Signs of the Smart City: Exploring the Limits and Opportunities of Transparency

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ABSTRACT

This paper reports on a research through design (RtD) inquiry into public perceptions of transparency of Internet of Things (IoT) sensors increasingly deployed within urban neighborhoods as part of smart city programs. In particular, we report on the results of three participatory design workshops during which 40 New York City residents used physical signage as a medium for materializing transparency concerns about several sensors. We found that people's concerns went beyond making sensors more transparent but instead sought to reveal the technology's interconnected social, political, and economic processes. Building from these findings, we highlight the opportunities to move from treating transparency as an object to treating it as an ongoing activity. We argue that this move opens opportunities for designers and policy-makers to provide meaningful and actionable transparency of smart cities.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in interaction design**.

KEYWORDS

Transparency, Smart Cities, Internet of Things, Design

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1 INTRODUCTION

Cities around the world continue to expand the integration of Internet of Things (IoT) senors within urban spaces [34, 84, 92]. These sensors ubiquitously collect data to perform a range of tasks: quantifying noise pollution levels [28], monitoring temperature [82] and air quality[86], counting foot-traffic [89], or automatically detecting gunshots [68], are just a few. Collections of IoT sensors make up a *smart city*: techno-political initiatives that amass large quantities of data about the environment, infrastructure, and people living in urban environments. Smart cities strive to use data to improve decision-making, automate public services, and enhance the overall efficiency of governance.

One recurrent issue with smart cities is determining how to leverage the benefits of data-driven governance without encroaching on individual rights and public privacy [87, 88]. Indeed, the power smart cities afford to the state (and private entities) to monitor and regulate public life is inherently in tension with individual rights and public privacy [35, 81, 91].What are the rights of people living in public housing facilities embedded with bio-metrics sensors that allow authorities to monitor and control how and who can access buildings [57, 72]? What is privacy in a city blanketed with facial recognition sensors that allow law enforcement to track and target people on streets [61, 92]? The answers to these questions are part of the ongoing discourse between cities, technologists, and academics on the ethical and political ramifications of the smart city [34, 50, 55].

The concept of transparency is gaining attention in response to the ethical and political dilemmas of the smart city [4, 71]. Indeed, transparency (or lack thereof) was at the center of the recent criticism and backlash faced by both the Quayside smart neighborhood project in Toronto [45, 67, 73] and the Smart StreetLights project in San Diego [4, 92]. These projects show how inadequate transparency–of development plans, data collection practices, or sensor placement–can exacerbate the tensions smart cities present for individual rights and public privacy. That being said, it remains unclear how designers and policy makers should understand transparency and respond to the concerns of residents and other stakeholders in the context of the smart city.

New York City Office of Technology and Innovation (OTI) is currently exploring the above questions in their efforts to understand the role public transparency should play in the city's growing sensor deployments. They approached us with a proposal to understand how physical, local signage could provide transparency of IoT sensors to people as they encounter the technology in everyday life. We used this proposal as the focal point of participatory design workshops hosted in collaboration with the OTI. In these workshops, city residents learned about IoT and the city's current plans for this technology and then completed a series of activities using physical signage as a medium for materializing their transparency concerns about several IoT sensors. 40 residents participated across three iterations of the workshop where they worked together in small groups designing mock signage to express what they felt should be made transparent about the sensors, why that transparency was important, and what they hoped that transparency would accomplish. We analyzed their "Signs of the Smart City" to develop an understanding of the limits and opportunities for transparency in the smart city.

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We found participants expressed a plurality of concerns for transparency some which have either nothing (or very little) to do with the technology itself. Indeed, rather than focusing solely on making the technology itself more transparent (by revealing the inner workings of the sensors) participants were concerned with transparency of *public participation, civil rights, contact and responsibility, economics, community value,* and *dissent*. We argue that these concerns people desired to reveal may open a new paradigm for HCI designers and city officials to explore, with regard to how to provide meaningful and actionable public transparency of smart cities. This would move beyond the tendency to frame transparency as a static object wherein the work of revealing is accomplished in singular, isolated, information processing tasks, to include frames of transparency as an activity wherein the work of revealing is accomplished in dynamic social interactions with policies, practices, sensors, people, and relationships. Using experiences related to participatory budgeting as a somewhat analogous example, we then unpick some of the key challenges and opportunities associated with this approach.

2 RESEARCH CONTEXT

This paper reports on a project initiated by the Director of Smart Cities + IoT Lab in New York City Office of Technology and Innovation (OTI). The city has been a leading proponent of open data and urban Internet of Things (IoT) initiatives, which has resulted in a significant expansion of networked devices being installed across city neighborhoods in the last decade; and subsequently impacted transportation, utility services, resiliency, health, safety, and quality of life, among other areas [48]. To date, IoT devices have typically been deployed by individual city agencies seeking out specific opportunities to improve operations or introduce new services. However, this patchwork approach may present a number of future challenges for governance, and so an IoT strategy has been initiated to coordinate and standardize use across government by the OTI [2]. The strategy introduces principles to guide design and implementation, and identifies challenges and opportunities for the city's use of IoT moving forward. Of particular relevance here is the identification of the need to implement IoT initiatives with transparency foregrounded. Specifically, the city's IoT strategy proposes that: *"there must be transparency and engagement with those affected by IoT use to ensure buy-in and trust"* [2]. The OTI approached the first author with an idea to explore how physical, local signage could provide transparency of IoT sensors to people as they encounter the technology in everyday life. The first author took this initial proposal from the city and formulated a participatory design approach using signage as the medium for city residents to explore and articulate their perspectives of transparency in the smart city.

2.0.1 Reflexivity statement. The research team behind this work is composed of the following. The first author had a previous relationship with the city during his time as a postdoc in a local university. Part way through formulating the project, he began working as a research scientist at his current company. This paper has been reviewed by the first author's company; however, the views here do not reflect the motivations of the company nor does the company have direct stakes in the work here. The company has a general interest in understanding public transparency and developing methodology for understanding end-user needs (like the workshops we designed) which could be applied to other products and services.

The first author worked closely with two officials from the OTI who helped craft the initial IoT strategy and were in charge of exploring public participation and transparency initiatives. The second author is faculty at a local university with expertise in smart cities and design research who came onto the project later to advise and help writing. While we all came from different institutions and personal perspectives, as a whole, we were aligned in a desire to make IoT technologies equitable and responsible. We were motivated to close the gap in understanding public perceptions and needs for transparency by taking a participatory approach grounded in the lived experiences of city residents. We were especially interested in engaging members of the public who have been historically marginalized and underrepresented in both technology development and public policy on urban IoT.

