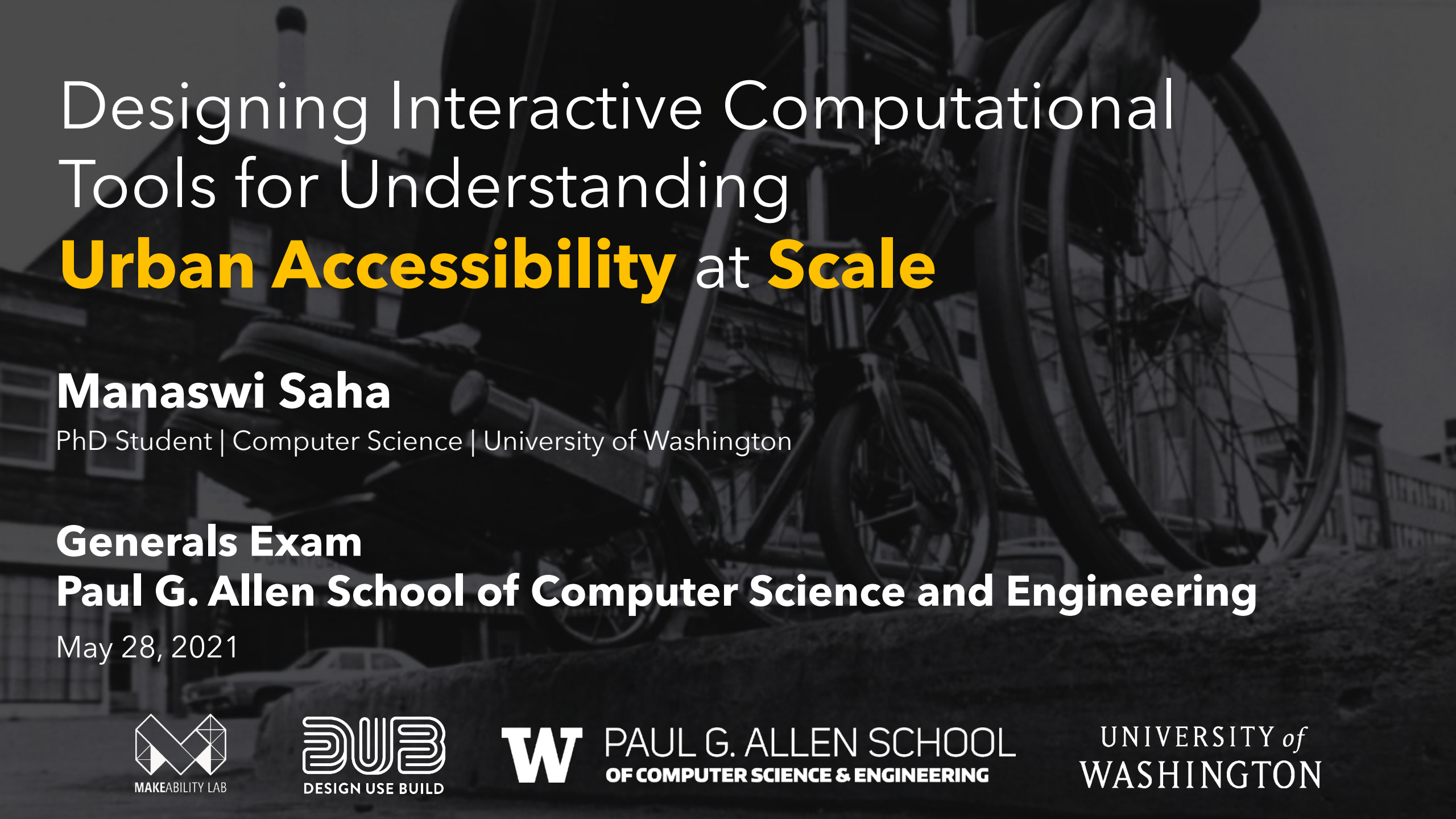


# Designing Interactive Computational Tools for Understanding **Urban Accessibility** at **Scale**


**Manaswi Saha**

PhD Student | Computer Science | University of Washington


**Generals Exam**

**Paul G. Allen School of Computer Science and Engineering**

May 28, 2021

MAKEABILITY LAB

DESIGN USE BUILD

PAUL G. ALLEN SCHOOL OF COMPUTER SCIENCE & ENGINEERING

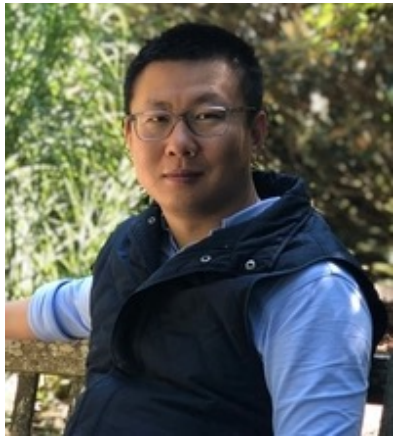
UNIVERSITY of WASHINGTON

INTRODUCTION

# COMMITTEE MEMBERS

**Jon Froehlich (Chair)**
Associate Professor
Computer Science

**Jeffrey Heer**
Professor
Computer Science



**Bo Zhao (GSR)**
Assistant Professor
Geography

**Anat Caspi**
Affiliate Asst. Professor
Electrical and
Computer Engg.

**Bill Howe**
Associate Professor
Information School

# Urban Accessibility

*Ease of reaching destinations or activities*

**Buildings** **Transit** **Pedestrian infrastructure**

INTRODUCTION

# DISSERTATION FOCUS


**Sidewalks**

*Pedestrian infrastructure*

**Mobility disability**

*People using Mobility Aids - MI individuals*

# 30.6

**million U.S. adults have a mobility impairment**

Source: US Census, 2010

# 15.2

## million use an assistive aid

Source: US Census, 2010


144 Spring St
New York
Google
Street View
CHANEL
CHANEL
CHANEL
CHANEL
CHANEL
WOOSTER ST
ONE WAY
NO PARKING
DIESEL
Spring St
Broadway-Lafayette
Station B, D, F, M
Prince St
Tap
SOHO
Google


144 Spring St
New York
Google
Street View
CHANEL
CHANEL
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ONE WAY
NO PARKING
DIESEL
NO CURB RAMPS
Spring St
Broadway-Lafayette Station B, D, F, M
Prince St
Tap
SOHO
Google


PHYSICAL OBSTACLES


SURFACE PROBLEMS


FedEx
INCOMPLETE SIDEWALKS


PHYSICAL OBSTACLES
NO CURB RAMP
SURFACE DEGRADATION

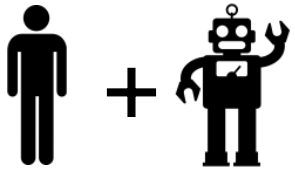

Accessible infrastructure
has a significant impact
on the **independence**
and **mobility of citizens**
[Thapar *et al.,* 2004 ; Nuernberger, 2008]

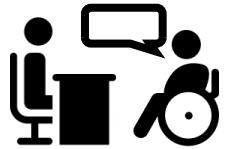
# MY TWO-FOLD VISION

**Transform** how we collect, quantify, visualize, and communicate urban accessibility data through interactive computational tools

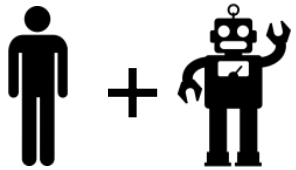
1. **Mapping** the physical accessibility of the world for people with mobility disabilities
2. **Empowering** people to bring about social change

# Urban Accessibility as a Three-Pronged Problem

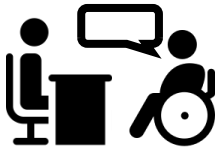




# People/Infrastructure Problem



# Data Problem



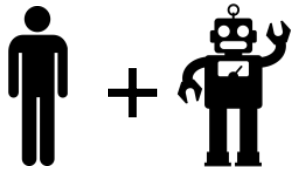
# Tool Problem

3 Research Problems and Threads

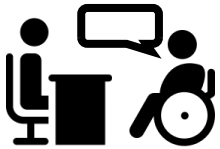
## Urban Accessibility as a Three-Pronged Problem

**Social-Political Environment Analysis**

**RQ1:** *Understanding the assessment / decision-making needs*:
"How do stakeholders assess urban accessibility and what are the factors in their decision-making processes ?"



