CitySense: A Civic Transparency Platform for Visualizing Underground Infrastructure and Building Public Trust

Apoorv Singh, Salomi Vaibhav Pradhan, Yuliya Semikina, Abdul Khadar Shaik
Pace University, New York, NY, USA
as84599n@pace.edu, sp02886n@pace.edu, ys03938n@pace.edu, as02240n@pace.edu

ABSTRACT
As cities modernize by moving utility infrastructure underground into utilidor systems, a critical challenge arises. The invisibility of these systems erodes public awareness, trust, and connection to civic maintenance. Through generative research with New York City residents, we identified a strong desire for transparent, real-time communication about underground work and recognition of the workers involved. In response, we designed and developed CitySense, a civic transparency platform comprising a mobile app and physical street installations. CitySense provides real-time visibility into utility health, an interactive underground map, issue reporting, and worker profiles. We conducted a 10-day field study with 10 participants, combining quantitative usage logging with qualitative interviews. Findings show that while transparency is highly valued, unclear labels and detached social features hindered usability. Users sought personalized, location-aware alerts and better integration of community engagement tools. We contribute design implications for civic transparency platforms, emphasizing clarity, contextual integration of social features, and personalized information filtering to foster public trust and participation in smart city infrastructure.

CCS Concepts
- Human-centered computing > Human computer interaction (HCI) > HCI design and evaluation methods > Field studies.
- Human-centered computing > Human computer interaction (HCI) > Interaction design > Interaction design process and methods.
- Applied computing > Computers in other domains > Computers in government.

KEYWORDS
Civic Technology, Transparency, Trust, Smart Cities, Urban Infrastructure, Utilidors, Field Study, Participatory Design

INTRODUCTION

The transition of urban utility systems (water, electricity, gas, internet) into underground tunnel networks, known as utilidors, represents a significant advancement in smart city development. While this shift reduces surface disruption and improves reliability, it introduces a new socio-technical challenge. The invisibility of essential infrastructure means that when critical systems vanish from public view, residents lose a tangible connection to the processes and people that maintain their city. This opacity can foster public skepticism, reduce trust in municipal governance, and diminish recognition for utility workers, whose labor becomes hidden from daily life [11,12].

Prior research highlights the gap between open data initiatives and meaningful civic accountability. This phenomenon has been termed "transparency theater" [5]. Studies also indicate that non-expert audiences struggle to interpret complex 3D geospatial models of underground systems [9]. There is a clear need for tools that translate technical infrastructure data into accessible, actionable, and human-centered forms to foster genuine public understanding and trust.

In this paper, we present CitySense, a civic transparency platform designed to make hidden urban infrastructure visible and comprehensible. CitySense combines a mobile application with physical street installations (kiosks and status poles) to provide real-time utility status, an interactive underground map, issue reporting, and direct engagement with maintenance workers. Our work is guided by the following research questions, derived from an initial generative study:

- What information builds public trust in underground utility systems?
- How can complex geospatial data be simplified into accessible visual metaphors?
- How can we provide genuinely accountable transparency, beyond superficial data displays?
- How do different stakeholders (residents, business owners, workers) perceive the value of such systems?

We detail the design and evaluation of CitySense through a 10-day longitudinal field study with 10 participants. Our mixed-methods approach combined quantitative usage instrumentation with qualitative interviews and task-based observations. The study reveals that while the core concept of transparency is highly valued, its execution requires careful attention to clarity, contextual integration, and personalization.

We contribute:

- A novel civic transparency platform (CitySense) designed to bridge the visibility gap in smart city infrastructure.
- Empirical findings from a longitudinal field study on how users engage with transparency tools in daily life.
- Actionable design implications for fostering public trust, awareness, and participation through human-centered civic technology.

RELATED WORK

Our work intersects research in civic technology, transparency and trust, and urban infrastructure visualization.

Civic Technology and Public Participation

Platforms like SeeClickFix demonstrate the power of citizen reporting for municipal issue management. However, trust erodes when reports go unacknowledged or unaddressed [10]. CitySense extends this model by closing the feedback loop. It provides status updates on reported issues and connects citizens directly with the workers responsible.

Transparency and Trust in Public Systems

Shkabatur [6] critiques "transparency theater," where data is released without mechanisms for accountability or public understanding. Genuine transparency requires communication that is actionable, timely, and contextual [5]. CitySense addresses this by presenting infrastructure data alongside human narratives (worker profiles) and clear impact information such as affected routes and timelines.