3 RELATED WORK

3.1 Smart Cities

The use of Internet of Things (IoT) sensing devices in urban contexts, e.g. for environmental monitoring, is a key aspect of so called *smart cities* initiatives, where discussion is typically focused around ubiquitous computing and the fine-grained or big-data analyses they facilitate, e.g. [11]. Following an approach to knowledge generation that is often inspired by Anderson's arguments about how big data puts an end to theory [8], this can result in large-scale monitoring of urban problems that are selected and framed by quantitative metrics facilitated by the existence of digital sensing devices. This perspective conceptualizes the city as a computer, a view which has received criticism from authors such as Shannon Mattern[66]. Drawing on Agrawal's notion of 'environmentality' [5], Gabrys further argues that this also recasts who or what counts as a 'citizen', which citizenship is articulated environmentally through the ways that monitoring and urban data practices are configured [42]. Hollands [52] describes the dominant smart city model (see e.g. [25]) as corporate and techno-solutionist, and argues that these commonly shared but idealized representations of this smart city model, which foreground 'efficiency' and 'safety', often pose more questions than they answer. For example, what type of relationship do people in the sensorized smart city have with their neighbours, community, and government? And do they live in a fair or equitable city? Similar questions, of particular interest for the research we present here, emerge from the visibility (or otherwise) of sensing technologies. These include, what role might sensing and monitoring technologies play (or be perceived to play) in surveillance? (see e.g. [38, 90]) and what might this imply for the residents' equity and inclusion? For example, in the US a line connects historical racism and surveillance technology, from slavery through to CCTV and predictive policing, see e.g. [18, 41, 63, 77]; while low-income communities experience the impacts of surveillance first and strongest [35, 49]. Scholars of surveillance studies highlight the role that smart city sensing technologies might play in optimizing and incentivising rather than prohibiting, and in nudging and cajoling towards regulated behaviors, see e.g. [43, 74]. Critical responses to

such relationships between sensors and people in quantified communities include calls for increasing seamfulness at their interfaces [30].

An alternative vision of what might make a city 'smart' is focused around small-scale and participatory initiatives, which respect local differences and highlight an holistic view of community members' wellbeing, e.g. [52, 59], and incorporates notions of playfulness and experimentation [46]. In these version, 'who makes the city' is a key matter of concern [19], with institutions providing platforms or infrastructures and the participation of different publics foregrounded. Models for enabling a more devolved and diverse smart city, e.g. 'DataCare' [39], highlight transparency in sensing and data practices as a key aim. IoT manifestos have also been put forward as further evidence that practitioners consider the role networked sensors play in creating possible futures 'a matter of care' as well as a matter of concern [40]. However, such practices often make demands on residents' time for civic participation, and longitudinal participatory design and planning, which can be challenging at urban scales [44], constrained by institutional frames [62], and requires 'persistent input' [47]. Moreover civic participation in general, and inclusion in smart cities programs in particular, likely reflects and exists within established geometries of power [84].

3.2 Transparency in the Smart City

The concerns at the center of recent smart cities controversies in San Diego, California [45, 67, 73] and Toronto, Canada [4, 92] illustrate the limits and opportunities for transparency. In 2016, The City of San Diego began a initiative to transform 3,200 streetlights into energy-saving, smart devices. These "Smart StreetLights" were equipped with sensors packages reconfigurable by design to serve a wide range of context and needs; which is partly why, when the initiative began, the specific users and use cases were left open. This lack of clarity for determining which city entities could access the sensors enabled the city's police department to covertly utilize the streetlights in various law enforcement efforts. These actions were widely condemned by the public and subsequently led to the formation of a coalition that forced the city to deactivate the audio and video recording functionality until oversight, and community engagement measures were in place [36]. In 2017, the city of Toronto commissioned the development of the "Quayside" smart neighborhood located on underused waterfront property. Quayside's extensive sensor network would integrate the physical environment into the digital environment, with the aim of enabling innovations to safety, convenience, and energy efficiency. However, this was met with opposition [21, 69, 76], particularly to how various public data and privacy concerns were addressed. The perception that entanglements of public decision-making processes with private financial motivations were deliberately obfuscated galvanized public opposition [75]; and ultimately, alongside the economic uncertainty caused by COVID-19, led to the project's termination [26].

The practice of transparency can be understood as a set of decisions about what it is important to make visible [22]. In the smart city these decisions require making some part of the assemblage of sensors, data, algorithms, policies, and organizations that make up these urban initiatives visible. Recently, this is being explored through the use of physical signage: the idea being that the information provided the sign could explain the sensors to people as they encounter it on the streets. This is exemplified in the use by a growing number of cities of Digital Trust for Places and Routines (DTPR) [1], a library of graphical icons and QR code portals that can be used to design signs for various urban sensing technologies. Following this model, San Diego might have made visible specific details about who is allowed to used data from the sensors and how. However, the impact of transparency in this form–essentially a physical form of interface level explanation–is questionable e.g. see critiques [12, 33, 64]. More importantly, while increased transparency is commonly associated with positive social values like fairness, accountability or trust; critical transparency scholars caution against such associations [14], by reminding that every act of transparency is also an implicit act of obscuring [6]. In fact transparency can often be performative [79], ineffective for the task at hand [7], or result in unintended consequences [56]. The varying levels of visibility enabled by transparency choices constrain how underlying phenomena are judged and governed [51]. This helps explain why the entanglements of politics, technologies, and finances evident in the Toronto project, and often inherent to the idea of the smart city, are not easily made visible.

In this paper we begin to unpick these challenges to transparency practices, and make initial steps towards highlighting an alternative approach based on an ongoing process of negotiating transparency as something that upholds over time and varies between stakeholders.

4 METHOD

This paper reports on a research through design (RtD) [93, 94] inquiry into public transparency of IoT in urban neighborhoods. In particular, we report on a series of participatory design workshops in which residents of different neighborhoods were invited to explore their own interpretations of the limits and opportunities of transparency with regard to the deployment of IoT in the places they live and work, through the metaphor of *'signs'*. Our workshop methods draw on prior examples of participatory design approaches applied to IoT and smart city contexts, e.g. [9, 57]. Informed consent was given by each participant at the start of each workshop, following a shared reading of consent forms and an opportunity for questions to be answered.

4.1 Participatory Design Workshops

We held a total of 3 workshops, each lasting roughly 2 hours, at 3 different public libraries branch locations. Each workshop followed a similar 4-step protocol, through which participants worked in small groups designing a *'sign'* to reflect their concerns about transparency of urban IoT. Participants were provided with refreshments, and compensated with electronic gift cards valued at 100 USD. We collected ethnographic observations, photographic data, audio recordings of conversations from each group, and their completed signs.

