. Occasionally, traffic engineers may question some of the access or time that CMU is granted for projects that don't directly benefit city operations, but Director Ricks perceives such projects as having a "*de minimis*" cost to the city (Ricks 2019).

A final aspect of project selection is the adamancy with which CMU maintains its inability to do consulting, given its status as a non-profit institution of higher education (Lightman 2019; Stafford 2019). As such, projects must both have a research component and represent something of interest to the city. Professor Stafford also noted that CMU cannot compete with consulting firms with regards to the timeliness, responsiveness, or willingness to research any project; some ideas that the city proposed would be more appropriate as an RFP for a consulting firm, or as a student project. The identification of which projects would be appropriate for CMU faculty represented a learning curve on the part of the city officials, creating tension at the beginning of Traffic21, since city officials had been asked for their problems, and, in some cases, the response was that those problems were outside the scope of faculty interest (Stafford 2019).

Partnership Structure: Deliverables & Check Ins

Once a project has been developed, Assistant Director Meixell identified goals and deliverables as "the whole thing," associated with the push-and-pull between the city and CMU (Meixell 2019). City officials usually meet with the university researchers at the beginning of a project to discuss and agree upon a deliverable (Arnold 2019b, 2019a; Lightman 2019). Depending

on the nature of the project, there may or may not be any more contact between faculty members and city staff until the mid-project or final project reports (Lightman 2019).

The Director of Innovation and Performance was vacant for approximately five months at the end of 2018, meaning that the main point of contact at the city for Metro21 was Chief of Staff Gilman (Lightman 2019). Executive Director Lightman and Chief of Staff Gilman currently have monthly check-ins for a broad overview of all Metro21 projects (Lightman 2019). Director Ricks perceives that many interested researchers contact either her or Assistant Director Pazuchanics, which she understands is suboptimal, given the discipline-specific nature of the DOMI. Thus, she assumes that when I&P had a head, the CMU researchers had a better time engaging with the city (Ricks 2019). Neither Assistant Director Meixell nor Assistant Director Pazuchanics seemed aware that Executive Director Lightman was having check-ins with Chief of Staff Gilman, as they both made statements about how such check-ins between Metro21 leadership and the city had tapered off since the previous head of I&P departed in August 2018 (Meixell 2019), and that it had peaked under the direction of the first Chief of I&P, Debra Lam (Pazuchanics 2019). Currently, I&P staff mostly deal directly with the researchers at CMU who are running individual projects (Meixell 2019). As such, deliverables, check-in schedules, and other particularities are still done on mostly an *ad hoc* basis directly between program managers and researchers (Pazuchanics 2019).

MetroLab and Pittsburgh

As was recounted in Chapter 1, CMU and Pittsburgh were the founding leaders of the MetroLab Network (Coyne 2015; Stafford 2019). In fact, MetroLab is still affiliated with CMU, as the initial MacArthur Foundation grant which funded MetroLab was directed to CMU, with the plan of creating a separate non-profit within three years of the launch (Stafford 2019). Professor Stafford notes that "there would be no MetroLab without Henry Hillman" and the funding that his

foundation provided to start Traffic21 (Stafford 2019). Now that MetroLab is separating from CMU, Metro21 is hoping to use MetroLab like any other member, suggesting ideas to the Network and working with its leadership to begin new programs (Stafford 2019).

As members of MetroLab, city and university officials independently pointed to the importance of MetroLab in creating a community of practice (Pazuchanics 2019; Meixell 2019; Lightman 2019; Garces 2019). Though I&P has seen three directors in five years, Executive Director Lightman already knew the newest I&P Director, Santiago Garces, because they had met through MetroLab when he was in a similar role in South Bend, Indiana (Garces 2019; Lightman 2019). Thus, MetroLab created "opportunities not only to share ideas but also to share people," (Garces 2019), allowing Director Garces to come to Pittsburgh and already know some of the main players at both the city and at CMU. While MetroLab is important for creating such connections, Assistant Director Pazuchanics actually points to the messaging platform, Slack, and the messages that are exchanged between him and his counterparts at other cities as also being integral to the community of practice, and seeing what other cities and universities are doing (Pazuchanics 2019). In addition to the community-building aspect of MetroLab, Executive Director Lightman hopes to use MetroLab to attract national funding for CMU by working with other cities and universities (Lightman 2019).

Partnership and Project Funding

As already highlighted, much of the initial funding for Traffic21 was given by local philanthropist Henry Hillman, and such support has continued (Lightman 2019; Stafford 2014, 2019). While some funding has come from national sources, such as IBM, Xerox, and federal funding agencies (Stafford 2014), much of the support has been local. In addition to the Hillman Foundation, the Heinz Endowments and the Richard King Mellon Foundation have been key

funders of Metro21 (Lightman 2019), in what Assistant Director Pazuchanics (2019) calls "directed philanthropy."

Like the initial focus on transportation associated with the funding from the Hillman Foundation, the funding from the Richard King Mellon Foundation and Heinz Endowments often have specific goals associated with the financial support. For example, the Richard King Mellon Foundation is interested in policing, and thus has supported the predictive analytics for policing project. Another project funded by the Richard King Mellon Foundation focuses on a large brownfield site, owned by local foundations in Pittsburgh (Lightman 2019). The Heinz Foundation has funded other work conducted by CMU for the city through Metro21, such as the analysis on smart LED streetlights.[14]

As most of the projects funded by Metro21 receive minimal seed funding,[15] seeking further funding is both necessary, and a specific goal of the Hillman Foundation support (Lightman 2019; Stafford 2014). Thus, many of the projects have sought federal funding from USDOT, NSF, and the Department of Energy (DOE). Assistant Director Meixell also exclaimed that the goal of Metro21, at first, was simply to spend the money that had been raised by CMU (Meixell 2019).

Project Analysis: Predictive Analytics, Road Monitoring, and OPERA

Project Benefits and Goals

With the Mayor calling CMU the "Research Arm of the City," (Lightman 2019; Ricks 2019), CMU has been approached to conduct numerous projects on the city's behalf. Generally, Assistant Director Meixell hopes that all projects will have direct operational benefits to the city,

[14] See Pittsburgh City contract #51450, November 12, 2014.
[15] For the 2018 RFP, 12 projects were funded through a total of $400,000 (Lightman 2019).

though she states that, for CMU, researchers primarily want to deploy their own technology on city streets (Meixell 2019). Executive Director Lightman expects all projects to be "novel [and] unique" while also directly improving the quality of life of local citizens and directly informing policy decisions (Lightman 2019).

On the other hand, it is widely recognized that the partnership with CMU exists, in part, to change the perception of the city and apply the luster that comes with a partnership of an internationally recognized university (Meixell 2019; Pazuchanics 2019; Stafford 2019). The Mayor wants to be seen as on the forefront of technology for cities (Meixell 2019). The sort of partnership is an "attempt of differentiation and research," on behalf of CMU to engage with Pittsburgh in new ways (Pazuchanics 2019) — an attempt to conduct more place-based research (Meixell 2019). Even if not all projects solve a specific problem for city officials, it may give them the necessary justification to ask city council for future expenditures (Pazuchanics 2019).

A consistent theme regarding the goals of the projects focused on the resource constraints faced by the city, thus necessitating the use of CMU researchers to advance projects that may otherwise have been done internally. When Director Ricks (2019) worked in Washington DC, the District Department of Transportation had an in-house research team, which does not exist in Pittsburgh. Lacking such a research team, Pittsburgh staff approach CMU. In this domain, some projects are meant to replace expensive and existing technologies, while others are meant to increase efficiency, reducing costs or augmenting staff time (Garces 2019; Meixell 2019). Assistant Director Pazuchanics (2019) noted that the partnership between CMU and Pittsburgh coincided with significant financial challenges for the city. While the support provided by CMU does not necessarily to replace staff, it augments staff's ability to understand future directions of

technology and developments that are occurring at a national or internationals scale (Pazuchanics 2019).

Predictive Analytics

City officials had specific goals in mind for both the fire inspections and predictive policing projects. Staff hoped to better prioritize fire inspectors' inspections of commercial buildings throughout the city (Meixell 2019). With over 20,000 commercial buildings and only two or three fire inspectors, a clear need existed to prioritize which buildings would receive inspections (Arnold 2019a; Meixell 2019). City officials did not agree, however as to whether CMU brought the project to the city, or the other way around (Arnold 2019a; Meixell 2019). Assistant Director Meixell (2019) attributes the intent to solve "a really specific operational problem," with a "dedicated team of individuals," at CMU who worked well with staff at the Fire Department as some of the reasons for the success surrounding the fire inspections project. City officials also appreciated that, for the predictive policing project, they "didn't have to buy new equipment," and could integrate the findings of the project directly into police operations (Meixell 2019). With regards to predictive policing project, there was a belief that the then-Police Chief Cameron McLay would be willing to partner on such a project; when Chief McLay left the city, there was concern that his replacement would not be as interested, though that proved not to be an issue (Arnold 2019a).

On the university side, researchers on the fire inspection project hoped to build on existing best practice and create dynamic (rather than static) models (Arnold 2019a; Singh Walia et al. 2018). The success of the predictive policing project is attributed, in part, to the fact that Professor Wilpen Gorr has been researching police for his entire career (Stafford 2019), and thus already had some of the necessary relationships to advance the partnership and work well with police (Meixell 2019).

Road Surface Monitoring

The city hoped that the road surface monitoring project at CMU would replicate the results of an existing technology at a significantly lower cost to the city (Meixell 2019). In spite of the existing technology being sufficient, the city wanted a product that would do it for free, and allowed CMU to test its product on city roads in exchange for the benefit this new technology was meant to provide. However, with no contract with the city, CMU was under no obligation to provide the necessary information to the city, leaving them in the dark and forcing them to hire an outside company (Meixell 2019). Executive Director Lightman views the technology associated with the Road Surface Monitoring as helping address city priorities, including expanding its use to predict landslides (Lightman 2019).

OPERA

The proposed OPERA project is meant to "facilitate deeper understanding of how our urban environments work and enhance the deployment of city resources, especially those related to transportation, safety and healthcare delivery," (Carnegie Mellon University 2019). However, Assistant Director Meixell is more skeptical, seeing the OPERA testbed as a way for CMU researchers to "suck up all the data from all of our phones" and advance the technological frontier. Thus, she sees CMU approaching the city as a means to access the infrastructure and regulations that are necessary to advance such a project (Meixell 2019). If the project is deployed, she would hope to see faculty from other disciplines and from the University of Pittsburgh engaged, to consider the ethical and policy implications of such a technological deployment (Meixell 2019).

Project Data

Data ownership has been a contentious issue throughout the partnership. The MOU does not contain language with regard to data ownership, and much has been determined on a project-by-project basis (Pazuchanics 2019). However, Executive Director Lightman identified data as *the* key component associated with all Metro21 projects, both data collection and open data/data sharing. She stated that intellectual property is something that should not be worried about if the problems are being solved together, as it is mutually beneficial to solve a problem and have the university own the intellectual property (Lightman 2019).

Predictive Analytics

For the project on predictive policing, none of the data that researchers are using is publicly available; rather, it is all police or city data (Arnold 2019b). Even the CMU researchers do not have access to the most granular levels of data, rather, researchers "receive aggregated versions of the information according to the grid they predefined," (Arnold 2019b). While most of the data for the fire prediction project are publicly available, the data that are not publicly available are shared with the researchers on a regular basis to support the project (Arnold 2019b). The decision regarding what data was needed, and how it was going to be shared, was agreed upon in the kick-off meeting and finalized by email (Arnold 2019b).