Visualizing Urban Infrastructure

Prior projects, such as the NYC 3D Underground Pilot, revealed that full 3D models are often too complex for public comprehension [9]. Successful wayfinding apps like Waze demonstrate the effectiveness of icons, color-coding, and simple metaphors. CitySense adopts these principles, using a subway-map-inspired visualization to represent the utilidor network and make it intuitively explorable.

Our contribution lies in synthesizing these domains into an integrated platform that pairs data transparency with human connection. We evaluate this platform in a real-world context over an extended period.

GENERATIVE RESEARCH: IDENTIFYING NEEDS AND OPPORTUNITIES

To ground our design in lived experiences, we first conducted a generative research study with five diverse New York City residents (see Table 1 for demographics). Methods included semi-structured interviews and a participatory design activity where participants ranked utility metrics for a public display.

Participants	Age	Role	Key Insight
Andrew	22	Student	Trust depends on perceived system integrity, not just data access.
Ananya	35	Physiotherapist	Values simplicity; "just tell me what's being fixed and for how long."
Diego	46	Café Owner	Prioritizes practical, timely updates over "fancy digital dashboards."

Samuel	38	Delivery Driver	Needs clear, icon-based alerts, not data-heavy paragraphs.
Karan	33	Data Analyst	Desires an integrated information hub, not five disparate apps.

Table 1: *Generative study participant profiles.*

Key Findings & Design Opportunities:
Our analysis revealed four key findings that directly informed our design:

- *Trust Deficit:* Participants expressed skepticism about municipal execution and maintenance. Transparency tools must communicate system integrity and governmental accountability to be effective.
- *Desire for Simplicity:* Across tech-savvy and non-tech users, there was a strong preference for clear, concise, and visual information—not raw data or complex dashboards.
- *Human Connection:* The invisibility of workers was a recurring concern. Participants felt that recognizing labor would build empathy and trust.
- *Actionable Awareness:* Information needed to be localized and timely to aid daily decision-making, such as commute routing or business planning.

These insights directly informed CitySense's core features: a dashboard with clear status alerts, an intuitive underground map, a reporting tool with feedback, and a worker profile section to humanize the system.

CITYSENSE: PLATFORM DESIGN
CitySense is a multi-channel transparency platform consisting of a mobile application and complementary physical installations.

Core Application Features

- *Dashboard:* The home screen provides an overview of "Critical Alerts" and "Recent Works" near the user, with color-coded statuses based on the utility type. The page can be viewed in Figure 1.

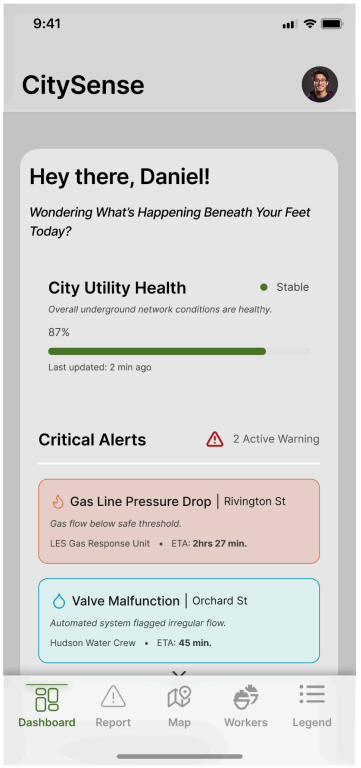

Figure 1: *The dashboard page.*

- *Interactive Map & Legend:* As seen in Figure 2, the toggle (bottom-right) reveals the underground utilidor network, color-coded by utility type (water, gas, electricity, etc.). "Trouble pins" indicate disruptions, tapping which reveal detailed impact reports.

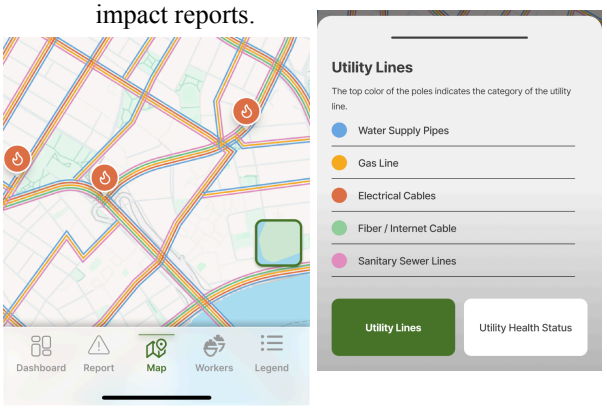

Figure 2: *The map page(left) and the legend overlay(right).*

- *Report Tool:* As seen in Figure 3, this tool allows users to report issues (such as leaks, outages) with description, location, and photo upload. A "Report Log" provides status updates on past submissions.