4.1.1 Recruitment. Recruitment for the workshops was done in cooperation with the libraries, making use of existing communication and marketing channels. Beyond the constraint that the workshops were to be conducted in English and that participants should be

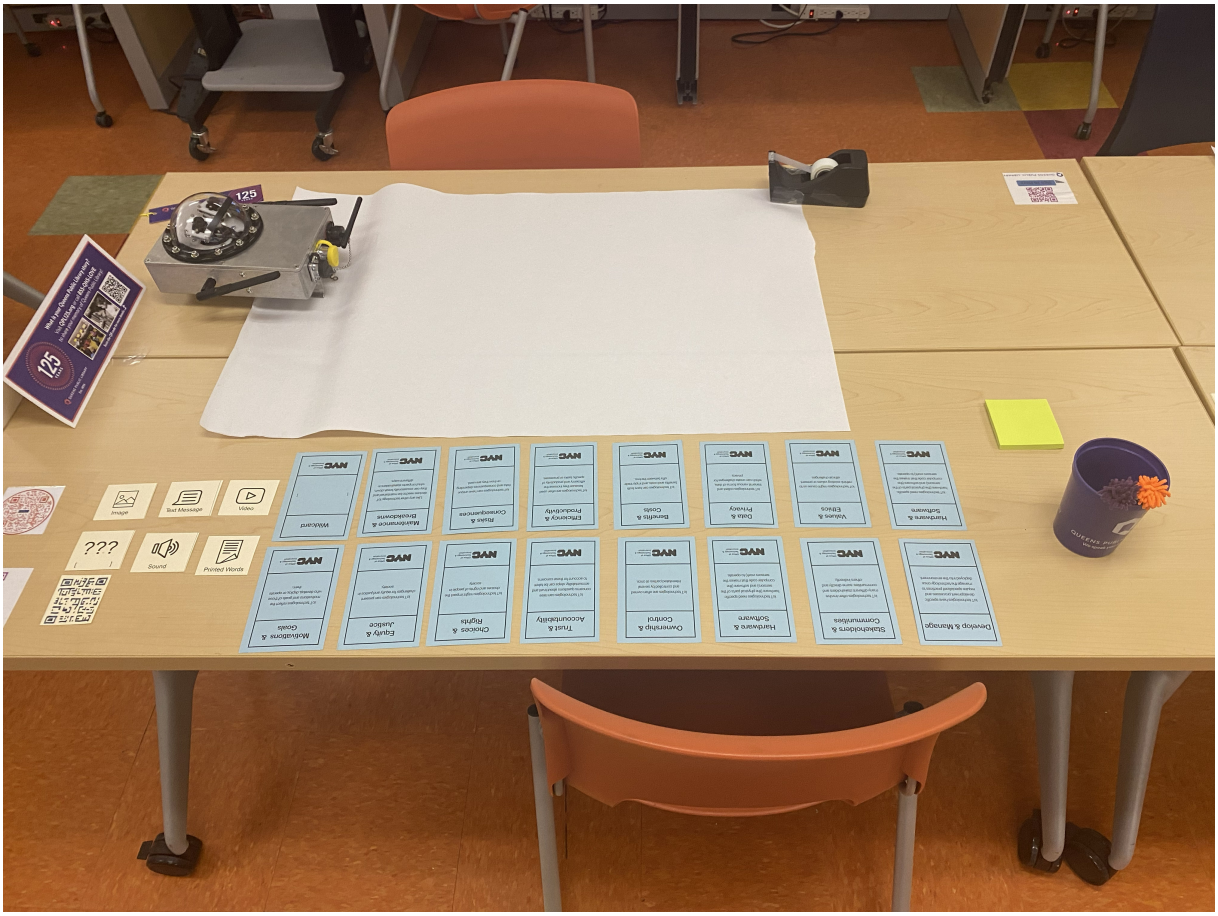

Figure 1: Activity Setup. The 'sign' worksheet is the large white flip-chart paper. The gray box with antennas sitting on the top right corner of the sign is the sensor. Directly below the sign, the blue cards are the prompts. To the right of the prompts, the yellow stack of post-in notes were used for the questions. To the left of the prompts, the tan cards are the media formats. We collected audio from each of these stations to document the design process of each sign

over 18, there were no specific criteria for inclusion or exclusion. Participation was anonymous, with the exception of first names for conversation and email addresses for compensation payments, and so we did not collect or ask for any demographic details. A total of 40 residents participated across three iterations of the workshop.

4.1.2 Protocol overview. Each workshop began with an introductory overview from the research staff and city officials to explain the purpose, aims, and background to the event. This was followed by round-table introductions. City officials then made a short presentation to introduce the topic of IoT sensing, and the city's strategy and objectives for IoT deployments, and to introduce the example IoT sensors that were used as inputs to the workshop. This was followed by a brief question and answer session about the presentation, and a round-table of thoughts and feelings about the IoT sensors showcased during the presentation. These activities typically took about 30-40 minutes of the workshops two hour duration. Participants worked in groups of 3-4 people to complete the remainder of the workshop, which consisted of 4 steps: (1) selecting prompts to identify the broad topics the group would address; (2) generating questions based on those topics; (3) detailing the layout and media format of the 'sign' that would be their workshop product; and (4) sharing out about their design process and discussions, and the intended impact of the 'sign' they created. Each group was randomly assigned 1 of the IoT sensors showcased.

4.1.3 IoT Sensors. The workshop featured four different sensors (see figure 2) currently deployed in New York City. We selected these four as exemplars to give participants an idea for the range of hardware, data, and use cases IoT can be applied (see appendix A.1). Each of the sensors were explained during the City officials opening presentation for the workshop described above. Following the presentation, we created small groups of three-four participants and assigned them to one of the sensors spread across the room in four stations. Participants then had the opportunity to physically engage/interact with the sensor and ask questions. Next to each sensor was a set of materials (see figure 1) the group would use to design signage for their sensor.

Figure 2: The Fours Sensors. From left to right: (A) computer vision sensor; (B) home-based noise sensor; (C) industrial noise sensor; (D) temperature and humidity sensor. See appendix A.1 for more details.

4.1.4 Selecting Prompts. We created a set of 10 design prompts to help in getting participants started with their exploration of urban IoT transparency. These were based on the following criteria. First, we wanted the prompts to reflect the interconnected social and technical dimensions of IoT technologies. Second, we wanted the prompts to invite a spectrum of potential interests that represent current and emergent issues, and engage pragmatic and philosophical concerns. Finally, we wanted the prompts to invite participants to contest received wisdom, to challenge, to push back, and to imagine differently. Our process for creating the prompts was 2-step. First, we used these criteria to generate an initial set of 24 prompts based on smart city and urban IoT literature and technical reports (see Appendix 2). To reach agreement, we iteratively discussed and voted on which best reflected the topics we felt were most relevant, relatable, and appropriate for the goals of the workshop; resulting in the final 10 prompts (see Table 1).

We asked each workshop group to select the 4 prompts that spoke to them most strongly, with regard to the IoT sensor assigned. For example, if participants were drawn to the prompt "Choices + Rights", they would select this prompt together with 3 others. The debate and negotiation amongst participants as they decided on the prompts was a key source of data captured with audio recorders placed at each table. After deciding on 4 prompts, the selected prompt cards were pinned to the group's 'sign' worksheet, and become the foundation for the design work that followed.