Assistant Director Meixell was concerned that the projects used algorithms too complex for her team to understand, and therefore sent Geoffrey Arnold to a coding class for professional development, hoping that he would then have the knowledge to engage with the algorithms that CMU was developing (Meixell 2019). He has also worked with the CMU researchers to include their findings on both the internal- and external-facing components of Burgh's Eye View, though

the publicly-facing findings have yet to be released, due to privacy concerns (Arnold 2019a; Meixell 2019).

Road Surface Monitoring

Assistant Director Meixell expressed frustration that the company created from the Road Surface Monitoring project, RoadBotics, had no contract or data sharing agreement with the city, providing them with no data and no beneficial service (Meixell 2019). Prior to his current appointment in Pittsburgh, Director Garces held a similar role in South Bend, Indiana, where he noted that RoadBotics wanted to own all the data that they collected in South Bend. However, he was able to negotiate with them to ensure that the data was publicly owned and available (Garces 2019). Additionally, RoadBotics "does not allow government customers to collect the data" that RoadBotics would then analyze ("Frequently Asked Questions" n.d.).

OPERA

As the project has yet to be awarded, and will not proceed without federal funding, there is not yet a formal agreement in place with regards to data ownership or sharing. However, the Request for Proposals for the award explicitly states open access to the research community, with collected data made available to the community "when possible."[16] Additionally, Assistant Director Meixell hopes that the data will be managed by a third party if OPERA is deployed in Pittsburgh (Meixell 2019).

[16] Platforms for Advanced Wireless Research Request for Proposals, August 1, 2018, http://www.advancedwireless.org/wp-content/uploads/2018/08/PAWR_RFP_Round_2_08.01.pdf.

Technology Transfer

A driving motivation behind much of the philanthropic support for Metro21 projects has been commercialization and technology transfer (Lightman 2019; Stafford 2014). As such, it appears throughout many of the projects associated with the partnership.

Predictive Analytics

Though some of the data associated with both the predictive policing and the fire risk projects are not publicly available, researchers remain committed to having an impact beyond the immediate project. The researchers associated with the fire risk project, for example, explicitly point to transfer as a goal, and have posted the basis for the algorithms online, for public replication (Singh Walia et al. 2018).

Road Surface Monitoring

Having been spun-off into a company, RoadBotics cites the use of its technology by nearly 100 governments on its website ("Company" n.d.). The company has been used both domestically and internationally.

OPERA

While OPERA is a proposed project, the stated aims of NSF and the PAWR Project Office is to advance pre-commercial research with reproducibility and scalability in mind.[17] Thus, though the *platform* may not be transferable per se, it is expected that the technologies tested on it would lead to commercial development.

[17] Ibid.

Community Engagement

According to Executive Director Lightman, every Metro21 project must have an outward facing component (Lightman 2019). However, Assistant Director Meixell notes that a critique of the projects initially undertaken by CMU was that humans were completely omitted (Meixell 2019). Executive Director Lightman points to working the School of Design and the College of Humanities and Social Sciences as an important piece to community engagement, though no specific examples of community engagement were offered (Lightman 2019).

Predictive Analytics

Though the initial scope of the fire risk assessment was limited to commercial buildings, researchers report that an assessment of fire risk for residential buildings was also developed, in order to inform community meetings hosted by the fire department (Singh Walia et al. 2018). While the predictive policing directly informs how police are deployed throughout the city on any given week, no one reported community engagement activities around this specific project. However, Metro21 did facilitate another project, related to community policing, which was scaled back due to sensitive timing issues not elaborated on by the interviewee (Lightman 2019).

Road Surface Monitoring

Speaking about RoadBotics, Assistant Director Pazuchanics noted that it exemplifies an internal-facing project that does not necessarily have a community-engagement component (Pazuchanics 2019). Such projects appear to obviate the need for community engagement, unlike the other projects highlighted in this chapter.

OPERA

While "community" is often mentioned in the RFP for the Platforms for Advanced Wireless Research, it most often refers to the research community, rather than the local community in which the platforms are deployed.[18] The lack of community engagement so far undertaken by CMU on this project is alarming to Assistant Director Meixell, who believes that doing community engagement, and partnering with other organizations, would benefit the researchers prior to the deployment of the project and collection of data (Meixell 2019).

Project and Partnership Future

The CMU-Pittsburgh partnership has already seen a mayoral transition, as Luke Ravenstahl was Mayor of Pittsburgh during the launch of Traffic21. As none of the city staff interviewed were present during his administration, it is difficult to say how the transition affected the partnership, though Metro21 did represent a reincarnation of the partnership when Bill Peduto became Mayor in January 2014. With Mayor Peduto having been reelected in 2017, and having announced intent to run again in 2021, Pittsburgh is in the midst of significant political stability. Mayor Peduto has been extremely supportive of Metro21 (Stafford 2019), and is supportive of using new technology generally (Meixell 2019).

Assistant Director Meixell, encouraged by the successes of the predictive analytics projects, hopes that that sort of project expands into other realms of city operations. In part, she believes the projects have been successful because the expertise of the CMU researchers fell outside of the domains typical for Metro21 researchers, with one faculty member in Public Policy, and the other one in Human-Computer Interaction. As such, she hopes that future projects will also

[18] Ibid.

continue to incorporate faculty members from public policy and design, to continue to inform the public-sector applicability of the Metro21 projects.

Similarly, Assistant Director Pazuchanics wonders how to bring other faculty members into the pool of existing research (Pazuchanics 2019). Given that Metro21 is largely about public-sector innovation funded by private philanthropies, he also believes that, so long as funding is available, this sort of city-university partnership will always hold water (Pazuchanics 2019). However, the legal instruments that guide the projects and partnership need to continue to be refined, with a greater understanding of how the city can transition from pilot to procurement, and how to better scope user-directed research (Pazuchanics 2019).

Chicago
Introduction

Much like the Pittsburgh case, the University of Chicago (UChicago) and City of Chicago (the City) have a long history. The focus of the present inquiry relates to the relationship between the two entities on the projects as proposed when they initially joined the MetroLab partnership. In order to understand this relationship and the projects, the following individuals were interviewed:

Name	Position
Charlie Catlett	Director, Urban Center for Computation and Data, University of Chicago
Kate Kusiak Galvin	Then-Executive Director, Urban Center for Computation and Data
Anne Dodge	Executive Director, Mansueto Institute for Urban Innovation, University of Chicago
Danielle DuMerer	Chief Information Officer and Commissioner for the Department of Innovation & Technology (DoIT), Chicago
Brenna Berman	Executive Director, City Tech; Former Chief Information Officer and Commissioner for the Department of Innovation & Technology (DoIT), Chicago
Tom Schenk	Former Chief Data Officer, Chicago

Though the relationships between UChicago and the City are expansive and varied, the current focus is mainly focused on the relationship between the city and the Urban Center for Computation and Data (UrbanCCD). The partnership between UrbanCCD and the City, and its flagship project, Array of Things (AoT) were among the items announced during the September 2015 White House Smart Cities Initiative Launch (The White House 2015). Additionally, UrbanCCD has been the main interface between UChicago and the Department of Innovation & Technology during the current Mayoral administration of Rahm Emanuel (Dodge 2019). This chapter will describe the relationship between UChicago and the City on research projects,

followed by a detailed examination of the various aspects of the relationship between UrbanCCD and the City and specific analysis of the projects undertaken underneath the umbrella of this partnership.

Antecedents to the Current Partnership

Interviewees were quick to point out that the relationship between UChicago and the City have been longstanding, with Chapin Hall a prime example (Berman 2019; Dodge 2019; DuMerer 2019). Chapin Hall, founded in 1860, transformed in 1985 to be a non-profit research institution primarily concerned with program and policy analysis relating to child welfare ("History – Chapin Hall" n.d.). The University of Chicago Consortium on School Research is another example of policy analysis that has existed since the late 20th century at UChicago on applied topics ("About Us" n.d.). In addition to Chapin Hall and the Consortium, there is a set of five "Urban Labs" at UChicago: the Crime Lab, Education Lab, Health Lab, Poverty Lab, and Energy & Environment Lab. Since the Crime Lab's founding in 2008, and the expansion to "Urban Labs" in 2014, the Urban Labs have used modern data analysis techniques across this breadth of topics and has conducted research with local governments across the United States (The GovLab 2017). Programs like Connect4Tots, which provided new parents with information regarding children's health, have been evaluated by Urban Labs researchers (Berman 2019).

These historical partnerships were largely driven by the desire to conduct research on topics where the city had access to data — typically, administrative data — that researchers at the University hoped to access, or, occurred in cases where the city needed an outside partner to conduct an analysis (Berman 2019). To some extent, the Urban Labs focus may be seen as an attempt by UChicago to conduct research on behalf of the city to demonstrate UChicago's

commitment to the city, as the Labs were launched at the same time as a massive revitalization of UChicago's Civic Engagement and External Affairs activities (Dodge 2019).

These antecedents to the current partnership can thus be seen as driven by a convergence in the interests between researchers at UChicago and practitioners at the city. Both groups had questions regarding policies and programs related to a host of activities undertaken in the context of local government; government often had control of the data, and researchers sought access to that data that otherwise would be fairly restricted. Importantly, each entity — Chapin Hall, the Crime Lab, the Consortium, etc. — should be seen as a separate entity within UChicago. Though they all fall under the umbrella of UChicago, each center does not necessarily share data outside of the individual entity, and they all act fairly independently (Dodge 2019).

Urban Center for Computation and Data

Since its launch in late 2012, the Urban Center for Computation and Data (UrbanCCD) has been working with the City of Chicago on a number of initiatives, notably Lakeside (Guzowski, Catlett, and Woodbury 2014), Plenario (Catlett et al. 2014) and the Array of Things (Catlett et al. 2017). The latter two efforts will be discussed in detail later in this chapter. Charlie Catlett, the Director of the Center, is a Senior Computer Scientist at Argonne National Laboratory, and Senior Fellow at the Mansueto Institute for Urban Innovation at UChicago; he has been at UChicago and Argonne National Laboratory since 2000.

UrbanCCD was initially funded by two grants, one from the National Science Foundation (NSF) to create a "Urban Sciences Research Coordination Network" and another by the MacArthur Foundation, a national philanthropy headquartered in Chicago, to further support the center (Mitchum 2013). According to its website, UrbanCCD "creates computational research tools and

leads initiatives … in ambitious efforts to understand and improve our cities" ("About UrbanCCD" n.d.).

Mansueto Institute for Urban Innovation

The Mansueto Institute for Urban Innovation was launched in 2016, with a $35 million gift to endow the center. Led by Pritzker Director Luis Bettencourt and Executive Director Anne Dodge, the Mansueto Institute is meant to be a central hub for much of the urban research at UChicago. For example, both UrbanCCD and the Center for Spatial Data Science are officially under the umbrella of the Mansueto Institute (Dodge 2019). Executive Director Dodge sees her role, and the role of Mansueto generally, as providing institutional stability for many of the projects and centers that pop up at UChicago due to individual principal investigators and grant funding. She noted that the other centers who engage with the MetroLab Network (mentioned above) are all on "soft money," whereas the Mansueto Institute's endowment supports a permanent operating budget with numerous staff members. Thus, she hopes that Mansueto will continue to exist and provide support to work with cities long after the current iteration of "sensors and data science" is the most exciting thing, and long after current principal investigators are at UChicago (Dodge 2019). However, she sees her job as supporting faculty in their interests, not necessarily to support the city of Chicago in any way. Specifically, Mansueto will support tenured and tenure-track faculty, primarily, and will support them in whatever urban research they are so interested in pursuing. If that research is with Chicago, that is good, but if that research is outside of the United States, that would probably be of more interest to the Director and other faculty members at the University. As such, Charlie Catlett has continued to be the main point of contact for UChicago with the city, and is the signatory on the MetroLab MOU (Dodge 2019).