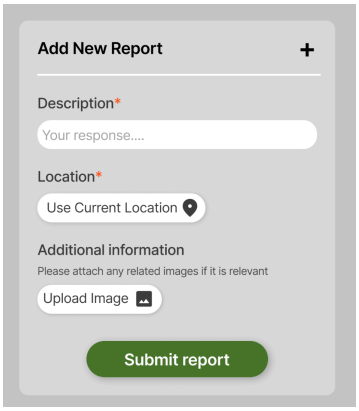

Figure 3: *The report form.*

- *Workers Page:* Features profiles of utility teams and individual technicians, with options to "Connect" (send a message of appreciation) or "Donate" (offer financial support). The worker profile page can be seen in Figure 4.

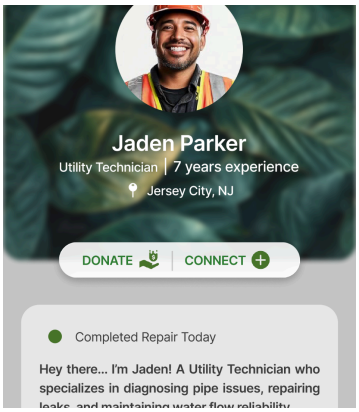

Figure 4: *An example of a worker's profile page.*

- *Physical Kiosks & Poles:* Street-side kiosks display the map, critical alerts, the legend and the worker highlight. In addition we have the color-coded utility poles with status lights (green=working, yellow=maintenance, red=line down) to provide at-a-glance awareness. Examples of each can be seen in Figure 5.

Figure 5: *Kiosk Display(left) and a sidewalk pole(right) for the gas line with a green indicator.*

High-Fidelity Prototype

The CitySense prototype was developed in Figma and is available for interactive viewing at: https://www.figma.com/proto/xtdcRoYKm2mTnZbSOxoihE/CitySense?node-id=18-6084&t=CwQqLfnhQL2mmgZH-1

FIELD STUDY: METHOD

To understand how CitySense fits into daily life and delivers long-term value, we conducted a 10-day longitudinal field study.

Participants

We recruited 10 participants (6 male, 4 female) aged 22 to 46, comprising 9 NYC residents and 1 business owner. Participants represented key user groups: daily commuters, delivery drivers, students, and small business owners. All regularly interact with or are affected by street-level disruptions.

Procedure

The study employed a mixed-methods approach:

- *Daily Guided Tasks:* Over 10 days, participants were given a new, specific task each day (e.g., "Explore Dashboard," "Report an Issue," "Use the Map") designed to systematically engage with all app features. They self-recorded

completion times and submitted written reports detailing their navigation flow, pain points, and impressions.

- *Instrumented Logging:* We tracked page views and navigation paths within the prototype to gather quantitative engagement data.
- *Post-Study Interviews:* After day 10, we conducted semi-structured interviews (15–20 mins each) to gather in-depth feedback on overall experience, perceived usefulness, and attitudes towards transparency and trust.

Data Analysis

- *Quantitative:* We analyzed page view frequencies, task completion times, and navigation funnel drop-offs.
- *Qualitative:* Interview transcripts and daily reports were analyzed using thematic analysis to identify recurring patterns, frustrations, and suggestions.

FINDINGS

The field study yielded rich insights into how users engaged with CitySense over time, revealing both strengths and opportunities for improvement.

Quantitative Findings

Task Completion Time: As shown in Figure 6, initial exploration tasks (Days 1 and 4) took the longest (average 200 to 203 seconds), indicating a learning curve. Later, goal-directed tasks (e.g., submit a report) were completed much faster (average 75 to 86 seconds), suggesting that core flows became efficient with familiarity.