4.1.5 Generating Questions. Having selected 4 prompts, we then asked each group to generate a set of questions in response. This was to help participants negotiate and articulate the particular concerns they wanted to explore. For example, if the group selected the prompt "Choices + Rights" the type of specific questions they might now generate could include, "How will my rights be protected?", "What recourse do I have if I have concerns?", "Do I have the option to opt in/out?". We asked participants to write down 2-3 questions for each prompt. Questions were written on post-it notes. We then asked participants to agree on 1 question for each prompt, which was then attached to the group's worksheet. Importantly, the goal in this step was not to answer these questions. Rather, this step was intended to create the space and opportunity, through conversation and articulation of concerns, for people to think through what is important to them, and questions would intentionally remain unanswered. These unanswered questions act as expectations towards their government: *this is what we want to know about the IoT you are bringing to our neighborhood.*

4.1.6 Detailing Media and Layout. The 3rd step in making the groups' representative 'signs' was to think about how the answers to their questions might be represented for other members of their community. The purpose of this was to help concretize their concerns in terms of: (1) priority, e.g. determining how much space might be allocated to the answer for each question and where it might be placed (in a top-left to bottom-right flow); and (2) communication, e.g. determining the modality and temporality of the messaging (text, icons, pictures, audio, video, QR codes, etc.). Here, participants considered questions such as, "What might catch a passerby's eye?", "How much time and attention should they need to commit to gain understanding?", and"What types of communication are appropriate in different contexts?". Our intent with this design challenge was to prompt rich discussion, push participants towards creating an artifact that captured their concerns and supported sharing out, and better understand transparency and how it might be communicated in the context of participants' everyday lived experience.

4.1.7 Sharing Out . The final step in the workshop protocol was the share out. Here, each group was given time to explain the design process of the 'sign' they had created to the larger group. This provides space for collective articulation of their concerns, fears, and hopes. To guide the share out we prompted groups with the following questions: (1) Why did you select these themes and ask these questions? (2) Can you explain the design intent behind the media formats and layout? and (3) What thoughts and feelings do you hope your sign will evoke?

5 ANALYSIS

We conducted a deductive thematic analysis [15, 17] of the data collected from the workshop, guided by the review of prior literature that informed our development of workshop prompts, focusing on the question: *"What was this group trying to make transparent through their 'sign' and why?"*, and reflexively considering our own position and perspective (e.g. with reference to our relationship

Table 1: List of themes and prompts presented to workshop participants

Title	Description
Data + Privacy	IoT technologies collect and transmit various forms of data, which can create challenges for privacy.
Benefits + Costs	Developing and using IoT technologies can have both benefits and costs, and present trade-offs between the two.
Choices + Rights	IoT technologies might impact the choices and rights of people in society.
Motivations + Goals	IoT technologies reflect the motivations and goals of those who develop, deploy, or operate them.
Efficiency + Productivity	IoT technologies are often used because they increase the efficiency and productivity of specific tasks.
Trust + Accountability	IoT technologies can raise concerns about trust and accountability; steps can be taken to account for these concerns.
Develop + Manage	IoT technologies have specific development processes and require specialized practices to manage the technology once deployed into the environment.
Equity + Justice	IoT technologies can change how equity and justice is experienced in a community.
Stakeholders + Communities	IoT technologies often involve many different stakeholders and communities: some directly and others indirectly.
Hardware + Software	IoT technologies need specific hardware (the physical parts of the sensors) and software (the computer code that makes the sensors work) to operate

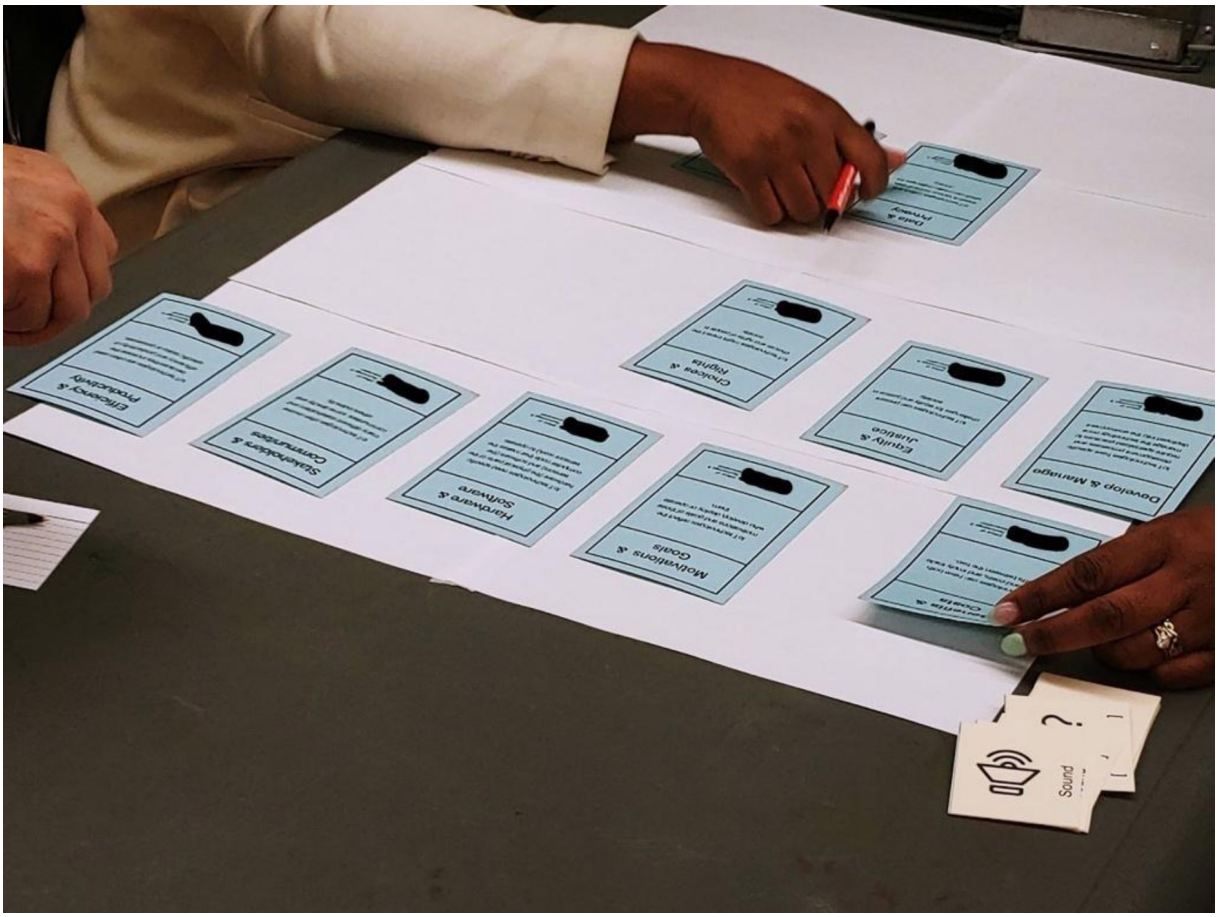

Figure 3: Participants sorting through which prompts to design their signage with

with the city and its representatives). We reviewed the completed 'signs' each group created, transcribed audio recordings of their discussions and share back presentations, ethnographic field notes taken by the first author at each workshop, and photographs showing the progression of the 'signs' throughout the activities. We probed the data to better understand how (and why) participants selected their prompts, how they questioned those prompts, how they sought to communicate their intentions through the layout and media formats of their 'signs', and what they hoped their articulation of concerns through the 'signs' would accomplish. This process enabled us to develop narrative descriptions of each group's work, highlighting salient themes in how the particular group articulated concerns around transparency. Last, we compared and discussed these individual narratives to identity overarching themes that best reflect the concerns of transparency manifested across the workshops.