Description of the Projects

The Array of Things and Plenario are the two flagship projects of UrbanCCD. They represent two distinct types of "smart cities" projects, with AoT focusing primarily on sensors and novel data, while Plenario advances open data and data integration.

Plenario

Plenario is a "a centralized hub for open datasets" that was built in partnership with the City of Chicago ("Plenar.Io - A Spatio-Temporal Open Data Platform" n.d.). The City's data platform, WindyGrid, was originally an internal facing platform that was developed in advance of a major international summit hosted in Chicago in 2012 (Catlett et al. 2014). UrbanCCD worked with the City and its Chief Data Officer to see how the data could be integrated and shown in a way usable both to the general public and researchers (Catlett 2019; Schenk 2019).

Array of Things

The Array of Things is a network of connected devices that have been deployed throughout the City of Chicago (Catlett et al. 2017; Thorton 2018). The devices (Figure 1) contain multiple subcomponents, including microphones, two cameras, sensors to detect temperature and various air particulates, and a computer. Each device (or "node") was built to allow for future adaptation and the addition of new sensors to be tested in the field (Catlett et al. 2017). AoT is built on the "Waggle" platform, also developed at Argonne National Laboratory (Beckman et al. 2016). AoT nodes thus collect data remotely on a variety of environmental conditions, and use novel computing technologies to process that data locally (i.e. on the node's computer) prior to sending data back to a central server, the "Beehive" (Catlett et al. 2017, 4). AoT data is then made publicly available. Initially, it was planned that Plenario would be the main source of AoT data, but given

the amount and complexity of the data generated by AoT, UrbanCCD has been developing a stand-alone AoT data portal (Catlett 2019).

The AoT nodes are distributed throughout the city (Figure 2), with more than 500 nodes planned (Thorton 2018). The plan, when fully deployed, is to have every citizen in Chicago live within two kilometers of a node, with 85 percent of the population living within one kilometer; UrbanCCD worked with the Center for Spatial Data Analytics at UChicago to identify where nodes would need to be deployed in order to meet these goals (Kusiak Galvin 2019).[19]

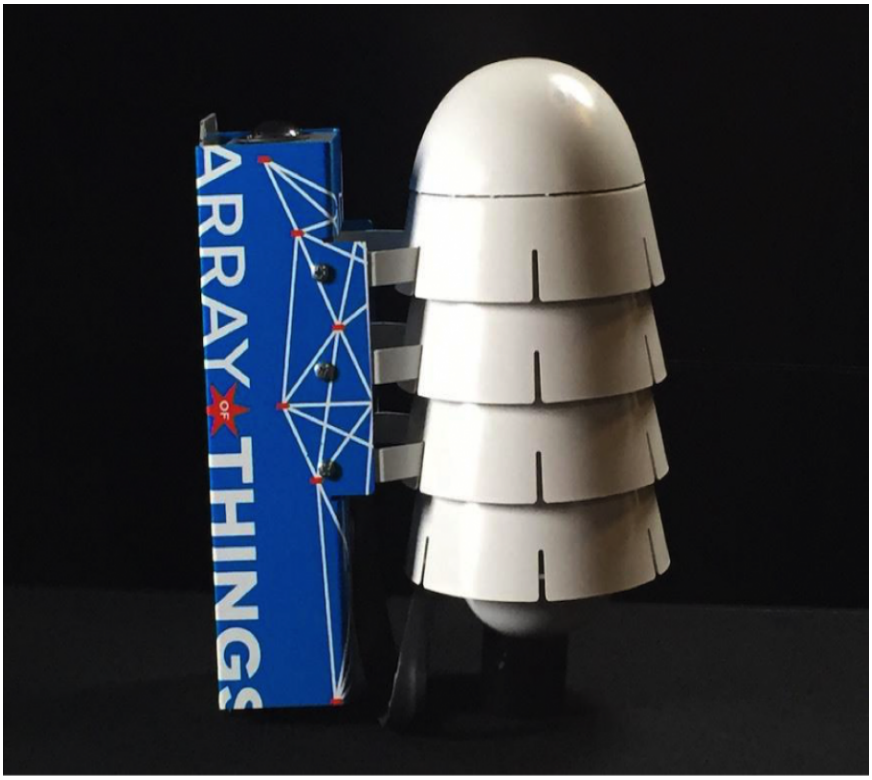

Figure 2 Prototype Array of Things Node. Source: UrbanCCD

[19] The interviewee provided no reasoning behind these specific numbers associated with the goals.

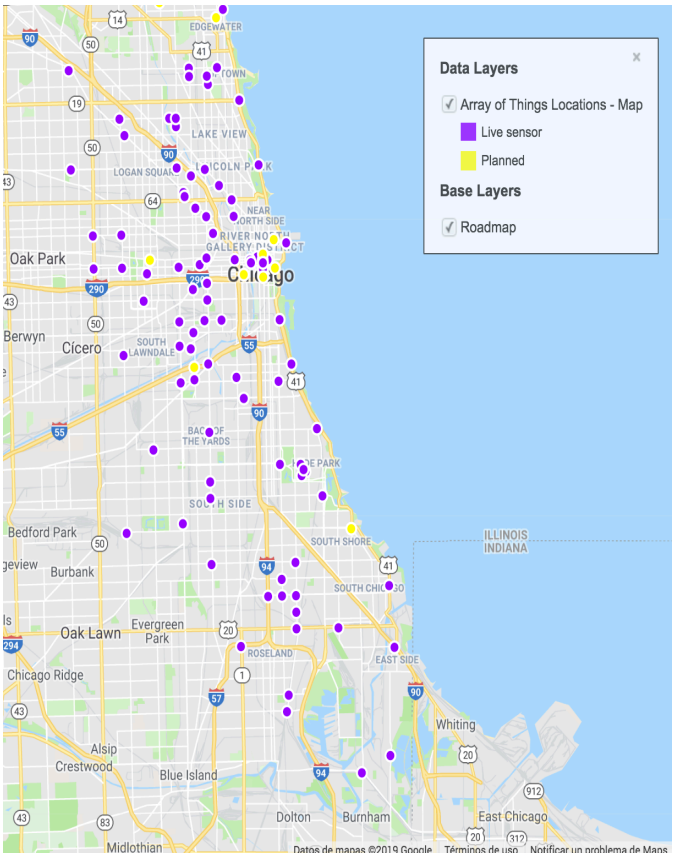

Figure 3 Map of Deployed and Planned AoT Nodes

UrbanCCD and Innovation and Technology: The Partnership

Partnership Structure: Formal Agreements

The partnership between UChicago and the City is largely driven by Charlie Catlett (Dodge 2019). However, Director Catlett states that he has no relationship with the City of Chicago, rather, he has relationships with the CIO and CDO and others, and that "our relationship with the City of Chicago is fully built on these relationship," (Catlett 2019). These relationships include an advisory council that Director Catlett served on towards the beginning of Mayor Rahm Emanuel's term, though CIO DuMerer notes that she met Director Catlett when he was Chief Information Officer of Argonne National Laboratory, which was nearly 10 years ago (DuMerer 2019).

Nonetheless, the Array of Things does have two contracts with the city, one for the pilot and one for the final deployment of the system (Kusiak Galvin 2019), though, as of April 2019, only the pilot agreement had been finalized. This contract governs installation, removal, deadlines, and other aspects of the project management. However, prior to the funding from NSF, the relationship between UrbanCCD and the City was much more *ad hoc* (Berman 2019), which mirrors the relationship for much of the Plenario deployment (Schenk 2019).

Specifically, the contract governs data collection and use, physical deployment, city rights, and UChicago responsibilities. Regarding data, though UChicago is the owner of the data, the City is given a perpetual license to the data, including for the release to the general public. The contract specifies exactly what sensors will be in the pilot nodes, and, other than the cameras that are part of the AoT, no personally identifiable information (PII) is to be collected by the nodes.[20] The contract also prohibits the sale of any data that is collected. The contract allows the city to retain significant power: only the city can end the pilot project — UChicago is obligated to continue collecting data from the AoT nodes during the pilot time period. Both the privacy policy and the governance policy of AoT are included as obligatory exhibits to the contract.

Partnership Structure: City Structure

Under Mayor Emanuel, the city underwent some restructuring and planning that allowed this partnership to function. First, the Chief Data Officer (CDO) is a Deputy Chief Information Officer (CIO), sitting within the Department of Innovation and Technology (DoIT) (Berman 2019; Schenk 2019). While the CDO position was originally established within the Mayor's office, it was moved to the DoIT in part to protect it from political changes (Berman 2019). The Deputy

[20] The contract spells out specifically how the PII is to be treated, including the limited access to those images, and the requirement that they be destroyed once the machine has been calibrated.

CDO oversees both the traditional information technology operations — including database management — and has new responsibilities, such as data analytics and data innovation, associated with the establishment of a new role (Berman 2019; Schenk 2019).

Brenna Berman's job description as Chief Information Officer (CIO) and Commissioner for the Department of Innovation & Technology (DoIT) included the charge to leverage city infrastructure through pilot programs to drive innovation (Berman 2019). As CIO, she had been given both the charge and authority to enter into such agreements with third parties, setting up the possibility of collaboration with UrbanCCD and other entities that would install technology on the city's infrastructure. This came, in part, from the Chicago Technology, which included 28 initiatives to create a "city fueled by technology." The third initiative of the Technology Plan is to "[i]mplement policies and infrastructure to allow for urban technology experimentation," with the hope that data collected in the public way will be of minimal cost to the city, while attracting researchers, companies, and talent Plan (Tolva and Berman 2013, 8, 31).

The stability of the current Mayoral administration has provided significant strength to the relationship. Former CIO Berman was in her position for seven years, and was a Deputy CIO prior to that appointment. Additionally, current CIO DuMerer was a Deputy CIO prior to her current appointment, providing remarkable stability and institutional knowledge of the projects (Berman 2019; DuMerer 2019). City officials pointed to the longevity of city staff as enabling relationships and institutional memory to be maintained, in spite of various transitions.

Partnership Structure: University Structure

Many of the interviewees pointed towards Director Catlett singularly as the reason for the reason that these projects have succeeded, with former CIO Berman noting that "he's a tinkerer" and that he has built an entire career on trying to understand cities computationally (Berman 2019).

While the partnership between UrbanCCD and the City is clearly defined by Director Catlett's role, there is little coordination among the other UChicago centers that have relationships with the city (Catlett 2019). Therefore, one of the goals of the Mansueto Institute is to begin to coordinate these research activates and ensure that the partnership with the city can outlast individual faculty and affiliates (Dodge 2019).

Executive Director of the Mansueto Institute Anne Dodge noted that Director Catlett, like many of the other applied researchers at UChicago, is not tenured nor tenure track (Dodge 2019). She notes that the tenured and tenure-track faculty members at UChicago are not interested in the sort of applied work that is undertaken with the city: technology deployment, program evaluation, and data science all fall outside of the incentives and structures that exist for UChicago faculty (Dodge 2019). Both Executive Director Dodge and former CDO Tom Schenk talked about UChicago as, primarily, a school that demurs from application; former CDO Schenk points to UChicago's longstanding refusal to grant a degree in Computer Science because it was too applied (Schenk 2019; Dodge 2019). Executive Director Dodge pointed out that UChicago hosts no school of engineering, nor urban policy, and that Charlie Catlett is an Argonne National Laboratory scientist first, UChicago faculty member second, giving him a unique vantage point to engage with research on smart cities with the city of Chicago (Dodge 2019).