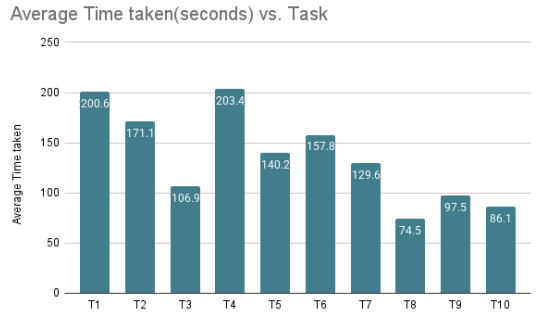

Figure 6: *Average task completion time (seconds) over the 10-day study period.*

Page Engagement: As shown in Figure 7 the Dashboard (50 visits) and Map (39 visits) were the most frequently accessed features, establishing them as the primary hubs for information. In contrast, the Donate and Connect overlays had the fewest visits (10 each), indicating low organic engagement with social features outside of assigned tasks.

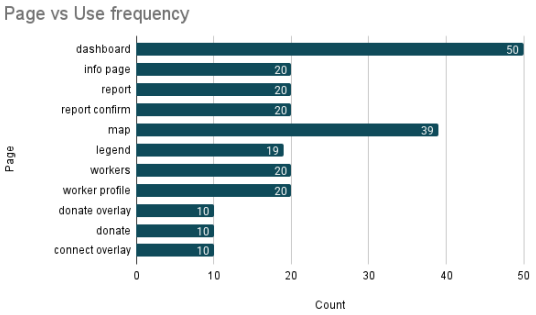

Figure 7: *Frequency of use plotted against all the individual pages.*

Qualitative Themes

Four major themes emerged from user interviews and reports. More information regarding the referred participants can be seen in appendix B.

- *Transparency is Valued, but Clarity is Crucial:* Participants unanimously praised the app's mission. One noted, "It's cool to finally see what's underneath all the construction" (P4). However, ambiguous UI elements undermined trust. Labels like "Predictive Insights" and unlabeled progress bars caused confusion. As one user asked, "Is this a forecast, or is it happening now? I can't tell" (P7).
- *The Map is Engaging but Not Yet Actionable:* The interactive underground map was described as "fascinating" and the "coolest part." However, users struggled to translate this engagement into practical use. One participant remarked, "I love seeing the lines, but what do I do if one is red near my house?" (P2). The map sparked curiosity but lacked clear calls-to-action linked to real-world decisions.
- *Social Features Feel Detached:* Worker profiles were highly effective at building trust. As one user stated, "Putting a face to it makes it feel more reliable" (P5). Yet, the Donate and Connect features felt like isolated additions. Another user questioned, "Donate to who? The worker or the city? It feels out of place here" (P9).

Users suggested contextual integration, such as a donation prompt after viewing a resolved issue in their neighborhood.

- *Demand for Personalization and Filtering:* A consistent request across all users was for tools to manage information overload. A business owner said, "I don't care about the water main in Queens. Let me filter just my block and just power outages" (P3). The lack of filters forced manual sifting, reducing the app's efficiency as a daily tool.

DISCUSSION AND DESIGN IMPLICATIONS

Our field study demonstrates that making infrastructure visible is only the first step. To foster genuine trust and habitual use, transparency platforms must be clear, actionable, and integrated into the user's personal context. We derive three key design implications.

Prioritize Interpretive Clarity Over Raw Data Display

Ambiguous metrics and jargon create "transparency theater." Designers should employ plain language, clear legends, and tooltips to ensure every data point is intuitively understood. For example, instead of "Predictive Insights," use "Expected Impact on Your Commute."

Embed Social and Participatory Features into Core Flows

Social features like donations or messages should not be siloed. They should be triggered contextually. For instance, after a user sees a "Work Completed" alert, the app could suggest "Thank the crew who fixed this?" This ties community engagement directly to tangible system outcomes.

Enable Personalized, Hyper-Local Views

A one-size-fits-all data dump is overwhelming. Providing user-controlled filters (by location, utility type, severity) and personalized alerts (e.g., "affects your commute route") transforms a generic transparency tool into a personally indispensable utility.

Limitations and Future Work

Our study has limitations. The 10-day duration may not capture long-term usage patterns, and our participant pool, while diverse, was limited to NYC. The prototype lacked full backend integration, which may have affected realism.

Based on participant suggestions, we plan to explore an Augmented Reality (AR) map view. This would allow users to point their camera at the street to see an overlay of underlying utilities. We also intend to implement the filtering and personalization system and conduct a longer-term deployment with a larger, more diverse user group.