6 FINDINGS

We organize our findings around six concerns for transparency reflecting the most salient themes from the workshops: *public participation, civil rights, contact and responsibility, economics, community value,* and *dissent*. Each of these is a distinct manifestation of what people thought should be made transparent and why. For instance, transparency of public participation concerns how to make the public participation processes used in a sensor's deployment more transparent to ensure public legitimacy. Likewise, transparency of civil rights concerns how relevant civil rights policies for a sensor can be made transparent to provide community members' sense of security.

The six concerns are not exclusive to specific sensors. For instance, transparency of community value was articulated in response to both the noise and flood sensors. While some concerns were more strongly tied to a specific sensor (e.g., transparency of civil rights for noise pollution sensor), it was not uncommon for concerns to overlap (e.g., *transparency of civil rights and pubic participation for the noise pollution sensor*). However, given that our goal at this stage is exploring how the concept of transparency can applied to IoT broadly, rather than determining the specific means by which an individual sensor might be made transparent, we chose to present the six concerns in their own right, as standalone, generalized perspectives of transparency. To help illustrate how these concerns emerged in the workshop activities, we include quotes (e.g., from share-outs and dialogue with city officials captured by audio recordings) as well as influential moments in a group's design process (e.g, a discussion kicked off by a specific prompt selection: **Stakeholders + Communities**).

6.1 Transparency of Public Participation

The first area of concern we identify is with regard to public participation. In particular, how making the process and outcomes of public participation transparent could be instrumental to facilitating community legitimacy for deployments of urban IoT devices. We illustrate this concern through a group from Workshop #2 who had selected **Stakeholders + Communities** as their starting point. This concern emerges as one participant in the group remarked, *"I'd like a sign that would tell us who did you involve in the process of this sensor being put here… what stakeholders in the community had some input it? I would want to know that they had talked to people ahead of time. Like, "we've involved members of clergy or you know, your community members, blah, blah.…we held open forums… we talked about this, so that's why this thing is here."* This statement illustrates a belief that public participation practices are needed in order to establish community-level relationships and understanding around the ways that urban IoT devices deployed in their neighborhood might actually be used.

The group's expectations for meaningful public participation grew as the workshop progressed, and resulted in a desire to make transparent the story of how deployments can become legitimate through a meaningful process of public participation. During the share-outs a member from this group stated, *We were thinking of telling a story… like I want to know who did you talk to.. you know, maybe a video that says like, hey, six months ago we talked to these community members.…then from that, the goal of this project is this then we would want you to be able to trust us and this device…*

6.2 Transparency of Civil Rights

The second concern we identify is with regard to civil rights. In particular, how transparency of civil rights policies is necessary for community members' sense of security. We illustrate this concern through a group from Workshop #1. The concern emerges through a process of questioning the OTE representative who had outlined the capabilities and proposed use-cases for the example urban IoT devices presented at the start of the workshop. Here we see an extract of a conversation around devices used to monitor environmental noise, (e.g. loud construction work after permissible hours.) These devices would be deployed on the outside of a complainant's window to record noise levels and use artificial intelligence (A.I.) to attempt identify the source of that noise automatically, following complaints to the city's 311 system (NB: In the US 311 is the phone number used for reporting non-emergency issues e.g., NYC311 is the New York City version of this service). The interaction starts with participant asking, *"Would the NYPD have access to this information? "* To which the OTE representative replies, *"No and well like I said it only activates one second every 10 seconds. And it's really like it's just like splashes of sound so you can barely pick anything up and it's intentionally designed that way. They don't want any liability like overhearing anybody's conversations… "*. This is followed up by another participant who then asks, *"Is any of the data going to be sold to third parties?"* This time the OTE representative replies, *"That's a great question. In some cases the city is working with third parties, like hiring companies to make the sensors. Would they get to do anything with the data? We're negotiating with some of the vendors to ensure that the city owns the data and the companies can't resell it or do anything with it."*

The first of these questions highlights a concern about the potential for surveillance, incidental as well as intentional monitoring, and especially with regard to the involvement of law enforcement. The second highlights a concern about privacy and data security, and the potential for commercial interests to play a role in data collection and use. Each of these concerns was raised on multiple occasions across the workshops. However, what made this group's articulation stand out was the effort they put into codifying the

response and making it available for community questioning. Specifically, they selected the **Choices + Rights** prompt, using it to declare, *"Every citizen should have a Bill of Rights. So we want to know what our rights are and what choices we can make as it relates to the sensor."* This would be the focal point of an interactive experience, as described by one the group members, *"Our sign is an interactive multimedia image. So when we tap on any of our prompts* ***(Choices + Rights; Data + Privacy; Motivations + Goals; Trust + Accountability)*** *it takes over the screen. So we tap on* ***Choices + Rights****, it reads us our Bill of Rights... tap on* ***Trust + Accountability*** *it plays the video explaining how you are going to hold yourself accountable to what you said you are going to be to do and how we can trust that."*

6.3 Transparency of Contact and Responsibility

The third concern we identify is with regard to a point of contact and civic responsibility. In particular, revealing which city officials can provide information about the deployed urban IoT devices, and where and how they can be contacted. We illustrate this concern through a second group from Workshop #1, who suggested that making contact and responsibility transparent would be a key way to provide community reassurance. This concern emerges during discussion of the **Choices + Rights** prompt when a participant speculated with their group members, *"Is there a number I can call to say this sensor is broken or the sensor is not where its supposed to be... or if I have other concerns about it and I want to talk to someone and ask questions can I call 311 or something like that... and maybe the sensor itself would have like an ID on it that I can reference it?"* This question speculates about the role that 311, a familiar service and initial contact point for many civic questions or interactions, might play in urban IoT.

This group were also concerned with revealing and better understanding the reasons behind deployments, as was made clear in when another participant in the group stated, *"The prompt that should have the most prominence is Motivation + Goals, because the first thing someone's gonna want to know is: "Why is this here? And what it does? And what does the city want to learn?"* This prompted our OTE collaborator to request clarification by asking, *"Can I ask a question? So like, one thing that, you know, from my perspective in thinking about this was that people would want to know who is doing this? So I guess my question is, like, for you all, is it like, is the city a monolith? Or are you thinking like, I want to know if this is the Department of Environmental Protection or Department of Transportation, because I'm not necessarily sure if that would be captured in the motivation and goals alone?"* To which the participant replied, *"Yeah, that's actually really important to know that like, okay, it's not the police department. It's Department of Transportation. That isn't a ShotSpotter? It's a totally, totally, different agency. I think that for me fell into trust and accountability. And that it should be like explicitly, like this is specifically the Department of Buildings and not just the City of Local Government generally."* This dialogue highlights the importance of revealing details about the organizations and people behind urban IoT deployments. The 'sign' this group created with their worksheet focused much more on the people and communication channels that exist (or should exist) around the technology deployments, rather than simply focusing on the technology itself.