Though there are applied research centers and activities at UChicago, Executive Director Dodge notes that, for nearly all of the applied research projects across UChicago, those researchers are primarily or wholly funded on grant dollars (Dodge 2019). These individual principal investigators run their own centers, pursue their own grant funding, and run independently. Thus, though UrbanCCD was established in order to work with the City of Chicago, it exists solely for projects that Charlie Catlett directs. As noted earlier, the Mansueto Institute has been established

to try and coordinate the many centers that focus on "urban" at UChicago. However, the center has not yet established many links with the city, and is only in the early days of identifying all of the relevant partners at UChicago.

Partnership Structure: Project Selection

Unlike Pittsburgh, where project selection can be spoken about in the abstract, the selection of Plenario and Array of Things have specific founding stories that can be attributed to specific people. There is no generalizable "project selection process" since the projects enumerated within the MetroLab partnership were based on projects that the city and UrbanCCD were already doing, on an *ad hoc* basis (Berman 2019).

Plenario was largely possible because of a willingness and ability of the City of Chicago to work with UrbanCCD on the development of this platform. Director Catlett observed the opportunity to build off of the internal city platform, WindyGrid, and worked with the relevant team members to open the data platform to the research community (Catlett 2019; Schenk 2019).

The Array of Things, as the story goes, arose out of a collaborative project between UrbanCCD and the School of the Art Institute of Chicago. Charlie Catlett was collaborating on a project where students had to develop an urban sensing project, when he realized how difficult it is to actually deploy sensors in the urban context. The challenges of accessing physical infrastructure, power, and data connectivity for such sensors became apparent when students had been assigned this project (Berman 2019). At the same time, Director Catlett was serving on an Advisory Committee for the City of Chicago (Catlett 2019), and engaged in conversations with the Chief Information Officer at the time about collaborating with the city on installing sensors, as "full implementation of a persistent scientific instrument would require partnership with city government," (Catlett et al. 2017, 1). Director Catlett drew out an idea for the Array of Things on

a napkin with CIO Brenna Berman, and the project grew from there (Berman 2019). Based on the third initiative of the Chicago Technology Plan (noted above) the AoT project fit with the City's desire to allow the city to be an "urban lab" (DuMerer 2019).

Additionally, Chicago was "willing to be first," for many of the technology projects on their infrastructure (Berman 2019), including the Array of Things, making it a natural partner for UrbanCCD. Additionally, Director Catlett describes discussions with other city officials revolving around the installation of new streetlights in the city, and wondering if an AoT node could be installed at the same time (Catlett 2019).

Partnership Structure: Deliverables and Check-Ins

The main deliverable from UChicago for the AoT pilot is the AoT nodes, and, later, the data collected by those nodes. As such, the AoT nodes were co-created, in part, through conversations with the city. That is to say, the city had a voice in what sort of sensors were included in the deployed nodes, and what sort of data would be collected.

While the original plan for AoT included sensors in order to capture the number of phone users in proximity to a node, public pushback resulted in the removal of those sensors from the final version of the nodes (Catlett 2019; Madhani 2016; Moser 2016). Conversations between UrbanCCD and city officials were centered around how one measures the "health of a neighborhood" (DuMerer 2019) and what sort of information would be helpful for city officials to elucidate challenges that they face in addressing problems within the city, while also capturing data that would be interesting for researchers trying to understand aspects of the city (Catlett et al. 2017). These conversations affected the final development of the AoT nodes, with the specific sensors solidified in the contract between UChicago and the city.

Regarding check-ins, Director Catlett and the Executive Director of UrbanCCD have biweekly calls or meetings with the CIO, providing project updates and information about any successes or hurdles (Berman 2019; Catlett 2019; DuMerer 2019; Kusiak Galvin 2019). Additionally, the CIO sits on the Executive Oversight Council of the AoT, and has veto power over any decision made by that council ("Array of Things Operating Policies" 2016; Berman 2019). Because Director Catlett is both the principal investigator on the project, and the main point of contact with the city, he is able to provide detailed information to the City about the status of the project at all times.

MetroLab and Chicago

In addition to the project-specific governance, the relationship between UrbanCCD and UChicago fits within the MetroLab Network framework. Though the President of UChicago and Mayor Emanuel signed the 2015 letter to President Obama to join the network ("Letter from University Presidents and Mayors to President Obama on the Creation of a Metro Lab Network" 2015), the original Memorandum of Understanding was likely signed by Director Catlett and CIO Berman (Berman 2019; Dodge 2019). Nonetheless, former CIO Berman sees the MOU as secondary to the other activities undertaken by the partnership, as many pieces of the UrbanCCD/City partnership had long been in place prior to the 2015 announcement (Berman 2019).

As such, the impetus to join the MetroLab network was driven in part by the desire to support a local philanthropic partner, the MacArthur Foundation, and President Obama, who had strong ties to UChicago, Mayor Emanuel,[21] and the City (Berman 2019; Dodge 2019). Thus,

[21] His former Chief of Staff.

though UChicago and the City did not "need" MetroLab for their partnership, they joined in order to support this national initiative in the hopes that it may support other city-university partnerships (Berman 2019). In addition to the goal of cultivating partnerships, former CIO Berman believes that MetroLab was meant to break cities out of their siloes, with the hope that technology and knowledge could transfer among different partnerships, but has not seen that aspect as successful (Berman 2019).

On the university side, Anne Dodge has found MetroLab helpful because, by going to the National Conference, she was able to do a landscape analysis of all of the UChicago researchers who view themselves as part of the partnership — many of whom came out of the woodwork for the first time at the conference (Dodge 2019). Executive Director Dodge sees MetroLab as also very interpersonal, pointing to existing relationships that UChicago researchers had with each other, and with MetroLab network staff (Dodge 2019). She plans on leveraging MetroLab in future years to continue to consolidate urban research at UChicago. By hosting the 2020 MetroLab Network conference at UChicago, she hopes to get all UChicago researchers in a room, to make sure they all know who is doing what (Dodge 2019).

Partnership and Project Funding

The primary funding source for the Array of Things is the National Science Foundation, with a $3 million grant.[22] This grant is meant to support the development and deployment of 500 AoT nodes in the city of Chicago. Importantly, the NSF grant does not include funding for future maintenance, setting up a long-term problem in order to continue the operation of AoT into the future (Berman 2019).

[22] National Science Foundation Award Number 1532133.

Additionally, the city provided an equivalent of $300,000 in an in-kind contribution of union labor, to support the deployment of the AoT nodes (Berman 2019). Because the nodes are installed on public infrastructure (light poles) they have to be installed by union labor, and UrbanCCD works closely with the technicians to ensure that the nodes are installed correctly (Catlett 2019; Kusiak Galvin 2019).

The pursuit of grants from federal, state, and non-government partners forms an important piece of what projects are pursued, since MacArthur and the NSF were both interested in the type of activities undertaken by UrbanCCD (Kusiak Galvin 2019). For the city, this is seen as a benefit, since the academic partner is able to pursue outside funding (Schenk 2019).

Project Analysis: Plenario and Array of Things

Project Benefits and Goals

Goal alignment is particularly important. The scientific goals of understanding *whether* and *how* a technology might work may not fit nicely with a desire for successful implementation. CDO Schenk continually pointed to using data to improve the quality of life for the citizens of Chicago, and said that, for any city-university project, one must ask if it is achievable, novel, and meaningful. Thus, the city and UChicago must seek a middle ground between research and practical use cases (Schenk 2019). City partners also understood that the University was not always the best partner for a given project, given academic schedules, and the risk of failure that comes with experimentation (DuMerer 2019). Nonetheless, alignment has seemed to be successful in Chicago, as they chose to deploy AoT nodes "in an area where there is both an academic research question to answer," and "a city service delivery issue that can be addressed or improved by the data" (Berman 2019).

Plenario

Plenario's benefit is that it simplifies and integrates existing data sources in novel ways, making data analysis easier, and removing some knowledge hurdles that would be required to work with city open data that is not always legible. Plenario was largely driven by an interest in automating and making more accessible the data on the internal WindyGrid and external OpenGrid data portals for the City of Chicago. As former Chief Data Officer Tom Schenk describes it, it was largely an experiment to see whether automation and integration of various data sources was possible (Schenk 2019). On the academic side, Director Catlett saw WindyGrid as a wealth of data that would be of interest to researchers if they had access, but, given the limited legibility of open data, knew that there needed to be software developed to clean the data and to integrate it with other existing open data platforms (Catlett 2019; Catlett et al. 2014).

The scientific objective was thus largely to enable the ability to easily access data about "about a particular place and for a particular window of time," while allowing both technical and non-technical audiences access to such a query (Catlett et al. 2014, 2–3). Given that Chicago already had WindyGrid and OpenGrid, however, Plenario's goals on the city end were largely to encourage collaboration between academic researchers and the city, and to build on existing collaborations (Schenk 2019).

Array of Things

The AoT project, from the UrbanCCD point-of-view, is largely about sensor capabilities and the data that can be collected and used from these novel sensors, for extending across natural and social science disciplines. Specifically, the scientific goals for the Array of Things revolved

around creating new data, developing "edge computing,"[23] and testing new sensors and devices (Catlett 2019; Catlett et al. 2017). Director Catlett, recognizing the existing skepticism about the use of low-cost sensors, said that it is helpful to consider these as "qualitative nodes" that can be used to alert researchers when high-cost sensors may need to be deployed. Director Catlett spoke about calibrating the sensors against existing high-cost air quality sensors, for example, by collocating some sensors in the initial pilot. Images collected by the nodes will also be calibrated by researchers, later training the nodes to do some image analysis remotely.

Tom Schenk noted that researchers are "always going to have their own internal research goals," that are distinct from the City's goals, and that "scientific experimentation and pragmatic implementation can get a little bit hairy at some points, because science is science and sometimes something doesn't work," (Schenk 2019). Within the contract governing AoT, the city's goals are stated quite explicitly: "the sole purpose of this Pilot is to generate data that will be analyzed with the goal of enhancing the lives of citizens and the enhancement of government services."

Based on the interview responses, the more specific goals and benefits of AoT for the city can be explained along three dimensions. The first is the benefit that would come with hosting such an ambitious project. By working on something that was "shiny and news worthy," the Mayoral administration could signal to tech companies that Chicago was open for these types of projects (Berman 2019). Working with AoT demonstrated that Chicago was willing to work creatively with companies to pilot novel technologies (Catlett 2019).

Second, the city had a number of use cases for the data that would be collected by the AoT nodes. The nodes' cameras, capturing the surrounding areas, would give city officials new

[23] Meaning computing happening locally at the node, rather than on a centralized computer.

information about ground and traffic conditions. This, in turn, could help the various departments with groundwater management and meeting Chicago's Vision Zero[24] goals. Temperature and particulate sensors would allow city officials to understand local environmental conditions, and link them to asthma cases. Given that the city was already interested in data-driven decision making (Berman 2019; DuMerer 2019; Schenk 2019), AoT was a natural partner, but part of the benefit for the city is that, rather than working with a company's proprietary solution, AoT is open and can function as a public utility without being a black box (DuMerer 2019).

