Visualizing Urban Accessibility
Investigating Multi-Stakeholder Perspectives through a Map-based Design Probe Study

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Urban Accessibility

Ease of reaching destinations or activities

Buildings  Transit  Pedestrian infrastructure
INTRODUCTION

APPROACH AND FOCUS

Sidewalk Problems

- Missing Curb Ramps
- Surface Issues
- Obstacles
- No Sidewalks
INTRODUCTION

APPROACH AND FOCUS

Sidewalk Problems

Stakeholders

- Policymakers
- Department officials
- Accessibility Advocates
- People with mobility disabilities
- Caregivers

Sidewalk Problems

- Missing Curb Ramps
- Surface Issues
- Obstacles
- No Sidewalks
INTRODUCTION

APPROACH AND FOCUS

Sidewalk Problems

Stakeholders

People using Mobility Aids

Target Community
KEY QUESTION

How might we utilize interactive visualizations to support communication and decision-making needs for urban accessibility?
INTRODUCTION

URBAN ACCESSIBILITY VISUALIZATIONS

21,584
OBSTACLES

8,468
SURFACE PROBLEMS

43,725
NO SIDEWALK
INTRODUCTION

URBAN ACCESSIBILITY VISUALIZATIONS

21,584 OBSTACLES
8,468 SURFACE PROBLEMS
43,725 NO SIDEWALK

Where are the (in)accessible areas of the city?
Why are they (in)accessible?
Where are the areas with highest repair needs?
PROBLEM: Stakeholders’ Visualization Needs

Understanding how stakeholders want to visualize and analyze urban accessibility datasets.
STUDY: RESEARCH QUESTIONS

**RQ1**
What are the **key visual analytic tasks and data needs for urban accessibility?**

**RQ2**
How might **key stakeholders’ sensemaking practices** differ?
METHOD: PAPER PROTOTYPE PROBE-BASED STUDY

25 participants across 3 cities: Seattle, DC, NYC
METHOD: PAPER PROTOTYPE PROBE-BASED STUDY

25 participants across 3 cities: Seattle, DC, NYC

Multi-stakeholder analysis with the five stakeholder groups
METHOD: PAPER PROTOTYPE PROBE-BASED STUDY

25 participants across 3 cities: Seattle, DC, NYC

Multi-stakeholder analysis with the five stakeholder groups

Three-part task-based study around sensemaking practices of interpreting map visualizations and answering their decision-making questions
Map Visualizations as Design Probes
Type 5: Choropleth

Type 4: Heatmaps

Type 3: Grid Maps

Type 2: Severity

Type 1: Point-based
Design Interviews

N=25

Department officials (e.g., DOTs)
Policymakers (e.g., elected officials)
Accessibility advocates (e.g., NGOs)
People with mobility disabilities
Caregivers

1. Initial Exploration of Maps
2. Visual Sensemaking Tasks
3. Critique and Reflections
 Task 1: Find three accessible and inaccessible areas in the city

 Task 2: Compare neighborhood accessibility for a manual wheelchair user vs person without a disability

 Task 3: Find an accessible neighborhood to live by comparing three neighborhoods

1. Initial Exploration of Maps
2. Visual Sensemaking Tasks
3. Critique and Reflections
Obstacles

Curb ramps

Missing Curb ramps

Surface problems
Why are we seeing this?

Obstacles

CURB RAMPS

MISSING CURB RAMPS

SURFACE PROBLEMS
There is a lot of problems highlighted in this area. It makes me wonder if that area has a lot of people of color who are disabled.

P15AM, an advocate assessing racial inequities
Socio-economic factors
Historic factors
Temporal factors
**Georgetown**
Highly affluent, historic area
82% White, 8.7% Asian, 6.2% Black

**Anacostia**
Lower socio-economic area,
92% Black, 5% Non-Hispanic White, 3% Other
FINDINGS: CATEGORIES

Key Data + Task Needs
RQ1

Sensemaking practices and differences
RQ2
FINDINGS: CATEGORIES

Key
Data + Task Needs

RQ1

Sensemaking practices and differences

RQ2
Diverse set of analysis tasks across stakeholder groups
Diverse set of analysis tasks across stakeholder groups

<table>
<thead>
<tr>
<th>Stakeholder Interests</th>
<th>Analysis Task Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>Analysis Goal</td>
</tr>
<tr>
<td></td>
<td>high-level</td>
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<tr>
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<td>(access to healthcare, jobs)</td>
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<td>DO</td>
<td>Analysis Task Needs</td>
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<td></td>
<td>(sidewalk, POI, transit accessibility)</td>
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<tr>
<td>ADV</td>
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</tbody>
</table>
RQ1: Key Visual Analytic Tasks and Data Needs