**Data Problem**



**Tool Problem**

**Urban Accessibility as a Three-Pronged Problem**

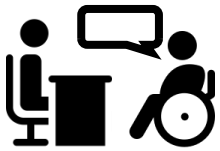
**3 Research Questions and Threads**

**Social-Political Environment Analysis**

**RQ1:** *Understanding the assessment / decision-making needs*: "How do stakeholders assess urban accessibility and what are the factors in their decision-making processes ?"

**RQ2**: *Creating comprehensive datasets:* "How do we gather sidewalk accessibility data at scale?"

**Scalable Data Collection**



**Tool Problem**

**3 Research Questions and Threads**

## Urban Accessibility as a Three-Pronged Problem

**Social-Political Environment Analysis**

**RQ1:** *Understanding the assessment / decision-making needs*: "How do stakeholders assess urban accessibility and what are the factors in their decision-making processes ?"

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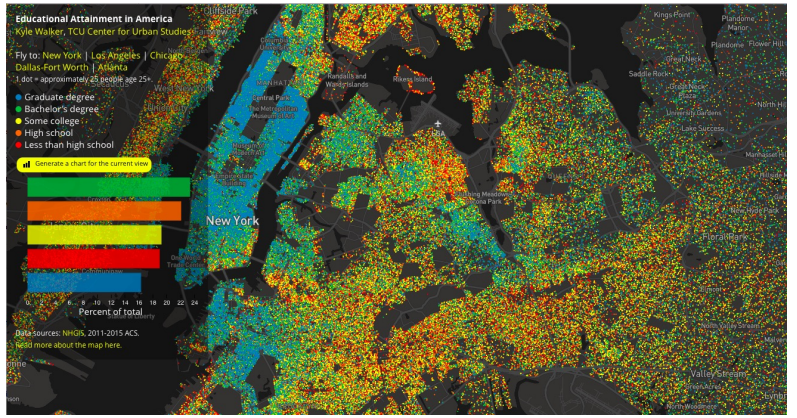



**Interactive Geovisual Analytics**

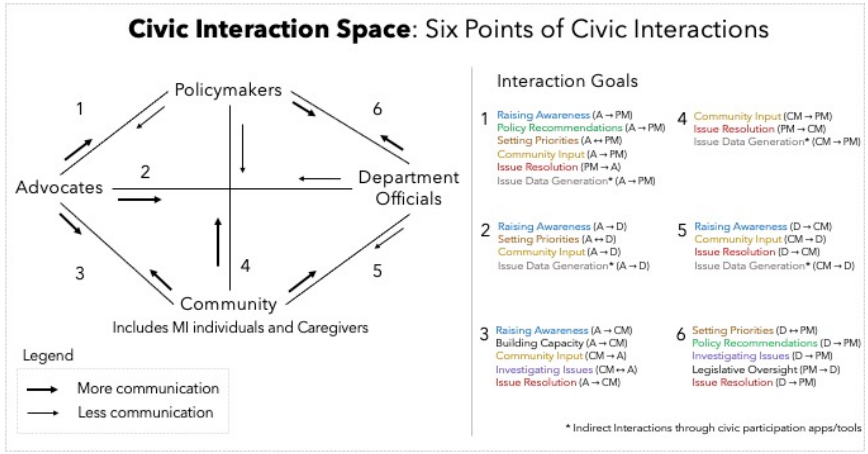
## Research Goals

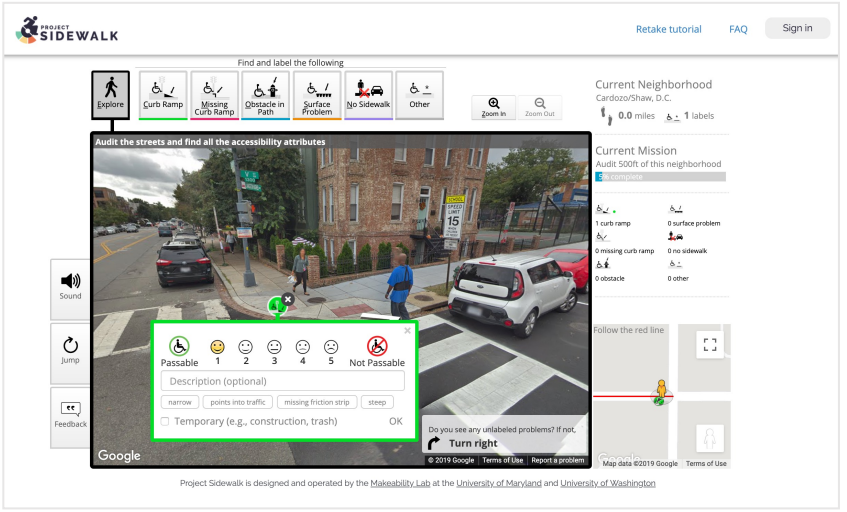
**Communication**
**Advocacy**
**Policymaking**

**RQ3:** *Utilizing sidewalk data to support the assessment / decision making needs*: "How might we utilize interactive visualizations of sidewalk data to facilitate effective decision-making, communication, and advocacy?"

**3 Research Questions and Threads**

## Urban Accessibility as a Three-Pronged Problem




## Socio-Political Environment Analysis

*Urban Accessibility as a Socio-Political Problem: A Multi-Stakeholder Analysis*
*CSCW'20*

# Understanding Urban Accessibility at Scale

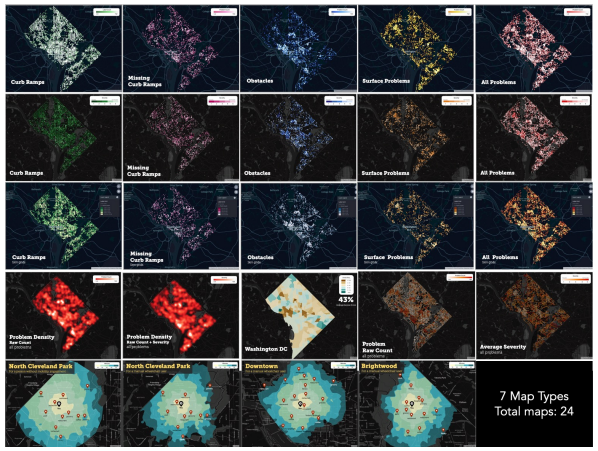
*Work Outline*

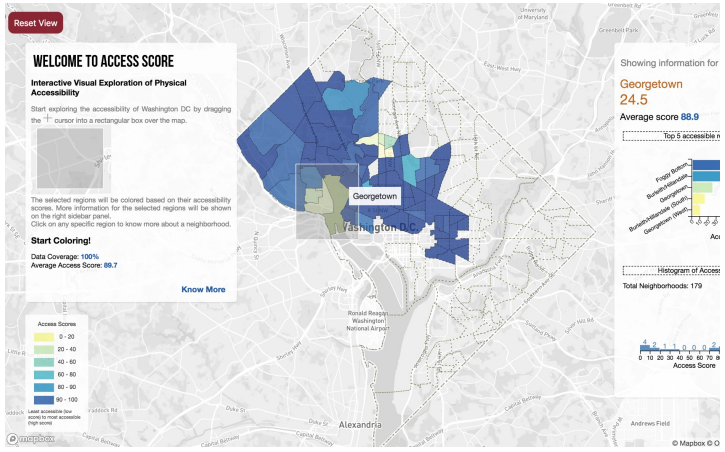
## Scalable Data Collection

*Project Sidewalk*
*CHI'19 | ASSETS'17*

## Interactive Geovisual Analytics

Goal: Developing design guidelines for interactive geovisualization tools
*Preliminary Work (ASSETS'18)*