As is implicit in all of these use cases, there is no promise that AoT will lead to policy change. AoT nodes are only recently releasing data, with the first city "hackathon" to explore the AoT data occurring in January 2019. Though city officials, from the Department of Transportation and the Department of Public Health see value in the data that is being collected by AoT nodes, no clear policy or action *changes* from AoT data were expressed (Berman 2019; DuMerer 2019).

Third, in addition to the technical use cases, continued collaboration between the University and the City is seen as a *de facto* benefit. By setting up opportunities to work with UChicago, other research projects can be spun out (Berman 2019), and working with an academic partner is attractive given the limited resources of the city (DuMerer 2019). Additionally, students who work on the project may later become interested in working with DoIT, increasing the city's workforce pipeline (DuMerer 2019). Director Catlett sees the educational aspect of the Lane of Things project as another benefit to the city, given the general interest in Science, Technology, Engineering, and Mathematics (STEM) education (Catlett 2019).

[24] Vision Zero is an international campaign to end traffic fatalities and serious injuries.

Project Data

Given the panoply of data that are being collected by each AoT node, which are being placed on public infrastructure, data ownership is of key importance. Though Chicago typically insists on owning any data that is generated in the public way (Berman 2019; Schenk 2019), that is not the case in the AoT case.

There are two principle reasons for UChicago's data ownership in this case. First, because the contract between UChicago and the City, and the contract between UChicago and NSF, both require open data, city ownership and UChicago ownership were seen as equivalent in this case. So long as the data are open, CIO Berman was agnostic as to who owns the data (Berman 2019). The open data aspect of AoT also fits with the conception of the project (Dodge 2019) and with the mission of UChicago as a nonprofit research institution (Kusiak Galvin 2019).

Second, given some of the privacy concerns that were raised during the development of the AoT, the choice to house the data at UChicago was made, in part, to protect citizen's privacy (Berman 2019; Kusiak Galvin 2019). Former CIO Berman cites the example of the event in which the Police Department were to request to see images from a specific AoT node. If the data were housed within the DoIT, such a request would be internal, with little transparency. Thus, by keeping the data housed at the UChicago the public would be aware of such a request, which would be dealt with through typical legal channels (Berman 2019). Additionally, the city points towards existing university mechanisms for protecting personal information as another benefit of allowing UChicago to retain ownership of the data (Berman 2019).

Technology Transfer

Plenario

Plenario, as a platform that can accept data sets from researchers anywhere in the world, does not necessarily fit the typical conception of "technology transfer." Nonetheless, Plenario has been used outside of Chicago. A 2014 article highlights the use of Plenario by the Sustainable Development initiative in San Francisco (Catlett et al. 2014). In order to extend Plenario from Chicago to San Francisco, some changes were made to the structure of the database, accommodating queries and data types that did not exist in the case as developed for Chicago.

Array of Things

The Array of Things has garnered significant national and international media attention. As such, numerous cities have reached out to UrbanCCD to inquire about deploying Array of Things (Thorton 2018). As of August 2018, Array of Things was being deployed in Palo Alto, Seattle, Portland, Denver, Detroit, Chapel Hill, and Syracuse (Array of Things 2018). Seeing the participation of both the local government and local non-profit as necessary, UrbanCCD works with the main point of contact to identify the other local partners for deployment (Kusiak Galvin 2019). To receive AoT nodes for deployment, other cities must agree to the open data terms, and must share the AoT data on the data portal. Additionally, local partners are able to identify the different sensors and types of data that they hope to collect, given the flexibility of AoT (Array of Things 2018).

Community Engagement

Following a 2014 article pointing to privacy concerns regarding the AoT project (Heinzmann 2014), the UrbanCCD and city partners began working with the Smart Chicago

Collaborative to run a series of educational meetings in communities where AoT nodes would be deployed (Berman 2019; Catlett 2019). The UrbanCCD team underwent a number of trainings in order to understand how to engage community members during public meetings (Catlett 2019), while the Smart Chicago Collaborative facilitated the meetings and recorded them for public information (Linn and Startz 2016). Multiple community meetings have been held in neighborhoods where the nodes are currently deployed, with more planned in the coming year (Catlett 2019).

As outlined in conversations and in the Array of Things Civic Engagement Report, a second critical piece of the public engagement was through the development of the Privacy Policy and governance document.[25] Both the American Civil Liberties Union (ACLU) and the Electronic Frontier Foundation (EFF) were consulted regarding the Privacy Policy, which was then made open for a six month public comment and changes through the use of an online tool called "MyMadison.io" (Catlett 2019; DuMerer 2019; Linn and Startz 2016). Additionally, responses to every comment made regarding the privacy policy garnered a response, which was then published online (Catlett 2019).[26]

The choice for the initial pilot locations was part of this community engagement strategy. AoT node locations were decided based on a rubric gauging community and institutional support (Catlett et al. 2017) and this was buttressed by a commitment never to install nodes in a community that was opposed to them ("Array of Things Operating Policies" 2016; Berman 2019). Furthermore, by requiring organizational support in the community, the AoT team relies on such organizations to ensure that there is use for the data once collected. This is due partially to a

[25] http://arrayofthings.github.io/final-policies.html
[26] https://arrayofthings.github.io/policy-responses.html

concern that, without such organizational support, communities would be unable to use the data to their advantage (Berman 2019).

Both city officials and UrbanCCD staff note the difficulty of conducting education at the same time that they were soliciting feedback on the policies associated with AoT. For example, some community members were interested in using AoT cameras for policing applications, while the cameras chosen for AoT were specifically too low-resolution to detect faces or other such information (DuMerer 2019).

Finally, the Executive Oversight Committee is set to be composed of members "from academia, industry, not-for-profits, and the community" ("Array of Things Operating Policies" 2016). This is one of the weakest aspects of the community engagement aspect of the AoT project, given that criteria for community members is not specified in the governance policies.

Placement of the nodes during the pilot program was driven by three components: citizen interest, organizational support, and governmental support (Berman 2019; Catlett 2019; Catlett et al. 2017). Thus, if citizens expressed interest in having AoT nodes come to the neighborhood (by contacting the UChicago team), if there was an existing organization in the neighborhood that could use or support the data analysis, and if there was interest from city government (legislative or executive branches), a neighborhood would be prioritized to receive AoT nodes.

Project and Partnership Future

Given the fact that the Mayor Emanuel administration ended on May 20, 2019, the topic of stability and longevity of the project was top-of-mind for many interviewees. Former CIO Berman pointed towards the internal organization of DoIT as a means to protect AoT from any political headwinds, given that a program manager is the main overseer of the daily activities of

the project (Berman 2019), while current CIO DuMerer noted that the AoT project is significantly high-profile that it seems unlikely any new administration would dismantle the project (DuMerer 2019). While the contract between UChicago and the city does allow the city to halt and take down the nodes, Director Catlett notes that it would likely be more costly for any new administration to take down the AoT than to allow the project to run its course (Catlett 2019).

While interviewees were confident that the mechanisms were adequate to continue running the AoT project, there was less clarity about the ability to develop new projects with as-of-then undecided Mayoral election. Given the claimed importance of strong Executive leadership from the Mayor and his administration (Berman 2019; Catlett 2019), it seems that new projects between UChicago and the city are not guaranteed.

Additionally, former CIO Berman noted that, for the most part, the city had never contributed money towards a smart city project (Berman 2019). Instead, outside funders, such as the federal government, had largely provided the support. Former CDO Schenk echoed this assessment, noting that if MacArthur and NSF decided to return towards a focus on basic research, then the partnership between UChicago and the city may return to the earlier state, where there was less engagement (Schenk 2019). Nonetheless, he finds the more likely outcome to be that both cities and universities will become more sophisticated partners, as both sides develop and understand more advanced technological applications (Schenk 2019).

Results and Analysis

Results

The preceding two chapters provided significant detail regarding the structure of the partnerships between Pittsburgh and Carnegie Mellon University and Chicago and the University of Chicago. Table 1 summarizes many of the aspects of the partnership, providing brief descriptions of how each partnership functions across eleven domains. Following the table is will be a brief analysis of some of the most important differences that are highlighted in the table. This is followed by an analysis comparing these two case studies to my original research question. This chapter closes with high-level considerations as to what these two cases mean for city-university smart city partnerships generally.

Table 1 Aspects of Smart City-University Partnerships in Pittsburgh and Chicago

	Pittsburgh	Chicago
Formal Structures	• Memorandum of Understanding • Moving towards "project charters"	• Memorandum of Understanding • Contracts for individual projects

City Structure	• Department of Innovation and Performance
	  ○ Information Technology
	  ○ Data Analytics and Open Data
	• Department of Mobility and Infrastructure
	• Department of City Planning
	  ○ Chief Resilience Officer
		• Department of Innovation and Technology
		  ○ Chief Data Officer
		  ▪ Information Technology
		• Chicago Police Department
		• Chicago Department of Public Health

University Structure	• Metro21
	  ○ Transit21
	  ▪ Mobility21
	  ▪ T-SET
	• Remaking Cities Institute
		• Mansueto Institute
		  ○ UrbanCCD
		  ○ Center for Spatial Data Science
		  ○ Urban Cognition Lab
		• Chapin Hall
		• Urban Labs
		• University of Chicago Consortium on School Research
		• Center for Data Science & Public Policy

Project Selection	• RFP process at the university, vetted by city officials • *Ad hoc* proposals of projects by faculty or city officials, funded through Metro21	• Proposals by UChicago faculty members to city officials ○ Co-creative process thereafter
Project Funding	• Metro21 provides seed funding to projects every year • Mostly local philanthropy • No direct city funding, staff and in-kind use of public way	• Mansueto Institute endowed, permanent support for staff • Individual centers pursue external funding • No direct city funding, staff and in-kind use of public way
Community Engagement	• Largely absent from CMU projects • Western Pennsylvania Regional Data Center conducts community trainings and office hours ○ City hopes community engagement will be more present going forward	• Smart Chicago Collaborative ran community meetings • Participatory design of privacy policy • "Lane of Things" student project

Check-ins	• Monthly check-ins between Executive Director of Metro21 and Director of Innovation and Performance (I&P)
	  ○ Mayor's Chief of Staff main point-of-contact in absence of I&P Lead
	  ○ Beginning meeting, mid-project report, and final report for CMU faculty
	• *Ad hoc* check-ins between research faculty and city program management
		• Bi-weekly check-ins between Director of UrbanCCD and Chief Information Officer

Project Goals	• City
	  ○ "Research arm of the city"
	  ○ Direct operational benefits
	  ○ Supplant resource constraints
	  ○ Prepare for future funding requests and procurement
	  ○ Change city's reputation
	• CMU
	  ○ Advance technical capabilities
	  ○ Engage in place-based research
	  ○ Respond to local philanthropy
	  ○ Leverage state and funding sources
		• City
		  ○ Increase understanding regarding air quality, vehicle near-misses, and ground quality
		  ○ Open city infrastructure for novel technologies and research: reputation and economic development
		• UrbanCCD
		  ○ Advance technical capabilities
		  ○ Support research community with novel, open data

Project Deliverables	• Differs by project • Determined at kick-off meeting	• 500 Array of Things nodes throughout Chicago • Spelled out in contract between UrbanCCD and Chicago

Tech Transfer	• Many projects commercialized and scaled	• Array of Things has expanded to other US cities
Project Data	• No consistent method for treatment • Some data owned by Pittsburgh, shared with researchers • Other data owned by CMU, with Pittsburgh access tentative	• Array of Things data owned by UChicago, fully open access • Chicago policy of open data for all data collected on public infrastructure

The most significant difference between the UChicago/Chicago partnership and the CMU/Pittsburgh partnership is the number and diversity of the projects that actually comprise the partnership. In Chicago, the projects undertaken by UrbanCCD under the umbrella of the MetroLab Network is limited to three projects, whereas Pittsburgh has undertaken 50 projects through Metro21, with 24 projects active as of January 2019 (Lightman 2019). The difference in the number of projects is reflective of the different university structures.