Diverse set of analysis tasks across stakeholder groups

**Analysis Goal**
- high-level
  - (access to healthcare, jobs)

**Analysis Strategy**
- mid-level
  - (navigability, connectivity, livability)

**Analysis Task**
- low-level
  - (sidewalk, POI, transit accessibility)

**Stakeholder Interests**
- PM
- DO
- ADV
- MI
- CVG

**Analysis Task Needs**
- Impact analyses
- Equity analyses

Assessing sidewalk accessibility of a street or neighborhood
Diverse set of analysis tasks across stakeholder groups

**RQ1:** Key visual analytic tasks and data needs

---

**Stakeholder Interests**
- **PM**
- **DO**
- **ADV**
- **MI**
- **CVG**

**Analysis Task Needs**

**Analysis Goal**
- high-level
- (access to healthcare, jobs)

Impact analyses
Equity analyses

**Analysis Strategy**
- mid-level
- (navigability, connectivity, livability)

Impact analyses
Equity analyses

**Analysis Task**
- low-level
- (sidewalk, POI, transit accessibility)

Assessing sidewalk accessibility of a street or neighborhood

Assessing the impact of sidewalk accessibility on healthcare access
RQ1: Key Visual Analytic Tasks and Data Needs

The tasks are on a spectrum from micro- to macro-level tasks with few shared tasks across stakeholders.
RQ1: KEY VISUAL ANALYTIC TASKS AND DATA NEEDS

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The tasks are on a spectrum from micro- to macro-level tasks with few shared tasks across stakeholders.

- **Stakeholder Interests**
  - PM
  - DO
  - MI
  - ADV

- **Analysis Task Needs**
  - **Analysis Goal**
    - High-level: (access to healthcare, jobs)
  - **Analysis Strategy**
    - Mid-level: (navigability, connectivity, livability)
  - **Analysis Task**
    - Low-level: (sidewalk, POI, transit accessibility)

Assessing sidewalk network connectivity for making investment decisions.
RQ1: KEY VISUAL ANALYTIC TASKS AND DATA NEEDS

Diverse assessment factors needed to be balanced for making decisions across these contexts.

MULTI-LAYERED TASK MODEL FOR URBAN ACCESSIBILITY

- **Stakeholder Interests**
  - **Macro (High) Level**
    - PM
    - DO
  - **Micro (Low) Level**
    - ADV
    - MI
    - CVG

- **Analysis Task Needs**
  - **Analysis Goal**
    - high-level (access to healthcare, jobs)
  - **Analysis Strategy**
    - mid-level (navigability, connectivity, livability)
  - **Analysis Task**
    - low-level (sidewalk, POI, transit accessibility)

- **Impact analyses**
- **Equity analyses**
Diverse assessment factors needed to be balanced for making decisions across these contexts.

**RQ1: KEY VISUAL ANALYTIC TASKS AND DATA NEEDS**

**FINDINGS:: TASKS AND DATA NEEDS**

**Analysis Goal**
- High-level: (access to healthcare, jobs)
- Mid-level: (navigability, connectivity, livability)
- Low-level: (sidewalk, POI, transit accessibility)

**Analysis Strategy**
- Impact analyses
- Equity analyses

**Analysis Task**
- Macro (High) Level: Task Spectrum
  - PM: Stakeholder Interests
  - DO: Analysis Goal
  - ADV: Analysis Task Needs
  - MI: Analysis Strategy
  - CVG: Data Needs

**Macro (High) Level**
- Sidewalk accessibility data (e.g., raw problem count)
- Population density (e.g., data on people with disabilities)
- Demographics (e.g., racial distribution, income levels)
- Topographical/terrain data (e.g., elevation, slope)
- Pedestrian traffic and collision data
- POI density (residential + business density)
- High-travelled destinations (POIs)
- Job data (for people with disabilities)
- Historical context (e.g., trends on investments made)

**Qualitative Datasets**
- Nature of problems (e.g., types of sidewalk obstacles)
- Images of problems
- Locations of POIs
- POI accessibility data (e.g., existence of stairs, elevators)
- Lived experience testimonials about “feeling” of a place
- Transit data (e.g., locations of metro stops)
- Geographic features labels (e.g., parks, water bodies, major arterials)

**Metrics**
- Problem count, severity (raw metrics)
- Total count, access scores, priority scores (aggregated/modelled metrics)
Diverse assessment factors needed to be balanced for making decisions across these contexts.