***Ongoing***: *Study 1* using paper map visualization prototypes
*Target: CHI'22*

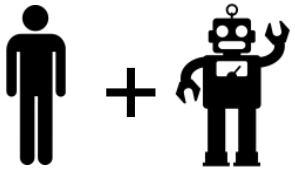
***Proposed***: *Study 2* using interactive visualization prototypes
*Target: CHI'23*

INTRODUCTION

# TALK OUTLINE

**30%**
**PAST**

**People/Infrastructure Problem**
Understanding the Socio-Political Civic Environment



**30%**
**PAST**

**Data Problem**
Addressing lack of data using crowdsourcing

**Tool Problem**
Developing accessibility-aware applications

**40%**
**ONGOING + PROPOSED**

INTRODUCTION

# KEY STAKEHOLDERS

# KEY STAKEHOLDERS

MI individuals

Caregivers

Advocates

.gov

Policymakers
Elected Officials

Department Officials
DOTs

# KEY STAKEHOLDERS

MI individuals

Caregivers

**People affected by inaccessible infrastructure**

Policymakers
Elected Officials

Advocates

Department Officials
DOTs

# KEY STAKEHOLDERS

MI individuals

**People who can bring change i.e., improve accessibility**

Caregivers

Advocates


Policymakers

Elected Officials

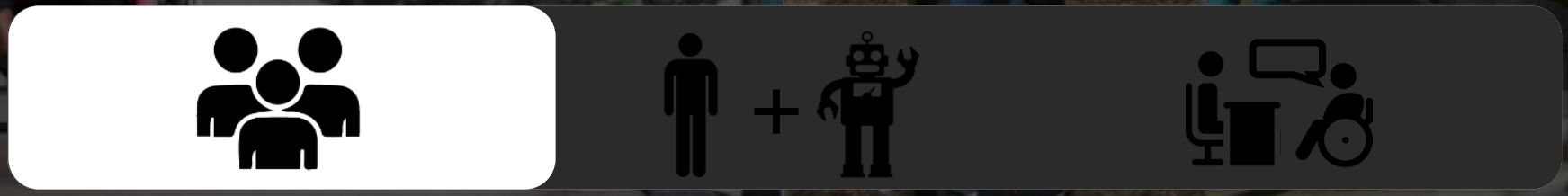
Department Officials

DOTs

# People and Infrastructure Problem: Socio-Political Environmental Analysis

RQ1: How do stakeholders assess urban accessibility and what are the factors in their decision-making processes?

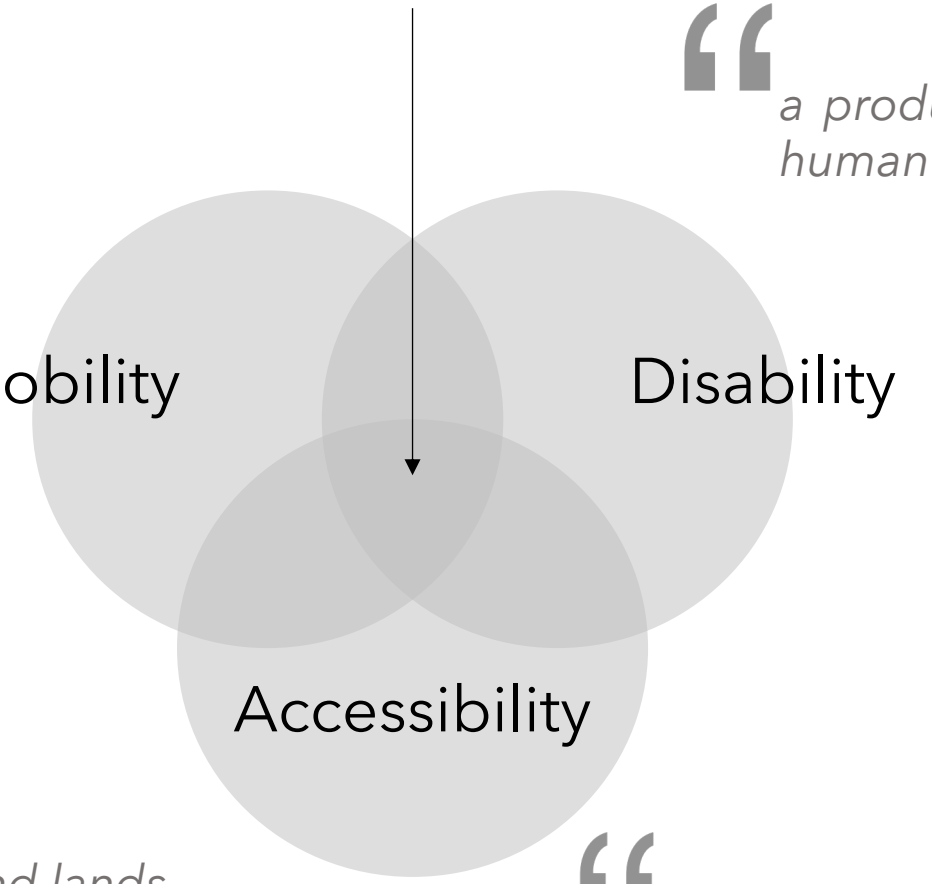
*Past Work*



PART 1: PEOPLE/INFRASTRUCTURE PROBLEM

# DEFINITIONS!

## Urban Accessibility




Trip rate
Proximity to destinations

> *a product of a dynamic interaction of human and the environment*
>
> (Hahn, 1985)

Urban Planning and Transportation

Human Geography

Disability Studies

Urban Sociology

> *Interactions between human and lands*
>
> (Hansen, 1959)

> *The ease or difficulty for people to reach opportunities and services*
>
> (Dalvi and Martin, 1976
> Wachs and Kumagai, 1973)

PART 1: PEOPLE/INFRASTRUCTURE PROBLEM

# SOCIO-POLITICAL MODEL OF DISABILITY

Social, Cultural, Economic, and Political Environment

**Individual**

*Hahn, H. (1985). "Toward a politics of disability: Definitions, disciplines, and policies". The Social Science Journal.*

# 1

What is the **socio-political context** of urban accessibility?

# 2

How do we enable **change** in the **socio-political context** of urban accessibility?

PART 1: PEOPLE/INFRASTRUCTURE PROBLEM : : METHOD

# INTERVIEW STUDY

**25 participants** across **3 cities**

**Multi-stakeholder** approach with **five** stakeholder groups

Questions around **assessment** approaches and **decision-making** practices

# KEY RESEARCH QUESTIONS

**RQ1** What are the information needs and challenges for assessing and making decisions around urban accessibility and the role of data and technology?

**RQ2** How do stakeholder groups communicate and interact together to assess priorities and make decisions?

**RQ3** What are the future design opportunities to improve existing assessment and decision-making practices?

# STAKEHOLDER PERSPECTIVE OVERVIEW

MI individuals

Safety and quality of physical access
Freedom and support to travel around a city

Caregivers

Advocates

Represent people in need
Fight for their rights and change the status quo
Closely engage with both citizens and government officials


Policymakers
Elected Officials

Department Officials
DOTs

# STAKEHOLDER PERSPECTIVE OVERVIEW

MI individuals

Caregivers

Advocates


Developing laws and policies
Prioritization and equitable distribution of resources
Manage funding amongst many competing issues

Policymakers
Elected Officials

Execute policies and make accessibility improvements
Schedule and prioritize maintenance projects
Allocate available funds to specific projects
Conduct ground assessments of urban infrastructure

Department Officials
DOTs

# FINDINGS OVERVIEW

**Data and Technology** Practices for Accessibility Assessments

**Interactions** between Stakeholders for Accessible Infrastructure Development

**Decision-Making Practices** for Accessible Infrastructure Development

**Challenges** in Accessible Infrastructure Development

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FINDINGS

# DATA AND TECHNOLOGY PRACTICES

## Two methods

In-person methods

Technology-based methods

FINDINGS

# DATA AND TECHNOLOGY PRACTICES

## Two methods

In-person methods

Technology-based methods

FINDINGS: DATA AND TECHNOLOGY PRACTICES

# TECHNOLOGY-BASED METHODS

## Remote Assessments

Department Officials

+ Caregivers


Policymakers

Advocates

*"As a legislator, we very **rarely got briefed with visual tools**. It was very sad."*

*"Honestly as an advocate, we would have been much more likely to **use finely grained visual tools** so that we could, from the ground up, **help develop policy**."*

~P18PM

FINDINGS: DATA AND TECHNOLOGY PRACTICES

# TECHNOLOGY-BASED METHODS

Remote Assessments







Most **commercial tools** are **not developed** keeping **accessibility needs in mind**; **insufficient** during actual usage.