6.4 Transparency of Economics

The fourth concern we identify is with regard to the economics of urban IoT deployments. In particular, revealing details about decisions over the relative costs and benefits when compared to other civic amenities and government funded services. We illustrate this concern through a third group from Workshop #1, who discussed how transparency over economic choices could help to increase community buy-in. We see this when participant from this group stated, *"Our most important prompt was the* ***Benefits + Costs****. And we envision that taking up at least 50% of our sign in a video format, in kinda of maybe like a TikTok reel that is like continuously playing. And the question that we wrote for this is "How does it benefit the community?" So that's the biggest one."* This participant then elaborated on why this was important to them by saying, *"See I care about this because I want to know if they are taking resources from other areas... Like public libraries....this is paid for with taxpayer dollars... to do this?"* More sarcastically, another participant in this group then added, *"It doesn't matter where the money comes from, they're gonna do this regardless... they would do that instead of feeding the homeless..."* This group's discussions highlight how decisions regarding the selection and deployment of technological responses to civic questions inevitably have impacts elsewhere, if only because budgets are finite. As a group, they are all too aware of how social services are underfunded in their community, and across the city more broadly, and they want their 'sign' to reveal not only the direct benefits and costs of any urban IoT deployment, but also how the choices and decisions fit into a larger conversation about government spending.

These concerns prompted debate between participants and city officials during the share-outs. Starting with the City representative saying, *"So this is interesting to hear about... the cost aspect of it. How does that play into it? Like would that change your feelings, knowing how much the city is spending...?"* In response, the original participant then said, *"That was really, really important, because my feelings on this would change if I felt like the city was allocating, taking resources from somewhere else where I think the funds would be more beneficial."* This group is not objecting to deployments out of hand, but the participants are keen to highlight how a focus on new technologies could be siphoning attention and funds away from other long-standing social issues, and they want the 'sign' they developed to reflect this expanded point of reference and encourage debate about how these choices are made.

6.5 Transparency of Community Value

The fifth concern we identify is with regard to the value that community members can expect to gain from deployments of urban IoT devices in their neighborhood. In particular, how the data that sensors generate might be grounded in practices that bring direct value to community members' lived experience. We illustrate this concern through a group from Workshop #3, which emerged when they were discussing the Benefits + Costs prompt with participant saying, *"Again, when you get the data? What you're gonna do with it? I know, you said it's gonna be available online. Why do I care? Do I care? Is that a pastime, or like a hobby, I'm gonna happen, go read data, just for the sake of it!? So I want to know how the data is gonna help me personally."* This participant is questioning one of their

group member's acceptance that making data available online is of value to community members, as it implies the expectation that community members will be intrinsically interested in, and have the available time and capacities to identify, explore, contextualize, and make sense of data. This reflects how currently widespread official attempts at providing transparency, e.g. providing open data portals, may be ineffectual and reliant on intermediaries [29] that are not always available.

As the activity progressed, this same participant developed their thoughts by saying, *"Why do I care about the data? Or checking it? As long as it takes care of my noise problem. Like when the fire alarm goes off, we still have to call the fire department? That doesn't make sense. They should come and check it automatically. They should have the noise detected and we shouldn't have to report it. That's efficiency."* In this statement, participant is challenging the city to act on the data that it is gathering, and to provide resources for responding to identified problems. In doing so they question whether the information sensors offer has value for community members if it does not have beneficial impacts on their day-to-day lived experience. Urban IoT deployments often aim at creating value for the city by increasing the efficiency of agency personnel and resource use. However, this participant views efficiency in terms of the time and effort required to actually resolve the problem. While these may be closely related, they are not necessarily the same thing. This finding highlights the need for transparency in how value for different stakeholders might be negotiated.

6.6 Transparency of Dissent

The final concern we identify is with regard to enabling community members to express dissent in ways that are visible to city, and also to others in their neighborhood. We illustrate this concern through a fourth group from Workshop #1, who were suspicious of the sensor as a technical object and also of its potential deployment as an artifact of social control and surveillance. This group made the **Trust + Accountability** prompt the focal point of their 'sign' making activity, using it articulate distrust of almost every aspect of the sensor. For example, having selected the **Hardware + Software** prompt, the question they asked of it was, *"Can we trust the hardware and software to do what it says it is supposed to do?"*. In response to selecting the **Data + Privacy** prompt, the question they then asked was, *"Who wrote the data and privacy law?"*. This was because, when the OTI representative had introduced the sensor they were responding to (see figure 1-A: experimental prototype that uses computer vision to automate foot traffic monitoring at busy intersections **??**) they had been told data would not be made available to the public and so they wanted to know why and who had decided that this data should be private. In addition, this group also expressed concerns, fears, and anger throughout, e.g. saying, *"We should be notified before these things are put up..."* and *"What is that? Why is it there? I don't like it. Uncomfortable..."* and *"I'm really suspicious of all of them..."* and *"it really don't seem to benefit us..."* For this group, issues were often framed as "us" against "them" (i.e., a struggle between adversaries). This was a sentiment that seemed to predate the workshop, but which design activities helped to articulate. Reading their worksheet 'sign' through this lens suggests a desire to reject both the sensor and the politics associated with its deployment, which can be seen as a source of surveillance and therefore of bureaucratic power that community members might wish to resist [18].

7 DISCUSSION

In this section we first outline the limitations to our study, before discussing our reflections on the design process and reporting on the response from our OTI collaborators to the outcomes. We close out the section by unpicking some of the challenges and opportunities associated with thinking of transparency as an ongoing and dynamic process.

7.1 Limitations

We note three main limitations to this work. First, there is something of a correlation between the transparencies highlighted in our findings and the prompts we provided as workshop materials. This correlation is in part due to priming participants with prompts based on a distillation of prior literature that highlights the interconnected social and technical aspects of urban IoT deployments; a practice that research highlights as beneficial to design processes [83]. It is also influenced by our approach to thematic analysis [15, 17], in which the review of prior literature that guided our development of prompts for the workshop informed our development of high-level themes and influenced the selection of illustrative examples. At this point, our analysis was also primarily based around the idea of *what* it is that should be made transparent, which is the predominant approach in prior transparency literature in HCI. While our presentation of results connects particular examples to individual themes, it should also be noted that there is not simply a one-to-one correlation between prompts and concerns. Aspects of multiple themes are present in most if not all of the work created by participants, and these connections better reflect ordering priorities and communication framing than delineated choices. Better appreciating this complexity was an important factor in shifting our perspective away from an information-centric perspective on transparency and towards a more process-focused view. However, it remains the case that an alternative reading of prior literature would result in a different set of prompts, and also in changes to the themes we highlight. The connection between how workshop prompts were selected and used, and the outputs produced by participants, is important and therefore requires acknowledgement. Second, we note the possibility that involving city representatives in the workshops may have introduced a power dynamic that affected participation. Based on our experiences, and the ways in which participants took the opportunity to interrogate the motives of urban IoT deployments, we do not think this was a major concern in practice. However, it does highlight the third limitation, which is that participants were self-selecting and so our findings are reflective of only a subset of community members. Further efforts are needed to create opportunities for others.