At UChicago there are a collection of centers (UrbanCCD, Urban Labs, Mansueto Institute, Chapin Hall, University of Chicago Consortium for School Research, etc.), each of which are pursuing their own projects, funding, and contracts, with little to no coordination. Each center has their own principal investigator and team. Though most of these centers participate in the MetroLab national conference (Dodge 2019), Charlie Catlett of UrbanCCD is the main point of contact on the MetroLab MOU, and only some of these centers would fall under the umbrella of smart cities.[27] While the Mansueto Institute is attempting to institutionalize and centralize some of this work, that institute will primarily support tenured and tenure-track faculty, rather than research faculty who comprise many of the existing centers (Dodge 2019).

[27] Others, such as Chapin Hall, sit more clearly within program evaluation.

By contrast, Metro21 is a center with no faculty and no projects. Rather, Metro21 is the institutional body that convenes researchers, raises and disburses funding, and centralizes contact between the university and the city of Pittsburgh. Whereas the principal investigators at UChicago each have their own, independent relationships with the relevant staff at the city of Chicago, most CMU faculty members go through Metro21 when they wish to engage with Pittsburgh to conduct research (Lightman 2019).

Reflecting the different university structures, there are different accountability structures between the two partnerships, resulting in different levels of satisfaction among city partners. In Chicago, contracts and data sharing agreements are formally written and agreed to among the different partners and for each project. By contrast, most projects undertaken by CMU have gone through the MOU signed by Pittsburgh and CMU, with a move towards "project charters" now underway. On the one hand, the Metro21 partnership allows CMU to undertake many more projects than at UrbanCCD, yet the bottleneck that exists within both the CMU and Pittsburgh organizations has limited the ability of Pittsburgh officials to manage the projects, creating frustration when CMU researchers miss deadlines, are difficult to reach, or do not provide data to the city.

Analysis

When considering the success of these two projects, it is necessary to refer back to the original research question: when governments and universities develop these partnerships, do they consider the long-term implications for citizens and the community, or are they thinking merely in terms of short-term political optics? Considering the question is primarily considering the process, it would be better to reframe the question with regards to outcomes, and pose the following question instead: do the projects and partnerships advance the good of citizens and the community,

because they considered long term implications rather than merely short-term political optics? The answer in both cases is an ambiguous "maybe."

Pittsburgh

The partnership between CMU and the city of Pittsburgh has clearly led to some good outcomes for the city and its citizens. Structurally, Metro21 has opened up the entire university to city officials. Metro21 speaks the modern language of research — seed funding —, while also capitalizing on the current interest in place-based research. By providing access to the city for interested researchers, and providing access to researchers for city officials, Metro21 has a transformative capacity for a city that otherwise lacks internal research capabilities. Many of the projects are innovative and changing city activities. Additionally, the technical assistance provided by CMU to the City is a perfect use for this partnership. Hopefully, collaborations with the University of Pittsburgh will also be strengthened, as the praise for the Western Pennsylvania Regional Data Center is notable, and may indicate that the mission of a local, public university has some alignment with the city's goals.

Pittsburgh is also pursuing smart city projects that can actively reduce cost, extend city resources, and change city policy. These projects show that Pittsburgh has developed the capacity to use the partnership not just to chase headlines, but to actualize knowledge towards better city government. Projects highlighted by interviewees, such as predictive fire analytics and better paving systems are both within the realm of "smart cities" according to the new director of Innovation and Performance, Santiago Garces, even if others may not have typically defined them as such (Garces 2019).

In this way, Pittsburgh is also figuring out what the partnership with CMU can get them, and what it is unable to provide. While a student project from CMU may not adequately answer a

question for Assistant Director of Mobility and Infrastructure Alex Pazuchanics, it does give him the ability to justify future budget requests to city council (Pazuchanics 2019). By distributing city officials with the capacity to engage with CMU researchers throughout multiple departments of the city, Pittsburgh is better able to address what problems might be solvable by CMU researchers.

However, Pittsburgh's initial missteps have created some lasting problems that have proven difficult to correct. Traffic21, spearheaded by a former mayor, left some projects on city streets — such as Surtrac and RoadBotics — that have caused headaches for current city officials. With no contract, data sharing agreement, or other process for managing the projects, city officials have been unable to get what they need from CMU researchers on those projects. The institutional dynamics from the projects have also persisted — contracts and other formal written documents are still mostly omitted from the project process, in spite of a stated desire from city officials to move towards project charters. Pittsburgh is missing data that it otherwise could have had access to, and it has set precedents regarding the use of the public way that it has found difficult to reverse.

Pittsburgh has also been limited by some of the more grandiose plans. No one city staff member has the sole responsibility to interface with CMU, and those city officials who do interface with the university all have multiple, competing priorities and tasks. This means that engaging with projects that over-promise-and-under-deliver results in wasted staff time and resources. While there are projects that city officials cite as successes, especially regarding predictive analytics and technical assistance, frustration over the more grandiose projects, especially those that are later commercialized, overshadow the successes. While the shotgun approach may have its benefits — allowing for some breakout successes that would otherwise be too big of a risk — a better balance between long-shot experiments and incremental projects that address operational problems may better assuage concerns about CMU's and Pittsburgh's competing goals.

The lack of community engagement in Pittsburgh is also a serious concern. Though Metro21 lists "Providing Enhanced Public Input on Metro21 Projects" as one of its Metro21-funded projects,[28] the project did not come up in any interviews. Projects like Surtrac — which, admittedly, was pre-Metro21 — rankled citizens when it prioritized motorized traffic over other modes of transportation (Snow 2017; Stafford 2019). Other projects, such as 5G wireless (the OPERA project) and predictive policing, both warrant citizen engagement, yet community engagement does not have a place in the partnership, and thus, is omitted from individual projects as well.

Though this may not be an obvious omission, Pittsburgh is missing the opportunity to receive revenues from the companies that are commercialized through the partnership and the use of the public way. Osborne and Gaebler (2015) make the argument that governments should be in the business of making money, not merely losing money. If Pittsburgh views the granting of its right of way as product testing for future commercialization, it could negotiate revenue sharing from future commercialization of technologies, addressing a key problem that was identified — resource constraints — while nonetheless subsidizing local economic development and innovation.

Chicago

Chicago's partnership with UrbanCCD has yet to generate results, but city officials remain hopeful that the partnership *will* benefit the city. By having specific use cases in mind, and working with departments to make sure that they were bought into the vision of the Array of Things, the city will hopefully be well prepared when the network of AoT nodes are fully deployed, and the

[28] https://www.cmu.edu/metro21/projects/enhanced-public-opinion.html. Accessed May 1, 2019.

sensors adequately calibrated. For its part, UChicago and UrbanCCD seem to have found an adequate balance between testing novel technologies and promising an accurate description of what it can provide to city officials.

The UrbanCCD and UChicago researchers and staff also seem to have been very conscious about formalizing safeguards and processes to keep the public protected. Though AoT nodes include two cameras, the promise of AoT is to process the images remotely (at the node), in order to transmit images that are of scientific use, but not invasive of privacy. Such protections are spelled out in the governance policies of AoT. The ability for the Chief Information Officer to veto any changes to AoT ensures that the city will not be overrun by changes at UChicago, unbeknownst to city officials. The UChicago data ownership, with a contractual obligation to provide the data openly, seems to have been an easy decision, assuaging citizens' concerns regarding the misuse of the images by the government, while ensuring public access. While the press highlights some concerns about the brevity of the AoT privacy policy (Elahi 2016), there seems to be little-to-no public consternation about the project as it was finally developed.

The community engagement aspect of the Array of Things project also bodes well for the partnership. Particularly impressive is the requirement that AoT deployments coincide with an interested community partner. Chicago seems to understand that open data does not necessarily result in citizen engagement and use of the data. By seeking community groups and non-profits, and working with local community members to train them on the use of AoT data, it seems that Chicago is legitimately committed to citizen empowerment through open data. As AoT expands from the pilot to full deployment, scalability will be key, as the commitment to only enter into neighborhoods that want AoT nodes ("Array of Things Operating Policies" 2016; Catlett et al.

2017) does not seem compatible with a goal to make sure the entire population of Chicago lives within two kilometers of a node (Kusiak Galvin 2019).

However, the partnership between UChicago and the city does face some barriers. Primarily, while the media and discussion regarding AoT couches it as a "UChicago" project, it is clearly an UrbanCCD, and, more specifically, a Charlie Catlett project. This does not bode well for future collaborations. As noted repeatedly by Anne Dodge (2019), the researchers at UChicago engaging in smart city projects with Chicago are neither tenured nor tenure-track. Essentially, UChicago is allowing research faculty to work within the university to do place-based research, but has not worked with the core tenured faculty to work with the city of Chicago. This makes the partnership between Chicago and UChicago tenuous, as Director Catlett is neither tied to the University nor is there a clear institutional support structure to support the work if he were to leave. While the Mansueto Institute may eventually serve that role, it does not clearly mirror the positive aspects of the Metro21 Institute at CMU.

Not only is the long-term partnership between UrbanCCD and Chicago somewhat tenuous, so too is the long-term success of AoT. While "build first, figure out later" is a common aspect of local government, AoT as of yet lacks a structure to ensure future operations. Without a plan to continue operations and upgrades, AoT nodes may, in the future, be a vestige on city infrastructure providing no functionality, costing the city electricity to operate or take down (Catlett 2019). By simple fact that the city is partnering with an academic partner on an experimental technology, inherent risk is involved for a project that may not pay operational dividends.

Though the city has "use cases" in mind for the data collected by Array of Things, it has yet to be seen if any policy changes will emerge from the data that is collected. Will the city quantify disparities and other inequity that is already known (Berman 2019), or will the city be

able to use the data to actually change policy and outcomes for the people of Chicago? With the recent mayoral transition, the longevity of the project, as a physical object, is in question, but so too is the use of the data collected by the project. If the political will to change policy based on the data collected does not exist, then the data produced by AoT provides little utility to the people of Chicago.

Finally, Chicago seems to be lacking a plan for long-term engagement on smart cities generally. In speaking about AoT and other smart cities projects with private companies, the value that Chicago brought was its willingness to go first (Berman 2019). As cities become increasingly wary about the value of going first, Chicago's pitch becomes less obvious. Beyond reputational benefit, AoT use cases, and possible economic development, it is unclear whether the city has a plan for continued innovation around smart cities.

Discussion

City officials and university researchers in both partnerships referred extensively to the reputational and secondary benefits of the projects. City partners viewed the partnerships as the ability to earn reputational prestige in the technology sector, hoping to attract private investment by signaling to partners that they were open to novel technologies and uses of the public way, by partnering with universities, who were seen as local resources, and, perhaps, as "safe" partners.

Additionally, these partnerships were clearly responding first-and-foremost to signals from funders, rather than city officials identifying problems, and then seeking funding to find solutions to those problems. While this is more obvious in the Pittsburgh case — where a private citizen initiated the decade-long partnership — it is consistent with Chicago as well. The MacArthur Foundation and the Chicago Innovation Exchange provided pilot funding for the Array of Things; additionally, the city has identified long-term sustainability as a core issue with the project, given

that NSF only provides funding for construction and deployment, not maintenance. Seeking funding and reputational benefits, and the concomitant press releases and news articles, demonstrates that short-term political optics clearly played a role in the decision to join these partnerships.