Department Officials

Policymakers





Advocates

+ Caregivers

"*As a legislator, we very **rarely got briefed with visual tools**. It was very sad.*"

"*Honestly as an advocate, we would have been much more likely to **use finely grained visual tools** so that we could, from the ground up, **help develop policy**.*"

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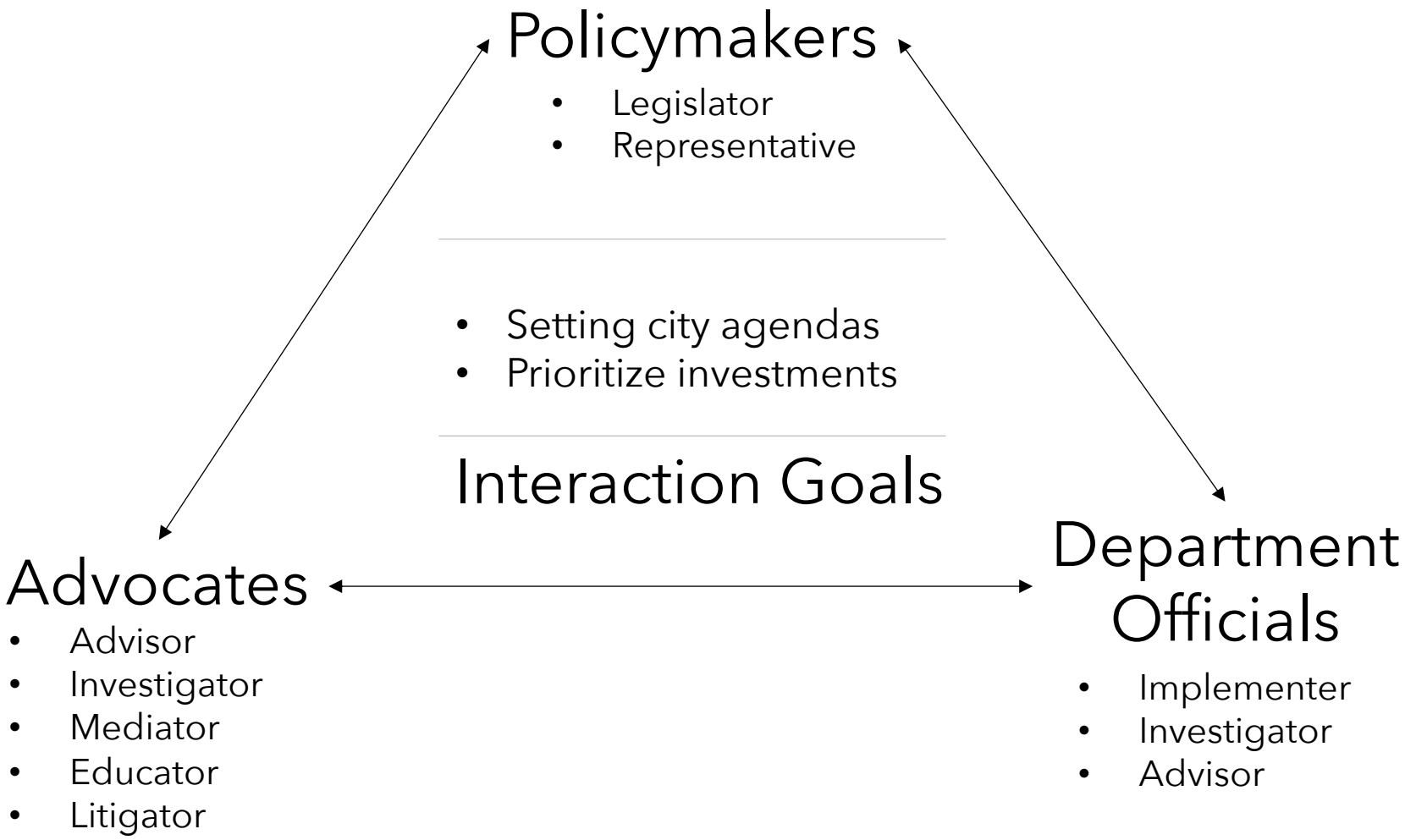
# INTERACTIONS BETWEEN STAKEHOLDERS



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**Challenges** in Accessible Infrastructure Development

# DECISION-MAKING PRACTICES

## Prioritization Practices

**Impact assessment** is crucial: equity, gentrification

> *The **city has a commitment**, and I have a commitment personally, [...] to try to make our city more equitable. To the extent that **inequities exist**, and they exist massively in [City-name], we need to be **making disproportionate investments** to **undo the disproportionate investments** that were made by prior generations.*
>
> ~P25PM

FINDINGS

# DECISION-MAKING PRACTICES

## Prioritization Practices

Impact assessment is crucial: equity, gentrification

Several **prioritization approaches** used

- infrastructure utilization
- proximity to destinations
- area demographics
- citizen complaints
- population density
- accessibility comparison

# FINDINGS OVERVIEW

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# CHALLENGES IN ACCESSIBLE INFRASTRUCTURE DEVELOPMENT

## Social, political, and economic challenges

Lack of political will

Lack of public interest

Conflicting responsibilities and priorities

Inconsistent regulations

Insufficient funding

# CHALLENGES IN ACCESSIBLE INFRASTRUCTURE DEVELOPMENT

Social, political, and economic challenges

Lack of political will

Lack of public interest

Conflicting responsibilities and priorities

Inconsistent regulations

Insufficient funding

## Public disinterest influences Political will

*At the end of the day, it becomes a political discussion of how much money do we think the citizens are willing to vote for...at the end of the day, it's going to be nine council members and the mayor deciding, '**here's what we think the population will bear**', and it becomes more of a **political discussion and less of a policy**.*

~P17PM

How do we enable **change** in the socio-political context of urban accessibility?