**RQ1: Key Visual Analytic Tasks and Data Needs**

**FINDINGS:**

Tasks and data needs

**Primary Accessibility Datasets**

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<tr>
<th>Stakeholder Interests</th>
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<th>Data Needs</th>
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<tr>
<td><strong>Macro (High) Level</strong></td>
<td>Analysis Goal (high-level) (access to healthcare, jobs)</td>
<td>quantitative datasets (sidewalk accessibility data (e.g., raw problem count), population density (e.g., data on people with disabilities), demographics (e.g., racial distribution, income levels), topographical/terrain (e.g., elevation, slope), pedestrian traffic and collision data, POI density (residential + business density), high-travelled destinations (POIs), job data (for people with disabilities), historical context (e.g., trends on investments made))</td>
</tr>
<tr>
<td><strong>Task Spectrum</strong></td>
<td>Analysis Strategy (mid-level) (navigability, connectivity, livability)</td>
<td>qualitative datasets (nature of problems (e.g., types of sidewalk obstacles), images of problems, locations of POIs, POI accessibility data (e.g., existence of stairs, elevators), lived experience testimonials about &quot;feeling&quot; of a place, transit data (e.g., locations of metro stops), geographic features labels (e.g., parks, water bodies, major arterials))</td>
</tr>
<tr>
<td><strong>Micro (Low) Level</strong></td>
<td>Analysis Task (low-level) (sidewalk, POI, transit accessibility)</td>
<td>metrics (problem count, severity (raw metrics), total count, access scores, priority scores (aggregated/modeled metrics))</td>
</tr>
</tbody>
</table>

**Stakeholder Interests:**

- PM
- DO
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Diverse assessment factors needed to be balanced for making decisions across these contexts

**RQ1: KEY VISUAL ANALYTIC TASKS AND DATA NEEDS**

**FINDINGS:**
- **Tasks and Data Needs**

**Quantitative Datasets**
- Sidewalk accessibility data (e.g., raw problem count)
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**Analysis Task Needs**
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- **Analysis Strategy**
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- **Analysis Task**
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**Stakeholder Interests**
- Macro (High) Level
  - PM
  - DO
- Micro (Low) Level
  - MI
  - CVG

**Data Needs**
- Impact analyses
- Equity analyses

**Datasets**
- Primary Accessibility Datasets
  - Sidewalk, POI, transit
- Complementary Datasets
  - POI density, population density, demographics, income, collision data

**Multi-Layered Task Model for Urban Accessibility**

**Stakeholder Interests**
- PM
- DO
- MI
- CVG

**Analysis Task Needs**
- Analysis Goal
  - High-level (access to healthcare, jobs)
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**Findings: Tasks and Data Needs**

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**Macro (High) Level**
- Analysis Goal: High-level (access to healthcare, jobs)
- Analysis Strategy: Mid-level (navigability, connectivity, livability)
- Analysis Task: Low-level (sidewalk, POI, transit accessibility)

**Complementary Datasets**
- POI density, population density, demographics, income, collision data

**Primary Accessibility Datasets**
- Sidewalk, POI, transit

**Stakeholder Interests**
- PM (PM)
- DO (DO)
- MI (MI)
- CVG (CVG)

**Analysis Task Needs**
- Impact analyses
- Equity analyses

**Data Needs**

**Multi-Layered Task Model for Urban Accessibility**
Findings: Categories

Key
Data + Task Needs

RQ1

Sensemaking practices and differences

RQ2
Findings

**CATEGORIES**

Key Data + Task Needs
RQ1

Sensemaking practices and differences
RQ2
FINDINGS: SENSEMAKING PRACTICES

RQ2: HOW DO KEY STAKEHOLDERS’ SENSEMAKING PRACTICES DIFFER?

Personal experiences drove sensemaking

Contextualizing patterns is a core sub-task

Personally relevant assessment factors influenced metrics used

Supporting diverse accessibility needs is key

Stakeholders’ decision context influenced map choices
FINDINGS: SENSEMAKING PRACTICES

RQ2: HOW DO KEY STAKEHOLDERS’ SENSEMAKING PRACTICES DIFFER?

Personal experiences drove sensemaking

Contextualizing patterns is a core sub-task

Personally relevant assessment factors influenced metrics used

Supporting diverse accessibility needs is key

Stakeholders’ decision context influenced map choices
Personal experiences drove sensemaking

Accessibility  Familiarity

Location  Familiarity

Map  Familiarity
RQ2: How do key stakeholders’ sensemaking practices differ?

Personal experiences drove sensemaking

Accessibility Familiarity

Location Familiarity

Map Familiarity

“...What I’m looking for here [StreetVis] is not just redness, but the distribution of redness across a particular area as it connects to other red markings...”

P7AC, an advocate analyzing connectivity
RQ2: HOW DO KEY STAKEHOLDERS’ SENSEMAKING PRACTICES DIFFER?