7.2 Reflections on the design process

New York City Office of Technology and Innovation initially approached us with a specific design problem: how to design physical,

local signage to provide transparency of the growing array of IoT sensors being embedded throughout the city. The presumption being that the information communicated by these signs accompanying the IoT sensing devices would not only help prevent criticism and backlash seen elsewhere regarding the of lack public transparency in smart city projects [36, 69], but also increase public trust in the city's operations. Our prior experiences led us to suggest a more participatory approach to this design problem, in order to include members of the communities likely to be affected by such deployments in the process. In this, our aims were initially largely in line with the design problem posed by the OTI, in that we would use the workshops to gather community requirements to determine the specific information that could be provided to help in making the purpose of particular devices transparent through signage. On deeper reflection, we have come to feel that the concerns expressed by workshop participants are not readily addressed by signage, and that instead they require an alternative conception of transparency. This is because the perception of transparency as something that might be achieved through signage is overly information-centric, focuses on static and isolated interactions, and is unidirectional in a way that can conceal politics.

7.3 Response from OTI

In contrast to the pivot away from signage our interpretation of the workshops afforded, our OTI collaborators remained largely in line with the original design problem. To that end, the workshops did generate various insights to inform their ongoing efforts to design and deploy signs. At the same time, officials recognized the need for work to address the concerns for transparency beyond information and signage. For instance, moving ahead with plans to develop public impact assessment for IoT deployments which could help address the concerns for public engagement. They also plan to support and advocate for recently proposed legislation around IoT civil rights. Last, they expressed interest in continuing to engage the public and explore how some of the successful elements of the workshops could become a model.

7.4 Limitations of information-centric transparency

Our findings highlight how the concerns participants raised are not primarily about obscured or hidden information that is waiting to be revealed, rather that they reflect a desire for things that don't yet exist. For example, the first concern identified was with regard to standards and practices for public participation in smart city deployments; the second requests a Bill of Rights for smart cities; the third requests a process of contact and responsibility that would fit into established 311 reporting services; and the fourth a reporting of the economic choices made when smart city technologies are adopted. Information about these concerns cannot be made visible to communities until these concerns are meaningfully brought into being. Our findings also highlight how participants often imagined that responses to their concerns would be dynamic and interactive experiences, and not simply 'signs' as static visual communication or information devices. The experiences they imaged included touch-based interactions with an IoT Bill of Rights, or using QR codes to gain access to real-time and contextualized data visualizations, and watching embedded Tik-Tok style videos about economic policies. These speculations imagine community members as actively engaged in the processes of making transparency, rather than viewing them as passive recipients of unidirectional information dissemination.

In addition, it was clear from the way participants engaged in workshop activities that the social aspects of working together to negotiate and express concerns is important. Throughout, participants challenged city officials, and took pride and ownership of the kinds of transparency they sought to enact. We might suggest that the workshop staged performances of transparency. City officials performed transparency by presenting the IoT strategy and making themselves visible and accessible in the workshops. While community members responded to that performance with questioning, debating, and rejecting, and by designing transparency 'signs'. These performances, the dialogue and debate among participants, and between participants and city officials, might be the most consequential impact of the workshops. These performances, the dialogue created in conflicts and questions directed at city representatives play an instrumental role in highlighting the politics of transparency. This is because transparency requires decision-making, which involves the exercise of judgment, moral authority, and agency over what should be revealed. We found that what participants sought to reveal were a number of concerns related to public participation, civil rights, economics, contact, and community value. Moreover, the reasons why they sought to make these more transparent were equally varied, including legitimacy, security, assurance, buy-in, individual appreciation, and distance. This plurality suggests transparency involves an ongoing process of negotiation and contestation, and that transparency is contingent and situated [22]. This contrasts with a common understanding of transparency as a goal and a good in itself [51], which can be seen in HCI discussions of smart cities (see e.g. [88, 92]) and also algorithmic systems (see e.g. [56]). Furthermore, that transparency can embed power relations, which we see in the opportunities created for revealed entities to be governed, and for delivering agency to act on what is revealed. To borrow a metaphor from Frederick Schauer, consider a comparison between the windows of a sunroom and a bathroom door [80], and ask questions such as, 'Who is deciding to make this transparent? And why?' or 'Who stands most ready to act upon and benefit from the visibility being created?'.

We should remain cognizant that the concerns raised by participants remind us that "*if something is made visible without meaningful ability to act upon it, that visibility risks normalizing what it was meant to govern*" [22]. Transparency signage may be at best a small component in a much larger set of activities necessary to address these concerns, while at worst it might represent the latest in a long list of empty, performative measures that use transparency to legitimize ongoing reconfigurations of power [13, 79]. If this is the case, what does our research suggest might be an alternative? Here we adopt Pelle Ehn's characterization of participatory design as a 'thing' that is both social and material [31] to highlight the opportunities that thinking of transparency as an ongoing activity presents for addressing questions of transparency in Smart City projects.

7.5 Opportunities from thinking of transparency as an ongoing process

Drawing on John Dewey, e.g. [24], Bruno Latour, e.g. [60], and Noortje Marres [65], Ehn stresses the importance of 'participating in public controversial things' [31] to the practice of participatory design. Such design 'things' assemble heterogeneous publics around problematic objects of concern in order to modify spaces of interaction and open up new ways of thinking and acting. As we reflected on our initial understanding of the design process and objectives we had brought forward, this insight helped us become aware that our focus had been narrow and our interpretation literal. Even though we had moved beyond the initial proposal to co-design physical signage, our focus had remained on an information-centric perspective of transparency in which we thought it important to understand what information city officials should provide community members to explain what happens when urban IoT devices are deployed their neighborhoods. From this perspective transparency becomes a largely static technical object. However, our reflection was revealing this to be less important than the work involved. This work was the activity of assembling social, technical, and material participants to enact a transparency that is dynamic, contested, and contingent. Ehn [31] highlights how important replacing static systems diagrams with prototyping activities was to the political process of engaging user participation in 'design-by-doing' [32]. We argue here for the similar importance of participatory activities to transparency.