These critiques notwithstanding, both Pittsburgh and Chicago have incorporated long-term thinking into some aspects of the partnership. In Chicago, the utility of the Array of Things was considered prior to deployment, with three specific use cases often cited. The structure of the project, including the privacy protections (both physical and legal) and open data requirement, also indicate that Chicago officials were careful to ensure benefits to the city were integral to the project. However, the problem that Array of Things is solving is one of *data*, not one of political support or change; while the city is able to get its reputational gain, and researchers are able to acquire data, no city policies have yet changed as a result of the Array of Things. Though deployment and data collection are nascent, it is not yet clear that the data will enable policy change.

In Pittsburgh, city officials in the prior administration were clearly unprepared or unable to protect long-term city interests during the initial launch of Traffic21, and current city staff are still dealing with the pitfalls of the rush towards deployment. However, with the current iteration of Metro21, and with the current team of city officials, there has been movement towards a structure that would allow for greater protections for the city and its citizens. City officials have a clearer idea of what CMU projects can get them, and are clamoring for community involvement in future projects.

A clear difference between the two partnerships relates to the technology transfer associated with the projects. While some projects in Pittsburgh have been successfully

commercialized and deployed in other cities, UChicago made explicit mention of the intention to *not* commercialize AoT. Deployment in other cities is still under the auspices of UChicago, in partnership with local university partners (Kusiak Galvin 2019). This choice seems related to the interests of the principal investigators at the respective universities. Interestingly and importantly, both UChicago and CMU faculty and staff made note that the university had to be mindful of the projects undertaken by researchers, given the nonprofit status of the institutions. In Chicago, this was also cited as the reason to not commercialize AoT.

Implications for City-University Smart City Partnerships

These two cases demonstrate some important factors that are generalizable to university involvement in smart city partnerships generally. Addie (2017) posited that working with universities is not necessarily progressive, given that universities still must work within the neoliberal commodification of education. In this way, we can see that smart city partnerships studied here do largely respond to, and seek approval from, funders and funding agencies. While cities may try to ensure benefits and goals align more closely to benefits that are good for the city (if not the citizen), the lack of city control over funding seems to be a persistent issue for city-university smart city partnerships.

These partnerships' successes and failures may also be peculiar to local histories and relationships, following the findings of Curry (2016, 2015). Long term success requires trust, structures, and knowledge that take significant time to develop. Universities may provide longevity in supporting a partnership, as many have faculty members and staff who outlast political leadership. However, universities can only offer appropriate services if their current incentives, structures, and areas of expertise align with the needs of their host city. There must also be a culture within the city that is disposed to working with outside partners such as a university in solving

problems. If city officials and staff have negative perceptions of the local higher education community, or have had negative experiences, those are significant barriers that must be overcome.

Local philanthropy directing smart city projects, due to a desire to enact change within city government, reflects a longstanding perception about the ineffectiveness of local government and the need to reform, stretching back to the early 20th century (Goldsmith and Kleiman 2017). While a belief that local government can be improved through new management techniques, access to novel data, and interaction with the non-profit sector is not necessarily negative, precautions must be taken to ensure that private interests cannot co-opt government activities through private funding. The decision to chase philanthropic dollars, in order to pursue technological solutions to problems that may ultimately be systematic and structural in nature, amounts to "tech goggles" in the words of Green (2019).

Szanton (1981, 72) categorized three types of projects for which outsiders may be brought on to help city officials: problem identifying, solution identifying, and implementation. Nearly 40 years later, it appears that university help on smart city problems are still primarily limited to problem and solution identification. Few projects among the many mentioned attempted to help city officials actually *change* policy. However, city officials do seem more adept at using university research to advocate for policy changes, though the impact of many of these projects are still unrealized.

One major change from the projects of the 1960s and 1970s is the extent to which technology adoption now represents policy implementation, even if that goes unstated. The decision to install traffic lights that optimize for automotive traffic flow *is* a policy decision; it could, instead, optimize for pedestrian or bicycle flow. Smart cities are assumed to be inevitable, and thus the underlying assumptions — about installing sensors in the public way, or optimizing

of certain mechanized functions — go unquestioned. The assumed inevitability thus leaves the fact that technological adoption is a policy decision. It prioritizes product acquisition, and the outputs, over funding or focus on other areas.

University-smart city projects, as currently conceived, have the added danger of hiding behind the veil of academic magnanimity and integrity. It is assumed that universities are better actors than companies who are acting within the smart city space, and thus they are a safe choice with whom to work. Malintent is clearly absent from any city actors presented in this thesis, and universities do have broader motives than profit-seeking associated with private companies. Nonetheless, the primary goals of universities are related to research and teaching. Though public universities may have a public mission, and though individual researchers associated with a given project may have broader goals as well, precautions should still be taken by cities engaging with universities on smart city research. Not only were conflicts presented between university goals and city goals, the deeper question of the goals of the citizen may be even farther astray.

This is not to say that universities do not, or cannot, play a positive role in advancing the good of the citizens through the use of smart city technologies. Faculty and students across any given university are deeply engaged in research and practice regarding improved social outcomes, democratic practice, community engagement, and other fields of research that, if combined with the current interest in smart cities, could transform local government and improve the lives of those living in our cities. What is necessary, therefore, is to better engage those members of the academic community when pursuing smart city partnerships. Among city partners, there is a clear interest to engage those parts of the academic community. In many ways, the research goals of the social scientists may align better with the goals of the citizens and the government officials than the research goals of the natural scientists and engineers, insofar as research outcomes of interest to

the social scientists are more clearly related to changed policies and outcomes among government officials.

Conclusion

MetroLab Network

Given the excitement surrounding and prominence of the MetroLab Network announcement at the White House in September, 2015, this thesis was meant, in part, to see how well the MetroLab Network did in accomplishing its goals. MetroLab was meant to achieve three things: establish and structure city-university partnerships, create a national network of practitioners, and transfer knowledge and successes among partners.

Given that I looked closely at only two cases, I am unable to evaluate MetroLab in terms of its first goal. CMU's Metro21 and MetroLab are deeply intertwined, and thus studying the relationship between the two organizations likely does not have transferable knowledge to other cases. In the case of Chicago, the relationship between UrbanCCD and Chicago also pre-existed MetroLab. While MetroLab introduced additional formal structure onto the partnership — by requiring the Memorandum of Understanding —, the MOU appears to have provided little value to the partners. Chicago appended MetroLab onto an existing partnership with UrbanCCD, missing an opportunity to broaden the partnership between UChicago and the city on smart city projects. Had I included other cases, I might have been able to say more about the efficacy of MetroLab with regard to its first goal. Comparing MetroLab to the Urban Observatories program, the *Urban Affairs Quarterly* issue on Urban Observatories was released in 1972, approximately three years after the launch of the program. As MetroLab progresses through its fourth year, it may consider evaluating its impact and the effectiveness of its structure against its goals. Both MetroLab Network Executive Director Ben Levine and Mansueto Institute Executive Director Anne Dodge mentioned the movement towards a new fee-based structure for MetroLab in the coming year, with a $10,000 per year free for university members. An evaluation of the program may help justify

such an expenditure to its current and potential members. This fee-based structure will coincide with the members recommitting to MetroLab, setting up the opportunity for MetroLab to encourage and incentivize structural changes to address some of the challenges I identified in this thesis. Suggestions for how MetroLab might be more helpful can be found later in this chapter.

The second goal of MetroLab, creating a practitioner network, has clearly been achieved. While MetroLab may have been formed at a fortuitous moment in history, it is clear that there now exists a community of city officials and university researchers engaged in research partnerships, and they are well connected to MetroLab. The annual MetroLab Network conference was highlighted by many interviewees as allowing them to meet with researchers and practitioners in both their home community and in other cities. Given the seemingly high turnover among city officials leading smart city projects in major US cities, having a network of practitioners in place seems to have benefited both academic and public partners.

With regard to the third goal, knowledge transfer, it may be too early to evaluate MetroLab's success. Even with a project like the Array of Things that pre-dates MetroLab, it is too soon to evaluate the results. It bears mentioning that MetroLab is currently working with the National Science Foundation to develop a Challenge Prize for NSF recipients, in the spirit of finding national-level implications.[29] MetroLab's "Innovation of the Month" also seeks to showcase projects among its members, again with an eye towards knowledge transfer.[30] This seems to be the holy grail of urban science research, dating back to the 1950s and 1960s: finding technological understanding and solutions from experimentation in cities that can be adopted by other cities nationally. While there may be findings that are nationally applicable (for example,

[29] NSF Award Number 1833054.
[30] https://metrolabnetwork.org/projects/innovation-of-the-month/

fire prediction), it is less obvious if there are policy solutions that can be generalized nationally. If smart city technologies are meant to change city operations — not merely represent technological improvements that can be implemented through procurement — then policy and politics will surely remain a central (and, thus, the story in each city will be different).

Limitations and Barriers

Drawing from only two case studies presents challenges for the generalizability of my findings to other MetroLab partners. Chicago, as the third-largest city in the US, is in a unique position, as compared to many other MetroLab partners. Pittsburgh is a much smaller city, but it has a strong regional higher-education ecosystem and has a longstanding history of engaging with regional anchor institutions. Pittsburgh also has a particularly active and wealthy local philanthropic community. UChicago, without a school of engineering or a department of urban studies and planning, is also an unusual partner for MetroLab. Additionally, both CMU and UChicago are elite private universities, whereas MetroLab's membership overall is composed of schools with great variety in research activity and focus, including a mix of public and private universities, and national and regional universities.

The barriers to making these partnerships successful, as identified by the partners, are many of the same barriers to successful partnerships identified in the 1960s and 1970s, as enumerated by Szanton (1981) and others. The academic culture and calendar persist in making faculty members challenging partners. Cities remain cash-strapped, and will respond to funders even if their problems are not directly solved by such programs. Both universities and cities are siloed institutions, where departments may not communicate and work together, even if synergies offered important opportunities.

These barriers may have presented themselves differently had other cases been selected. For example, at the Georgia Institute of Technology, a public university, interviewees stated that serving the state and city was a clear part of their academic mission, something that is missing at CMU and UChicago. Some MetroLab partners are actually regional consortia, such as the Texas Research Alliance or the Boston Area Research Initiative. Some cities, such as Boston and Oakland have more robust technology teams within City Hall, giving them a sophistication that other cities lack. In spite of these limitations, I offer some possible ways of overcoming these barriers, as some of the traits of these partners exist in many cities and universities.

Recommendations

These recommendations are aimed towards cities and universities that are creating, or re-envisioning their partnerships. The context of these recommendations sits within the MetroLab Network, meaning that there are at least three institutional actors in a city-university partnership, including MetroLab. The recommendations presented here sometimes relate to the university, sometimes to the city, and sometimes to MetroLab. Regardless, it is in the best interest of both partners to insist that the other partner has the structures in place that are outlined below. Doing so will result in improved outcomes. Table 2 summarizes my recommendations and action steps.