# KEY OBSERVATIONS

**Tools and data** enabled a lot of the decision-making process

**Collective voice** played a role in changing the status quo

Example: Disability activism, citizen complaints

# KEY OBSERVATIONS

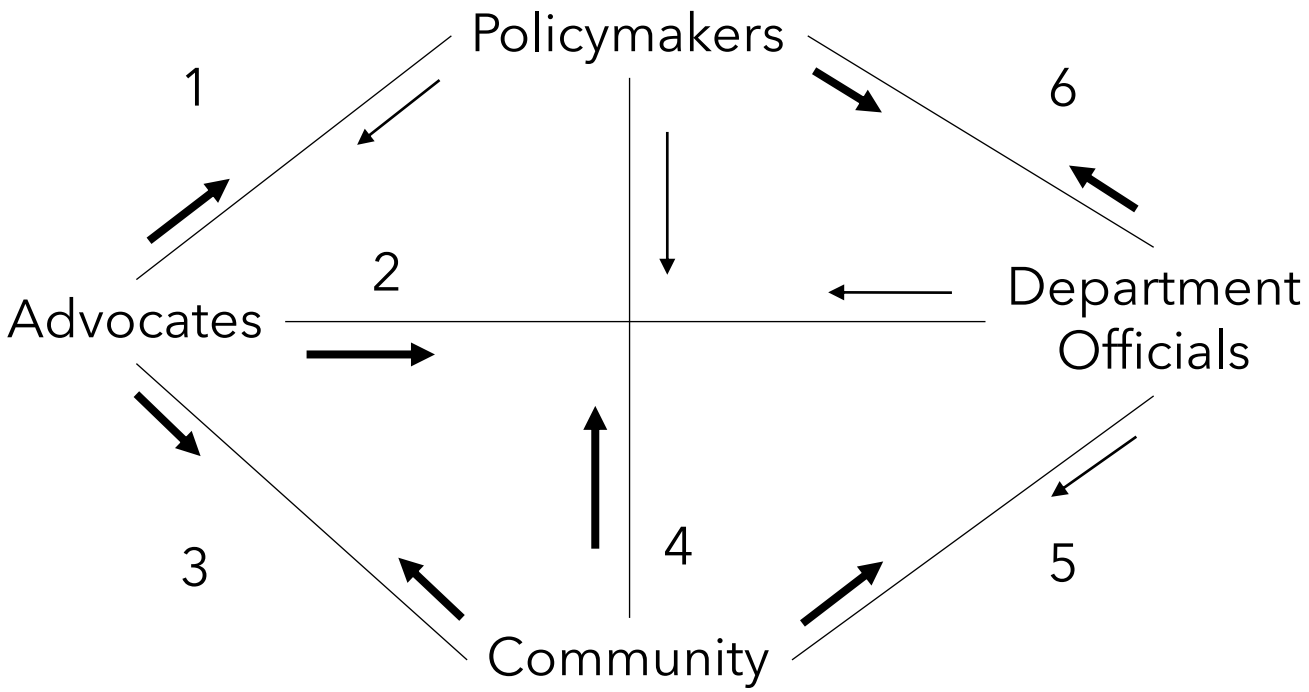
**Tools and data** enabled a lot of the decision-making process

**Collective voice** played a role in changing the status quo

Example: Disability activism, citizen complaints

How do we facilitate **civic interactions** through technology?

# **Civic Interaction Space**: Six Points of Civic Interactions




Includes MI individuals and Caregivers

Legend

- More communication
- Less communication

## Interaction Goals

**1**
- Raising Awareness (A → PM)
- Policy Recommendations (A → PM)
- Setting Priorities (A ↔ PM)
- Community Input (A → PM)
- Issue Resolution (PM → A)
- Issue Data Generation* (A → PM)

**2**
- Raising Awareness (A → D)
- Setting Priorities (A ↔ D)
- Community Input (A → D)
- Issue Data Generation* (A → D)

**3**
- Raising Awareness (A → CM)
- Building Capacity (A → CM)
- Community Input (CM → A)
- Investigating Issues (CM ↔ A)
- Issue Resolution (A → CM)

**4**
- Community Input (CM → PM)
- Issue Resolution (PM → CM)
- Issue Data Generation* (CM → PM)

**5**
- Raising Awareness (D → CM)
- Community Input (CM → D)
- Issue Resolution (D → CM)
- Issue Data Generation* (CM → D)

**6**
- Setting Priorities (D ↔ PM)
- Policy Recommendations (D → PM)
- Investigating Issues (D → PM)
- Legislative Oversight (PM → D)
- Issue Resolution (D → PM)

* Indirect Interactions through civic participation apps/tools

# SOME FOCUS AREAS

## Improving **Community Input and Government Feedback**

(increase government feedback – more transparency)

## Supporting **Advocacy Efforts**

(providing tool support to organize efforts well – make data gathering easier)

# CONTRIBUTIONS

Developed a deeper understanding of the **interactions** and **tensions between stakeholders** (decision makers)

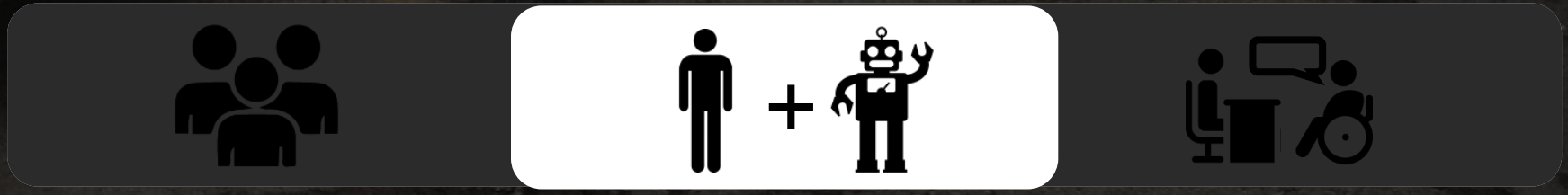
Mapped out these interactions in a **Civic Interaction Space** for future **technological interventions** facilitating decision-making and communication between stakeholders

Published at **CSCW 2020**: Saha, M., Chauhan, D., Patil, S., Kangas, R., Heer, J., & Froehlich, J. E. (2021). ***Urban Accessibility as a Socio-Political Problem: A Multi-Stakeholder Analysis***. Proceedings of the ACM on Human-Computer Interaction, 4(CSCW3), 1-26.

# Data Problem: Scalable Data Collection

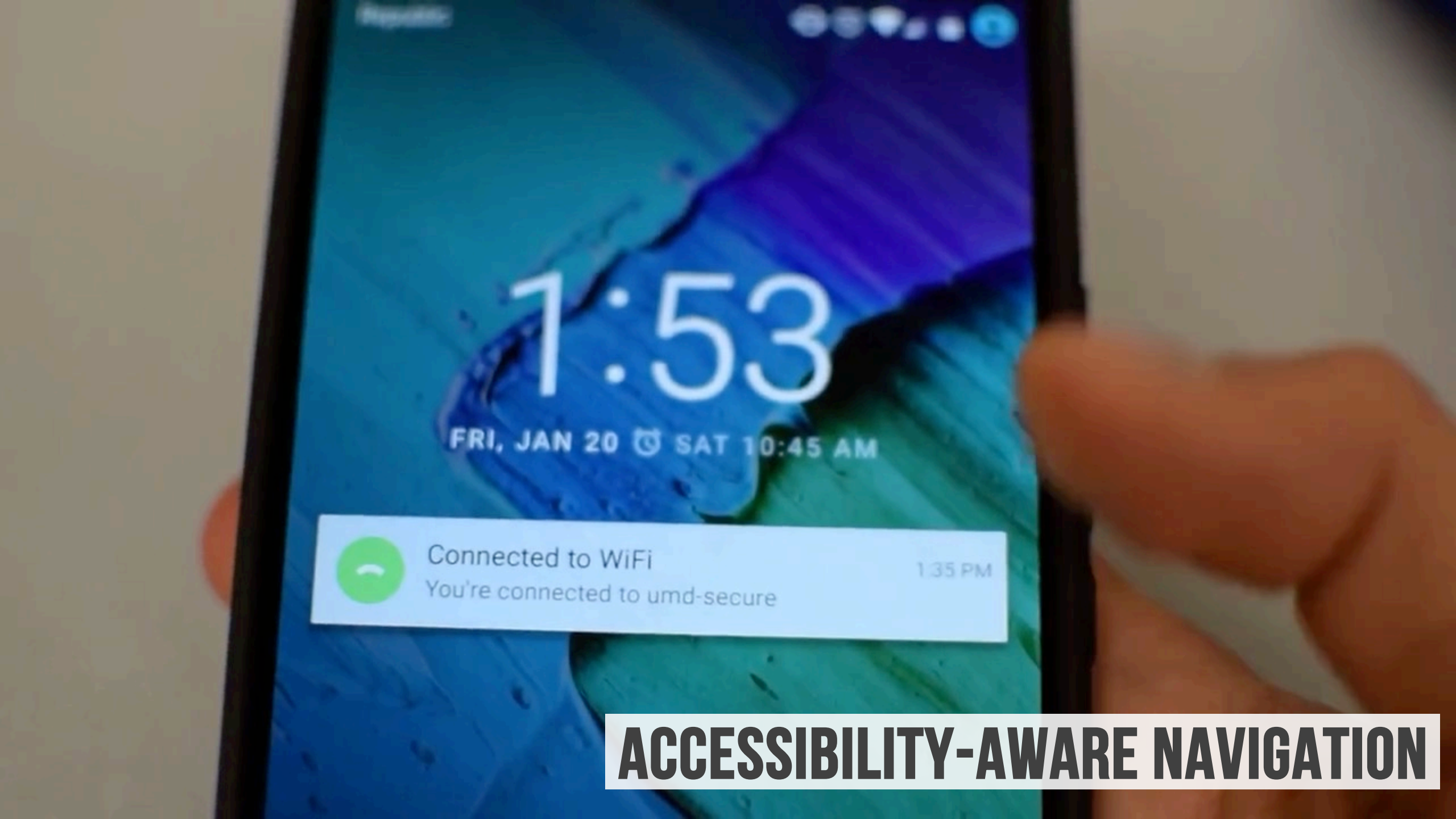
RQ2: how can we gather sidewalk accessibility data at scale?