Personal experiences drove sensemaking

Accessibility Familiarity

Location Familiarity

Map Familiarity

Map’s utility depended on the alignment with a user’s mental models
**RQ2: HOW DO KEY STAKEHOLDERS’ SENSEMAKING PRACTICES DIFFER?**

Personal experiences drove sensemaking

Accessibility Familiarity

Location Familiarity

Map Familiarity

Map’s utility depended on the alignment with a user’s mental models
Key Data + Task Needs

RQ1

How do we handle the diverse assessment factors needed across varied decision-making contexts for urban accessibility?

Sensemaking practices and differences

RQ2

How did individual differences in stakeholders' needs and experiences impact sensemaking processes?
Findings: Categories

Key Data + Task Needs RQ1

How do we handle the diverse assessment factors needed across varied decision-making contexts for urban accessibility?

Sensemaking practices and differences RQ2

How did individual differences in stakeholders' needs and experiences impact sensemaking processes?

Given these challenges, how might we utilize interactive visualizations to support communication and decision-making needs for urban accessibility?
<table>
<thead>
<tr>
<th>Design Considerations (C)</th>
<th>Example Application of Design Considerations</th>
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<tbody>
<tr>
<td>Establishing Data Trust</td>
<td></td>
</tr>
<tr>
<td>C1: Make clear where the data comes from (Data Provenance)</td>
<td>Document data sources and collection information</td>
</tr>
<tr>
<td>C2: Make clear how data is modeled (Analytic Provenance)</td>
<td>Provide explanation of the algorithms/models used</td>
</tr>
<tr>
<td>Handling Diverse Assessment Factors</td>
<td></td>
</tr>
<tr>
<td>C3: Support for adding diverse datasets</td>
<td>Advocates can add their personally collected data in their desired format (e.g., Excel, CSV)</td>
</tr>
<tr>
<td>C4: Support multivariate analysis: both analyzing across accessibility assessment factors and visualizing diverse datasets</td>
<td>Policymakers assess the impact of inaccessible infrastructure on MI individuals to reveal inequities</td>
</tr>
<tr>
<td>Supporting Shared Stakeholder Tasks</td>
<td></td>
</tr>
<tr>
<td>C5: Support for varied, often conflicting, stakeholder group needs</td>
<td>MI/Caregivers assess navigability of a neighborhood Department officials assess equity in distribution and prioritization of resources and investments</td>
</tr>
<tr>
<td>C6: Support for individual differences (e.g., familiarity with maps, accessibility, location)</td>
<td>MI/Caregivers’ view tailored to localized data and neighborhood and street level maps (e.g., Isochrones)</td>
</tr>
<tr>
<td>C7: Support for adjusting to visualization user needs as an analyst or target consumer</td>
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</tr>
<tr>
<td>Supporting Comparisons</td>
<td></td>
</tr>
<tr>
<td>C8: Make it easy to compare between multiple data, map, and geo-contextual views (e.g., providing historical context on accessibility investments across locations)</td>
<td>Department officials comparing accessibility of multiple locations within and across cities</td>
</tr>
<tr>
<td>Building Persuasive Stories</td>
<td></td>
</tr>
<tr>
<td>C9: Support for audience-driven message framing by adding relevant contextual data</td>
<td>Framing for policymakers: show impact of investments on citizen’s quality of life</td>
</tr>
<tr>
<td>C10: Support for exporting audience-driven stories in multiple visualization formats</td>
<td>Framing for MI/Caregivers: show impact of inaccessibility on their personal life</td>
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</table>
Design Considerations

- Data Trust
- Diverse Factors
- Shared Tasks
- Supporting Comparisons
- Building Persuasive Stories
ACKNOWLEDGEMENTS

TEAM

Professors

Jon Froehlich  Jeffrey Heer

Students

Siddhant Patil  Emily Cho  Evie (Yu-Yen) Cheng  Chris Horng

Devanshi Chauhan  Rachel Kangas  Richard McGovern  Anthony Li

https://makeabilitylab.cs.washington.edu/people/
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CREATE
Center for Research and Education on Accessible Technology and Experiences
UNIVERSITY of WASHINGTON
Visualizing Urban Accessibility
Investigating Multi-Stakeholder Perspectives through a Map-based Design Probe Study

Key Theme
Socio-political and personal nature of urban accessibility influenced how stakeholders understand and use visualizations

Accessibility  Location  Map/Data Analysis Skills

Key Findings
Personally relevant assessment metrics were used during sensemaking
Maps complying with personal mental models of accessibility were preferred
Relevance to individual decision-making context was a key determinant

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On the job market! Industry research

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