CONCLUSION

CitySense demonstrates the potential of civic technology to bridge the growing gap between complex smart city infrastructure and public understanding. Our generative research revealed a deep-seated need for simplicity, accountability, and human connection. The longitudinal field study confirmed that while the vision of transparency resonates strongly, its execution must be meticulously crafted to be clear, actionable, and personally relevant.

The lessons from CitySense extend beyond utilidors. Any system aiming to make institutional processes transparent must design for interpretability, integrate community feedback loops meaningfully, and prioritize the user's context. By doing so, HCI researchers and designers can help build not just smarter cities, but more trustworthy and engaged communities.

ACKNOWLEDGEMENTS

We thank our study participants for their time and insights, and our course instructors for their guidance. This work was conducted as part of the IS 628 Research Methods for UX course at Pace University.

REFERENCES

1. 3D NYC Underground. 2021. Visualizing the City’s Foundations. NYC Department of City Planning. Retrieved December 1, 2024 from https://www.nyc.gov/site/planning/data-maps/3d-underground.page
2. Christopher A. Le Dantec and Robert G. Farrell. 2012. The Social Lives of Homeless People: A Study of Technology Use in Street Survival. In Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work (CSCW '12).

ACM, New York, NY, USA, 1043–1052. DOI: https://doi.org/10.1145/2145204.2145361
3. Clara Penicault, Amina Hussein, Jameson Lee, and Mark T. Smith. 2018. Citizen Trust through Temperature Transparency in Utilidor Monitoring Systems. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 412, 1–12. DOI: https://doi.org/10.1145/3173574.3173986
4. Danaë Metaxa, Michelle S. Lam, James A. Landay, and Jeffrey Heer. 2021. Social Visualization and Urban Planning: A Decade Review. IEEE Transactions on Visualization and Computer Graphics 28, 12 (2021), 4501–4515. DOI: https://doi.org/10.1109/TVCG.2021.3098240
5. Jennifer Pierre, Khairil Rahman, and Jofish Kaye. 2022. Transparency Theater Revisited: A Systematic Review of Open Government Data. Proceedings of the ACM on Human-Computer Interaction 6, CSCW2, Article 287 (2022), 1–28. DOI: https://doi.org/10.1145/3555165
6. Jennifer Shkabatur. 2014. Transparency With(out) Accountability: Open Government in the United States. Yale Law & Policy Review 31, 1 (2014), 79–140.
7. Jonathan Lazar, Jinjuan Heidi Feng, and Harry Hochheiser. 2017. Research Methods in Human-Computer Interaction (2nd ed.). Morgan Kaufmann Publishers, Cambridge, MA, USA.
8. Jordan Sterling. 2025. The Subsurface City: Planning for Utilidor Integration. Urban Futures Press, New York, NY, USA. ISBN 978-1-2345-6789-0.
9. NYC Mayor's Office of Technology and Innovation. 2022. NYC 3D Underground Pilot Project Final Report. City of New York. Retrieved December 1, 2024 from https://www.nyc.gov/assets/oti/downloads/pdf/3d-underground-pilot-report-2022.pdf
10. SeeClickFix. 2023. Annual Civic Engagement Report. SeeClickFix Inc. Retrieved December 1, 2024 from https://www.seeclickfix.com/annual-report-2023
11. Victor Korotaev. 2016. Infrastructure Invisibility and Public Perception. Journal of Urban Technology 23, 4 (2016), 45–62. DOI: https://doi.org/10.1080/10630732.2016.1235789
12. Yvonne Rogers, Helen Sharp, and Jenny Preece. 2023. Interaction Design: Beyond Human-Computer Interaction (6th ed.). John Wiley & Sons, Hoboken, NJ, USA.

APPENDICES

Appendix A - Task list for each day

Day	Task
01	Explore Dashboard
02	Inspect a critical alert
03	Report an issue
04	Explore the Map and Legend
05	Check further information for any highlighted area on the map
06	Explore the workers page
07	View any worker's profile
08	Try to donate to a worker
09	Try to connect with a worker and check the ratings
10	Submit another report

Appendix B - Participants

Participants	Age	Role
P1	22	Student
P2	22	Part time worker, Student
P3	23	Part time worker, Student
P4	25	Full time worker
P5	28	Full time worker
P6	24	Full time worker
P7	43	Full time worker
P8	31	Full time worker
P9	29	Full time worker
P10	42	Business Owner