*Past Work*

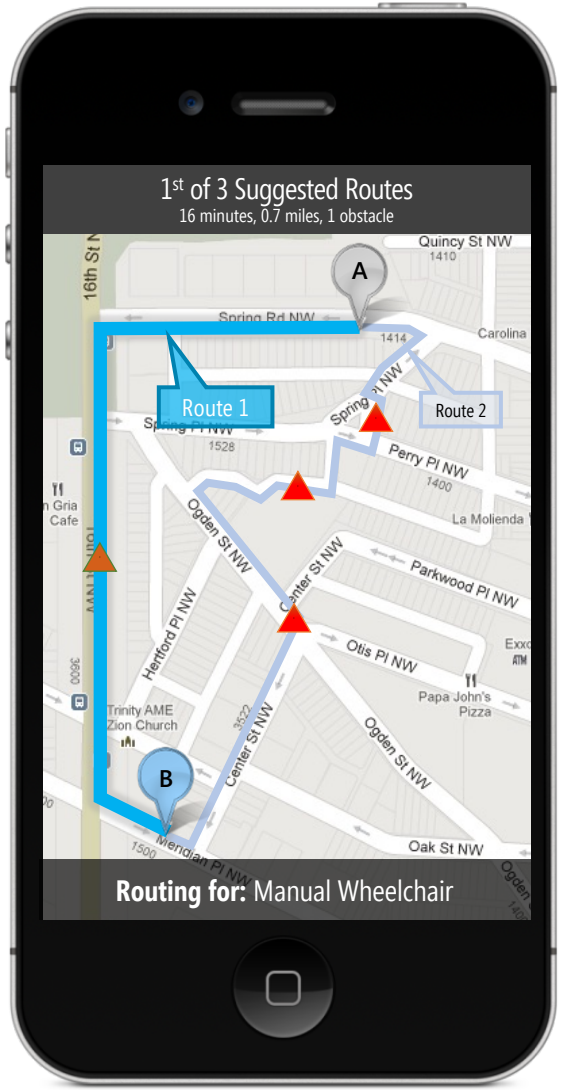


The National Council on Disability noted that there is **no comprehensive information** on “the degree to which sidewalks are accessible” in cities.

**National Council on Disability**, 2007
The impact of the Americans with Disabilities Act: Assessing the progress toward achieving the goals of the ADA


1:53
FRI, JAN 20
SAT 10:45 AM
Connected to WiFi
1:35 PM
You're connected to umd-secure
ACCESSIBILITY-AWARE NAVIGATION

# ACCESSIBILITY-AWARE NAVIGATION




Routing for
Manual Wheelchair User


Alternative routes

Mobility barriers along the route

Reset View

# WELCOME TO ACCESS SCORE

**Interactive Visual Exploration of Physical Accessibility**

Start exploring the accessibility of Washington DC by dragging the + cursor into a rectangular box over the map.

The selected regions will be colored based on their accessibility scores. More information for the selected regions will be shown on the right sidebar panel.
Click on any specific region to know more about a neighborhood.

**Start Coloring!**

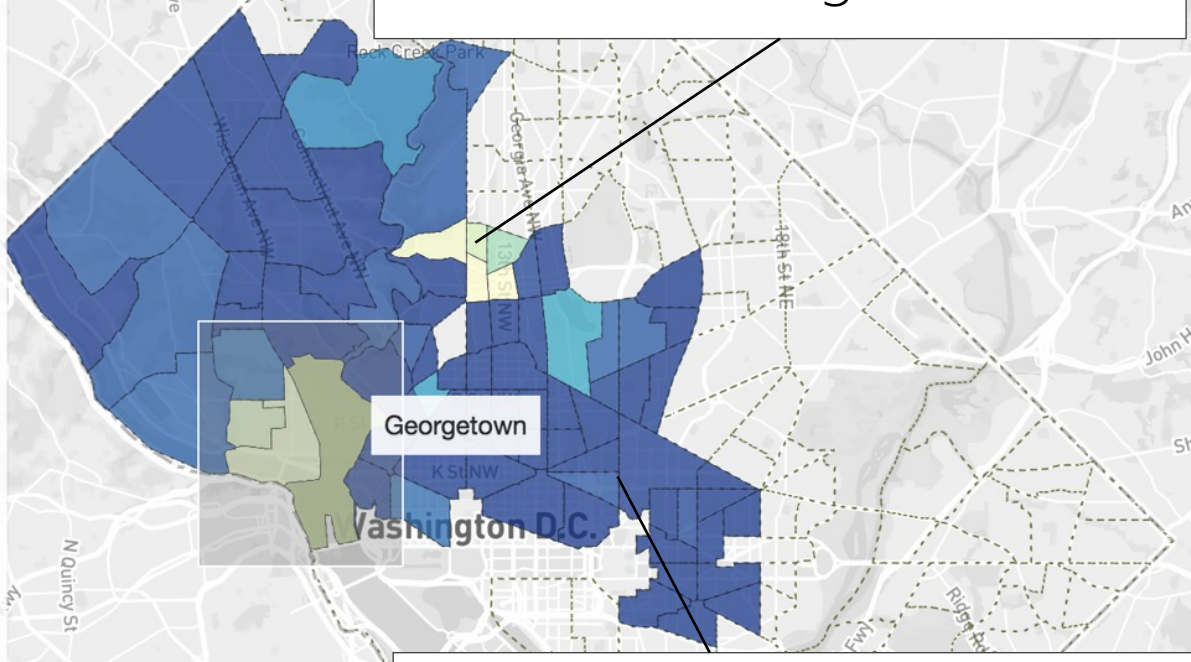
Data Coverage: **100%**
Average Access Score: **89.7**

**Know More**

Access Scores
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 90
- 90 - 100

Least accessible (low score) to most accessible (high score)