Taking participatory budgeting (PB) [85] and deliberative consultation (DC) [37] as analogous starting points, we imagine opportunities and foresee challenges for 'transparency things'. PB is particularly instructive because it is an example of participatory civic practice that has been widely implemented, including in New York City, in different configurations deemed suitable for local situations, and convened digitally or through in-person meetings. Digital support for DC processes has been the subject of inquiry for digital civics scholars. The case study we have presented here highlights the opportunity for participatory design activities to democratize how urban IoT projects are framed and planned, or even in deciding whether they should go ahead, prior to local deployments. With sufficient resources and engagement, we might envision an ongoing process similar to the original PB process of Porto Alegre in Brazil, in which citizens assemblies elect delegates to ensure local priorities are followed through [85]. However, this is probably not a practical likelihood for 'transparency things', given the demands on time and effort that would be made. Other models of PB are to greater or lesser degrees digital implementations with processes transferred online. Menendez-Blanco and Bjørn [70] unpick the implications of choices made in Madrid's digital PB implementation, providing a cautionary warning about how design choices can limit engagement in online processes. In particular, they note limited opportunities for deliberative debate, and for scoping and self-regulation, which they ascribe to an individualistic and competitive framing. Towards the other end of the scale, Johnson, Al-Shahrabi and Vines [53] discuss digital support for smaller DC processes that meet people where they are. The authors describe the value offered by structuring discussions through prompts and turn-taking, which mirrors our own experience of design prompts providing a framework through which concerns can be expressed. However, the authors also raise an important challenge when highlighting the social capital needed to get people 'into the room' in the first place. This is particularly important with regard to interactions with government and municipal authorities, where there may be problematic trust relationships [23, 27]. In our workshops, we found the presence of city representatives provided an opportunity for holding to account. However, participants were self-selecting and so important questions of power, trust, and participation remain open to further inquiry.

Gooch et al. [44] describe an effort to conduct participatory activities at scale that mixes in-person events and online activities. They note that in-person events result in dialogues that are more strongly situated in local communities, and recommend using in-person events as a way to mitigate tensions between personal connectedness and engagement at scale. This may be particularly informative to the context of urban IoT deployments, where programs may be initiated city-wide but concerns reflect neighborhood diversity. Moreover, in response to situations that change dynamically after programs have been initiated and technologies deployed. In his discussion of 'design things', Ehn [31] considers both *use before use* (participatory design) and *design after design* (meta-design). This is also informative when thinking about 'transparency things' for urban IoT, where it may not only be important to engage in anticipatory envisioning, but also to remain open to change in use where participation may be separated in time and space. This requires infrastructuring environments that are configurable and adaptable to change in use. In the civic context, such infrastructuring might include the use of public libraries as sites of ongoing deliberation [10, 58], supporting both digital and in-person activities at set times and opportunistically. It also acknowledges the importance of supporting effective *public work* [16, 20] and empowering communities with the understanding that transparency is not a static entity, but is contestable and reconfigurable as situations change.

8 CONCLUSION

Our collaborators initially approached us with a specific design problem: how to design physical, local signage to provide transparency of the growing array of IoT sensors being embedded in throughout the city. The presumption being that the information communicated by these signs accompanying the IoT sensing devices would not only help prevent criticism and backlash seen elsewhere regarding the of lack public transparency in smart city projects [21, 54, 92], but also increase public trust in the city's operations. Our prior experiences led us to suggest a participatory approach to this design problem in order to include members of the communities likely to be affected by such deployments in the process. At first, our aim was largely inline with the initial design problem posed by the OTI: we would use the workshops to gather requirements from the public to determine the specific means by which an individual sensors might be made transparent with signage. However, our experiences running the workshops described in this paper has led us to a different endpoint.

We argue that the concerns expressed in the workshops–public participation, civil rights, contact and responsibility, economics, community value, and *dissent*– are not readily addressed by, and

conflict with the form of transparency signage is best suited to provide. We located the source of this conflict in the shortcomings of the information-centric transparency provided by signs. Subsequently, we argued this mode of transparency is fundamentally limited as a frame for engaging the complexities of transparency in the context of the smart city. To address this limitation, we provided an alternative frame– transparency-as-activity– which we argue is more amenable to providing meaningful transparency in the smart city.

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A APPENDIX

A.1 Sensor Descriptions

(1) **Computer Vision Sensor:** Prototype developed by New York University [78] . Stereo camera and microphone to monitor traffic flows by counting vehicles and observing mode conflicts. WiFi connectivity and 120V power.

(2) **Home-based noise sensor:** Project development by New York University supported NSF grant [3]. Microphone to

detect noise with a backend that can process audio samples using machine listening to determine source of noise. WiFi connectivity and 120V from the tenant apartment. The device is mounted outside of a window. Data is shared with NYC Department of Environmental Protection.

(3) **Industrial-based noise sensor:** Project development by New York University as part supported NSF grant [3] . Microphone to detect noise with a backend that can process audio samples using machine listening to determine source of noise. WiFi connectivity and 120V power. The device is mounted near construction sites. Data is shared with NYC Department of Environmental Protection.
(4) **Temperature/Humidity Sensor:** Project development by NYC Technology Innovation Office in collaboration with NYC Dept of Transportation and the Office of Climate and Environmental Justice. Sensors are mounted to street signs and collect temperature and humidity data in different neighborhoods to compare the street level environments and create a baseline to understand how interventions could benefit residents. LoRaWAN connectivity and battery powered.

A.1.1 Original 24 Prompts

(1) Develop + Manage: IoT technologies have specific development processes and require specialized practices to manage the technology once deployed into the environment.
(2) Stakeholders + Communities: IoT technologies often involve many different stakeholders and communities: some directly and others indirectly.
(3) Interaction + Engagement: IoT technologies create new forms of interaction with the environment and may need new opportunities for public engagement with people.
(4) Citizenship + Laws: IoT technologies can alter how we understand citizenship norms and laws that uphold and protect those norms.
(5) Hardware + Software: IoT technologies need specific hardware (the physical parts of the sensors) and software (the computer code that makes the sensors work) to operate.
(6) Values + Ethics: IoT technologies might impact existing values and present ethical challenges.
(7) Ownership + Control: IoT technologies are often owned and controlled by several interrelated parties at once.
(8) Data + Privacy: IoT technologies collect and transmit various forms of data, which can create challenges for privacy.
(9) Relationships + Communities: IoT technologies can create new or disrupt old social/political/economic relationships and communities.
(10) Solutions + Problems: IoT technologies are technical solutions to specific kinds of problems cities want to address.
(11) Benefits + Costs: IoT technologies provide specific benefits that should outweigh the costs for developing and using the technologies.
(12) You + Us: IoT technologies can impact you and us as people living together in society.
(13) Trust + Accountability: IoT technologies should be trustworthy, and to do so, need specific mechanisms for accountability.
(14) Human + Machine: IoT technologies need combinations of human and machine labor to operate.
(15) Roles + Responsibilities: IoT technologies require new job roles and responsibilities to operate.
(16) Choices + Rights: IoT technologies might impact the choices and rights of people in society.
(17) Efficiency + Productivity: IoT technologies are often used because they increase the efficiency and productivity of specific tasks.
(18) Action + Freedom: IoT technologies enable new forms of action that might impact how we understand freedom.
(19) Risks + Consequences: IoT technologies can have unique risks and consequences depending on how they are used.
(20) Equity + Justice: IoT technologies can present challenges for equity and justice in society.
(21) Private + Public: IoT technologies alter norms around what is considered private and public.
(22) Services + Organizations: IoT technologies create or improve public services and might require new organizations to manage them.
(23) Effect + Environment: IoT technologies have specific effects on the environments they are embedded in.
(24) Motivation + Goals: IoT technologies reflect the motivations and goals of those deploying them.