Table 2 Recommendations for Smart City-University Partnerships

Basis for Recommendation	Recommendation	Entity	Immediate Actions
Avoid the Pitfalls	Formalize Desires, Data, and Deliverables	-City -University -MetroLab	• Reformulate MOU to require statements regarding data ownership and project charters • Project charter should address deliverables
	Work with funders to address city interests	-City -MetroLab	• Negotiate with local funders to address philanthropic and city interests • Work with federal funders to give more flexibility in projects • Provide technical assistance to protect cities as they accept grant funding
	Mitigate Effects of Service Delivery Experiments	-City -University	• Defer to civil service employees and city planners • Ensure transparency and clear communication to citizens about project impact • Distribute harms and benefits of projects throughout the city
Adopt the Good	Distribute Expertise Throughout City Government	-City -MetroLab	• Keep primary point of contact, but expand allies and users throughout city departments • Provide professional development opportunities to long-time staff
	Find Ways to Engage Across the University	-University	• Create university-wide advisory board for smart city partnerships • Establish sustainable funding that exists outside of specific departments or schools • Provide seed funding that encourages interdisciplinary teams and proposals from non-traditional departments
Create What's Missing	Build True Citizen Engagement	-City -University	• Allow citizens to suggest projects to the city and university • Establish citizen advisory board • Use Participatory Action Research when designing projects
	Use City Power to Monetize "Free" Use of Infrastructure	-City	• Develop revenue-sharing or fee-sharing agreements for projects that plan to commercialize

Avoid the Pitfalls

Recommendation #1: Formalize Desires, Data, and Deliverables

This should go without saying, but no partnership is set up for long term success unless formal agreements (i.e. documents) have been signed that will protect all parties involved. It is okay if city officials and university researchers have different desires — they work for different institutions and have different responsibilities. However, if formal, stated goals cannot be agreed upon by both parties, then at least one party will surely be disappointed later.

Data are the crux of most smart cities projects. Almost every project is either aiming to create data, integrate data, or use data in some innovative way. Without clear guidelines regarding data ownership, sharing, and privacy, partners set themselves up for, at minimum, frustration. The worst outcome is the commodification of citizen's data with no commensurate public benefit. Before engaging, both partners should ask: what problem are we trying to solve? In order to solve that problem, what do we need to know? Is the project under consideration going to get us the information we need to solve the problem? Referring again to desires, it is okay if university researchers and city officials prioritize different data, and want to solve different problems — so long as they both end up with the data they need, and are able to solve the problem they want to solve.

Though it is up to the partners to decide how they want to structure data ownership and data sharing, the current best-practice emphasizes open data. Depending on the type of data that are being collected, open data may raise privacy concerns. Even if the data are not *open*, city officials should insist on clear policies that ensure their perpetual access to any data collected in a public way; otherwise, citizens will be left vulnerable.

While there seems to be an assumption that academics are difficult to work with, unresponsive, and generally poor partners, adopting such a perspective when designing a partnership is a sure road to frustration. Partnerships depend on deadlines being met and products being delivered. City officials in Chicago and Pittsburgh expressed excitement about working on experimental and novel technologies. If the university partner over promises or under delivers, there will be disappointment that will affect future partnership opportunities.

MetroLab will soon require partners to recommit to the network, and to pay a $10,000 annual fee for the first time. As this happens, MetroLab should insist that updated MOUs include a paragraph outlining how project charters for each new project will be formulated. Such charters should be clear about deliverables. Additionally, MOUs should include statements regarding data ownership, data privacy, and data sharing.

Recommendation #2: Work With Funders to Address City Interests

For decades, philanthropic organizations and federal agencies have assumed that they know best. Cash-strapped city officials are offered money, but only if they change their practices to follow what the funders have in mind. This sometimes results in wasted city staff time, when staff either try to shoehorn what they would rather be doing into the funding they have received, or do what they know they would rather not do, in order to keep the flow of cash running. Such a situation is unlikely to produce sustainability: funders walk away if they do not see the results they were hoping for, while cities will refuse to support and absorb projects that do not achieve the desired results.

When working with local philanthropies, cities may be able to negotiate grants and gifts that address their interests in explicit ways. They may choose to accept funding to pilot and try funders' ideas, while also asking for an equal amount of funding to implement their own preferred

solutions. “Growing the pie” in this manner allows philanthropies and cities to both feel like they are getting what they want out of a funding agreement.

Ideally, smart city partnerships should be developed with flexible funding, the goal of which is local innovation, rather than national technological development. This would allow cities to work with local partners without directly responding to philanthropic or federal priorities. National philanthropies, and the federal government, may not be able to be so flexible, however. This funding solution may mirror what used to be called a Community Action Program, rather than operating through federal science agencies.[31] Nonetheless, NSF is working with MetroLab on a challenge prize for Smart and Connected Communities,[32] which may present itself as an opportunity for some flexibility as MetroLab partners respond to the call for proposals.

This offers another opportunity for MetroLab to play a leadership role. By convening its partner cities, MetroLab could work with national philanthropies to develop a novel funding program, with fewer strings attached. Additionally, MetroLab could provide technical assistance to localities as they negotiate with funders and universities, to make sure cities are protected against wasted staff time, or losing out on compensation they should be receiving. Best practices should be developed with regard to what cities should expect from funders and partners.

Recommendation #3: Mitigate Effects of Service Delivery Experiments

In a laboratory, one runs experiments. Sometimes experiments achieve the outcomes expected while other times, things go terribly wrong. At all times, researchers monitor the lab, measuring results and taking note of any irregularities. In a city, citizens have expectations that

[31] For a history of the Community Action Program, see DeFilippis (2004)

[32] NSF Award Number 1833054.

local government will deliver services and work for them. Experimenting with those services runs the risk of causing harm to city-dwellers, even if those harms are unintentional on the part of city officials or researchers. City residents also assume that they are free to go about the city with a reasonable expectation of privacy and autonomy. The city-as-a-lab mentality offers an opportunity to disrupt services, and can view inhabitants as nothing more than units against which to measure outcomes. This potential disruption of services produces risk for service users, and for the city and university.

There are three concrete actions that city and university partners can take to mitigate this risk. First, partners should defer to civil service employees when implementing technological solutions. City planners, traffic engineers, social workers, and others, should be included in project teams. If something seems high-risk to those city employees, engineers, and case workers who have experience working with the delivery of an affected service, partners on both sides should take heed. Second, transparency and information sharing are key. Citizens should know when to expect service disruption, and who to call if something goes wrong. It is important to not merely communicate this information through technological means, as not everyone on the receiving end of a technology experiment will be technologically savvy. While this may greatly increase the cost of a project, implementing Recommendation 2 should help address this concern. Third, smart cities projects should be distributed throughout the city, so that neither the benefits nor any adverse impact accrue only to certain populations. Again, this may increase the cost associated with a project, as pilot locations that are impacted may not be the most convenient. Developing a set of guiding principles and working with funders to meet the costs associated with such principles is surely worth the increased cost.

Adopt the Good

Recommendation #4: Distribute Expertise Throughout City Government

Political support and leadership are key components of city-university partnerships as currently designed. While having a single designated point of contact in the Mayor's Office or the Information Technologies office will make generating and maintaining political support easier, it is not ideal. When an entire city government's innovation ecosystem is housed within one office, it can easily disappear during a mayoral transition. Having a point of contact is necessary, but distributed expertise and commitment are equally important to making partnerships work.

When expertise and know-how about novel technologies and data science are distributed throughout the city, a broader range of problems can be identified, solutions are more likely to be implemented, and more allies will exist to advocate for the continuation of a partnership when a new administration takes power. The Pittsburgh model, which has staff with smart city expertise in IT, Transportation, and City Planning, allows for multiple types of smart city projects to take shape.

City officials should curate professional development opportunities among staff who work across departments that are interested in, or could benefit from, smart city technologies. MetroLab may be able to work with national philanthropies to develop curricula to promote professional development for city staff. By creating a network of city staff who are aware of smart city technologies, Director-level officials will be able to coordinate research, consolidate projects when necessary, and better coordinate with university researchers. Until such expertise is incorporated across the city, we are more likely to see smart cities efforts as one-off projects that primarily revolve around procurement and incremental improvement, rather than as drivers of city-wide transformation. Once expertise is distributed throughout city government, newly created experts

and allies can advocate for the continuation of the partnership after a mayoral transition has taken place.

Recommendation #5: Find Ways to Engage Across the University

University smart city partnerships are beginning to utilize expertise in the social sciences, adding a critical perspective on possible technology-focused solutions that is not likely to emerge from engineering or data science experts. CMU's model, requesting proposals from across the university, is a good idea. University partnerships should continue to build on this idea by not only opening up opportunities to faculty in non-engineering or non-information science fields, but by actively seeking them out.

In order to operationalize this recommendation, universities may need to provide financial support for administrative staff and center directors who would otherwise need to rely entirely on grant funding or departmental support to cover salaries and expenses. This may require annual funding from the university, an endowment from a philanthropic source, or annual funding from local government. Providing core funding in this way may frustrate administrators (who are hoping that city-university partnerships will make, not cost, money), but an advisory board including faculty, staff, and senior administrators can ensure that university resources are well spent. A new center can provide seed funding to encourage research projects across the campus, and actively encourage interdisciplinary teams and proposals from non-traditional departments.

Create What's Missing

Recommendation #6: Build True Citizen Engagement

Today, citizen engagement for smart cities means involvement in projects that have been pre-approved by university researchers and city government, and thus are likely to be adopted.

Citizens are *only asked to get involved after* such projects have been selected. At that point, they are informed about projects and *may* be given a chance to comment on the goals of a project. Though some projects are primarily inward-facing (meaning that they will not have a direct impact on citizens), many projects will impact city dwellers' daily lives. Predictive policing, traffic management, and environmental sensors all inform government decisions that affect city inhabitants, yet citizens are not really partners in designing such projects. Under the current model, citizens can only have an effect on project design and implementation within the confines of what researchers and city officials have already scoped. What has yet to be incorporated into city-university partnerships is citizen participation in the identification and initial development of projects.

There are three steps that could be taken to implement this recommendation. First, citizens should be empowered to propose smart city projects to city-university partnerships. Partnership directors and staff could hold office hours and take part in community meetings to inform residents about what smart cities *means*, and ask for their feedback and ideas. Technology-enhanced methods of public participation are already available to encourage feedback and citizen input.

Second, cities should put together citizen advisory boards to be involved in their smart city partnerships. Citizens, appointed by the mayor or city council, would be able to propose projects and rate the priority given to various projects proposed by the city and the university. When creating such an advisory board, the city should ensure geographic, demographic, and other kinds of diversity. Special focus should be given to the users of city services, and those from marginalized communities who are most dependent on those services.

Third, true citizen engagement also means training researchers and city officials on community engagement techniques that allow for co-identification of problems that need to be

addressed, as well as the techniques to solve them. Participatory Action Research may be a useful framework here (see, for a primer, Greenwood and Levin 2007). Recent studies that used participatory action research to build community wireless networks demonstrates its value in this context (Mehta 2017).

Recommendation #7: Use City Power to Monetize "Free" Use of Infrastructure

If university partners plan to commercialize the products they produce, there is no reason the city should miss out on a share of the revenue they helped to generate. From the use of city technicians, city electricity, or the use of public rights of way, these and other in-kind contributions should be tallied to be certain that subsequent commercialization takes account of the city's contributions.

Cities need to develop policies regarding the way public infrastructure is used in experimentation. In Chicago's case, the sale of the Array of Things data was explicitly prohibited by the partnership contract, while UChicago chose not to commercialize the nodes that were created. In Pittsburgh, multiple commercialized smart city projects were initiated, yet the city operates them parallel to, rather than integrated with, the city's economic development initiatives. If citizens are subsidizing technology development by subleasing public rights of way, they should see returns on that subsidy in the form of long-term revenue streams from licensing.

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