**Green-Yellows** indicate inaccessible neighborhoods



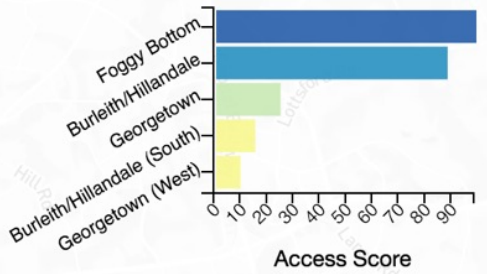

**Blues** indicate an accessible neighborhoods

Showing information for the selected area

Georgetown
24.5

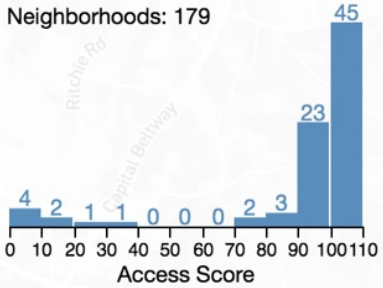
Average score **88.9**

Top 5 accessible regions




Histogram of Access Scores

Total Neighborhoods: 179




# INTERACTIVE VISUALIZATION OF ACCESSIBILITY DATA

THESE APPLICATIONS HAVE

# HUGE DATA

REQUIREMENTS

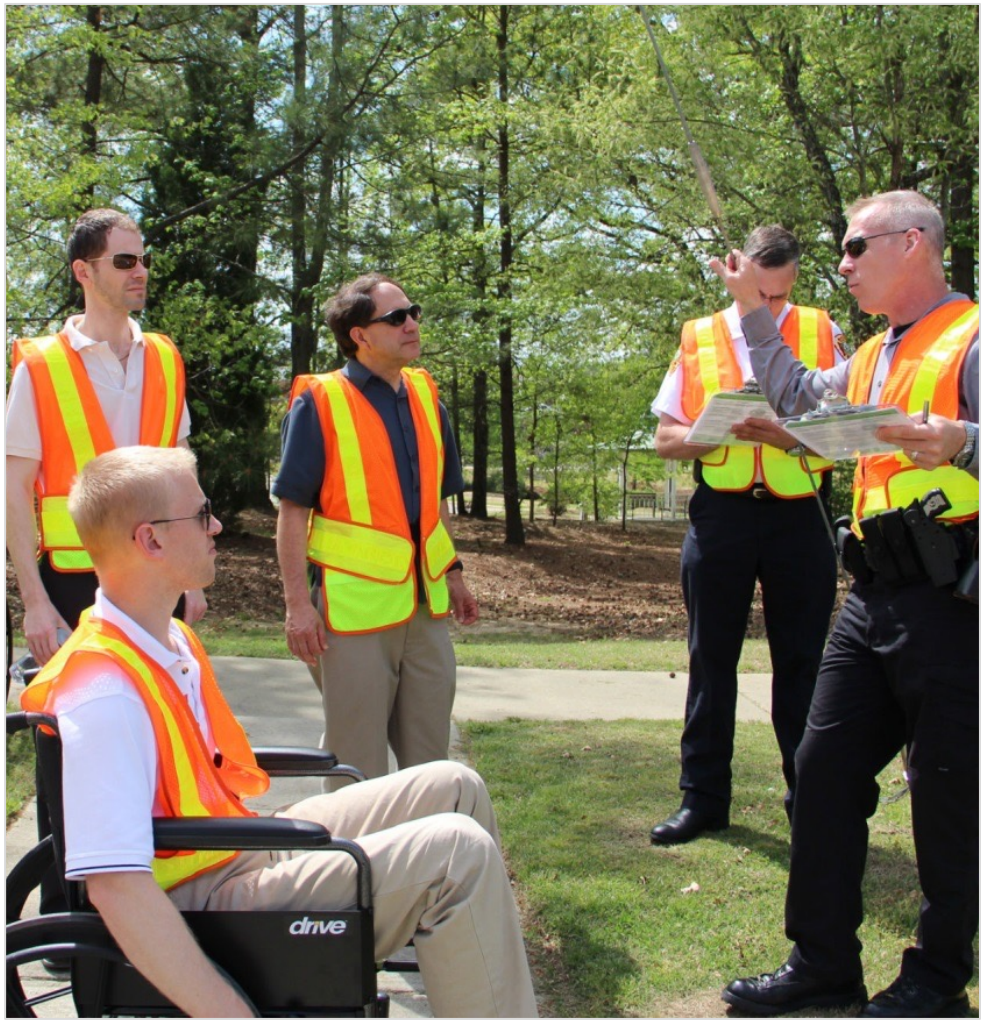
THESE APPLICATIONS HAVE

# HUGE DATA REQUIREMENTS

How do we get this data?

PART 2: DATA PROBLEM : : MOTIVATION

# TRADITIONAL PHYSICAL AUDITS

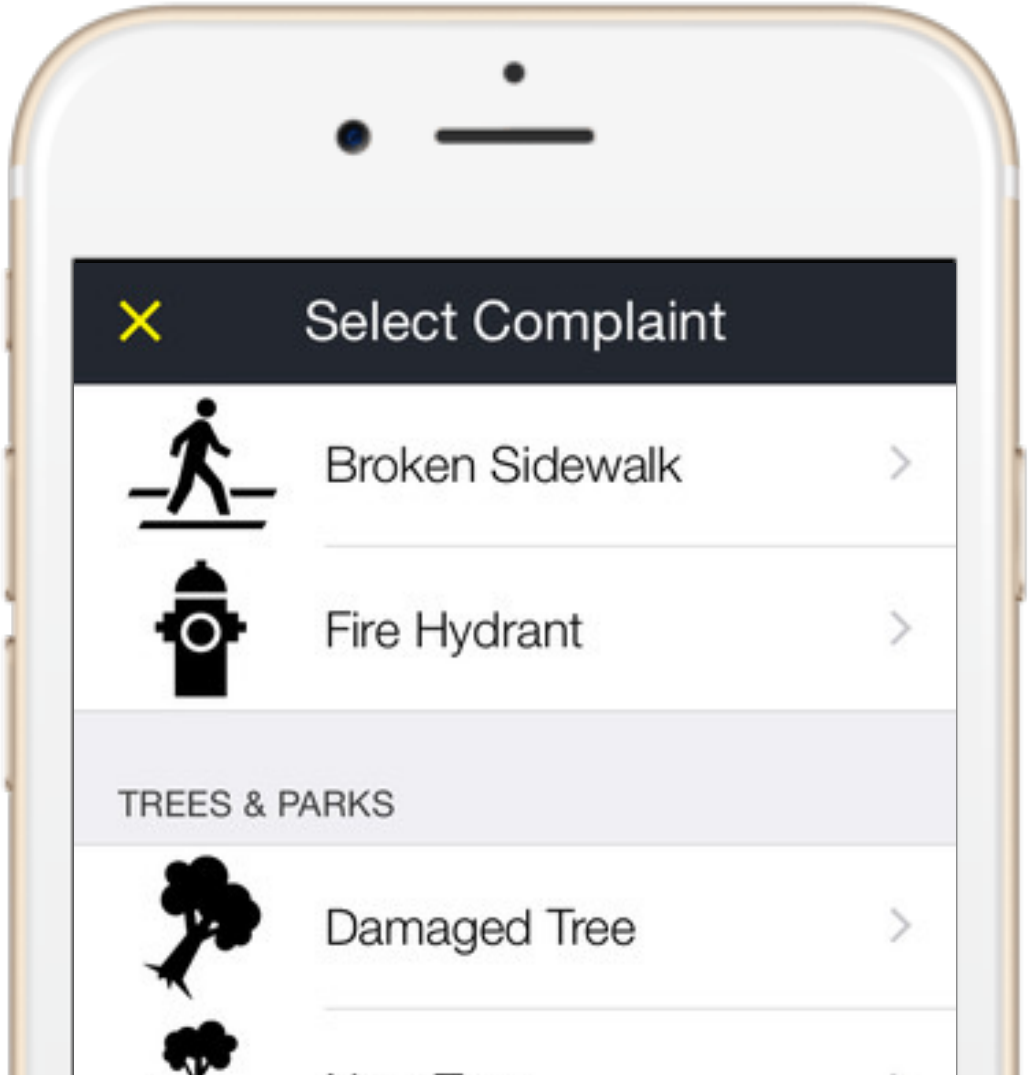



Walkability Audit
Wake County, North Carolina

Walkability Audit
Wake County, North Carolina


Safe Routes to School
Walkability Audit
Rock Hill, South Carolina

# MOBILE REPORTING SOLUTIONS




http://www1.nyc.gov/311/index.page

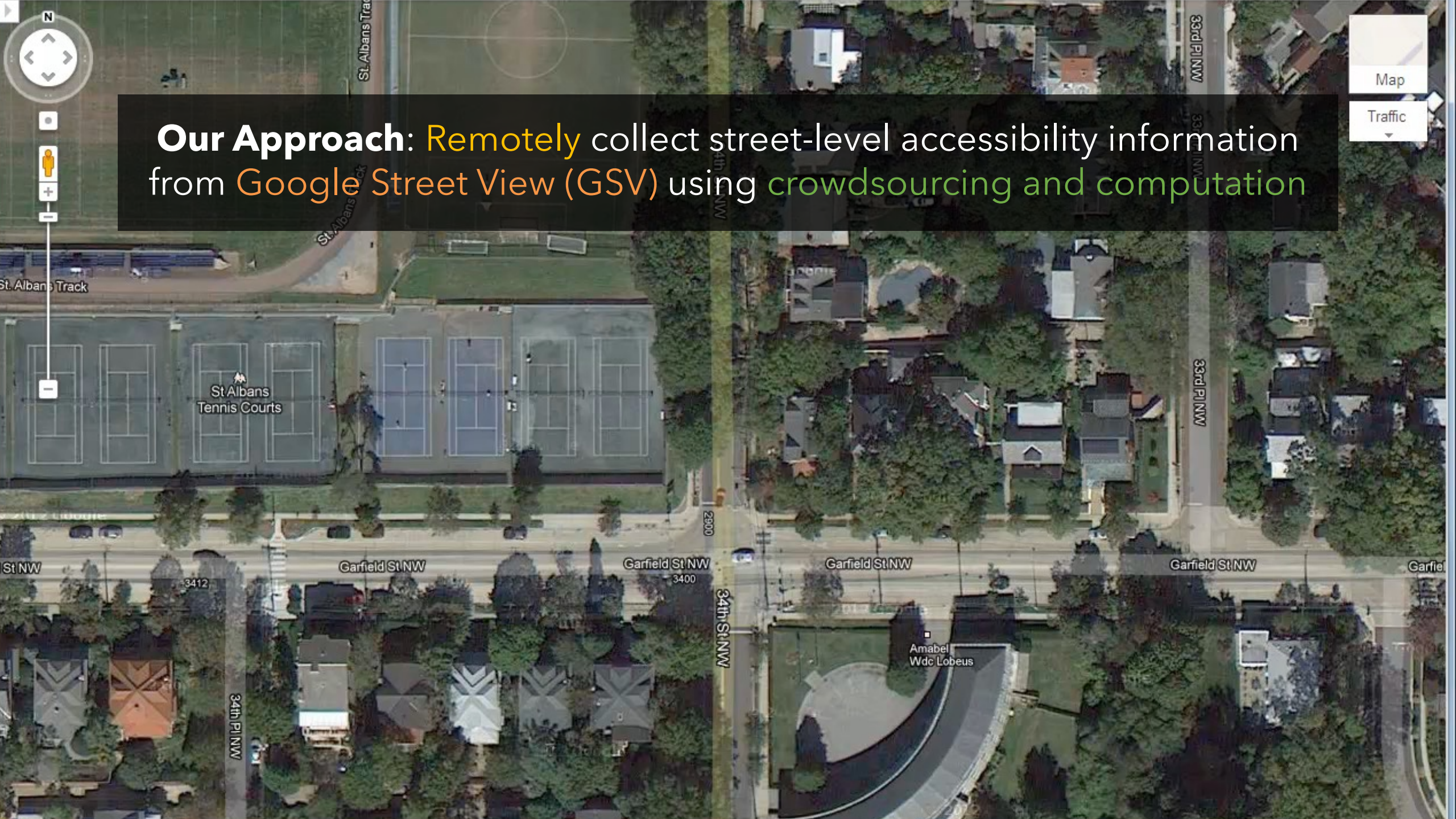
PART 2: DATA PROBLEM : : MOTIVATION

# CHALLENGES OF TRADITIONAL APPROACHES?

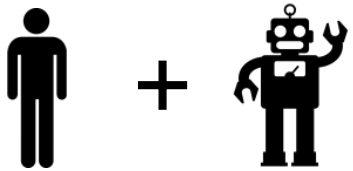

Slow, Manual, and Laborious

Huge Cost


Localized


Our Approach: Remotely collect street-level accessibility information from Google Street View (GSV) using crowdsourcing and computation
Map
Traffic
St. Albans Track
St Albans Tennis Courts
33rd Pl NW
Garfield St NW
3412
3400
2900
34th St NW
34th Pl NW
Amabel Wdc Lobeus

How do we enable **large-scale** **data collection** of sidewalk accessibility across **diverse** **users** with **technology**?



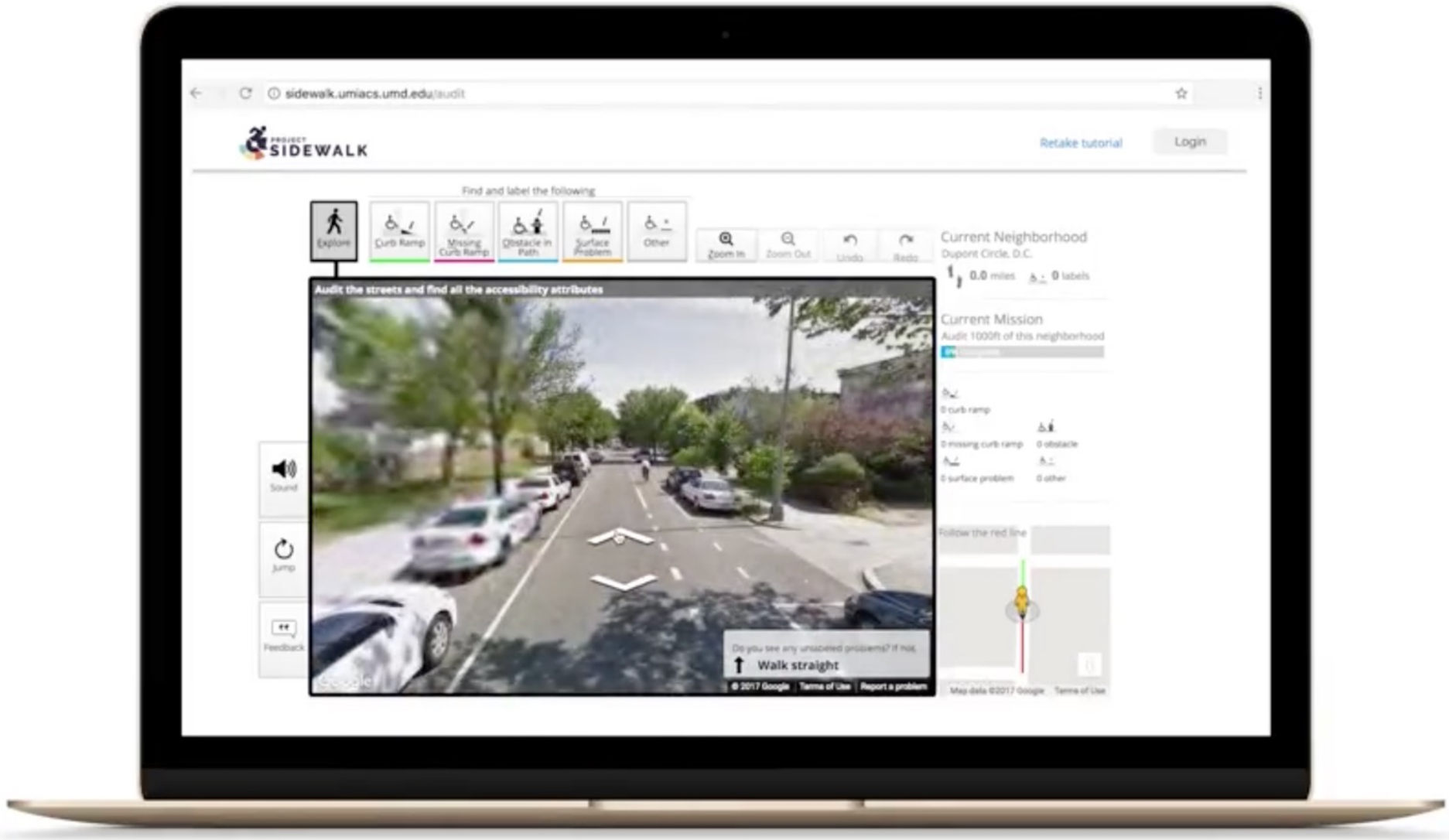
# PROJECT SIDEWALK

HTTP://PROJECTSIDEWALK.IO

**01**
**EXPLORE**

**02**
FIND PROBLEMS

**03**
ASSESS SEVERITY



01
EXPLORE

02
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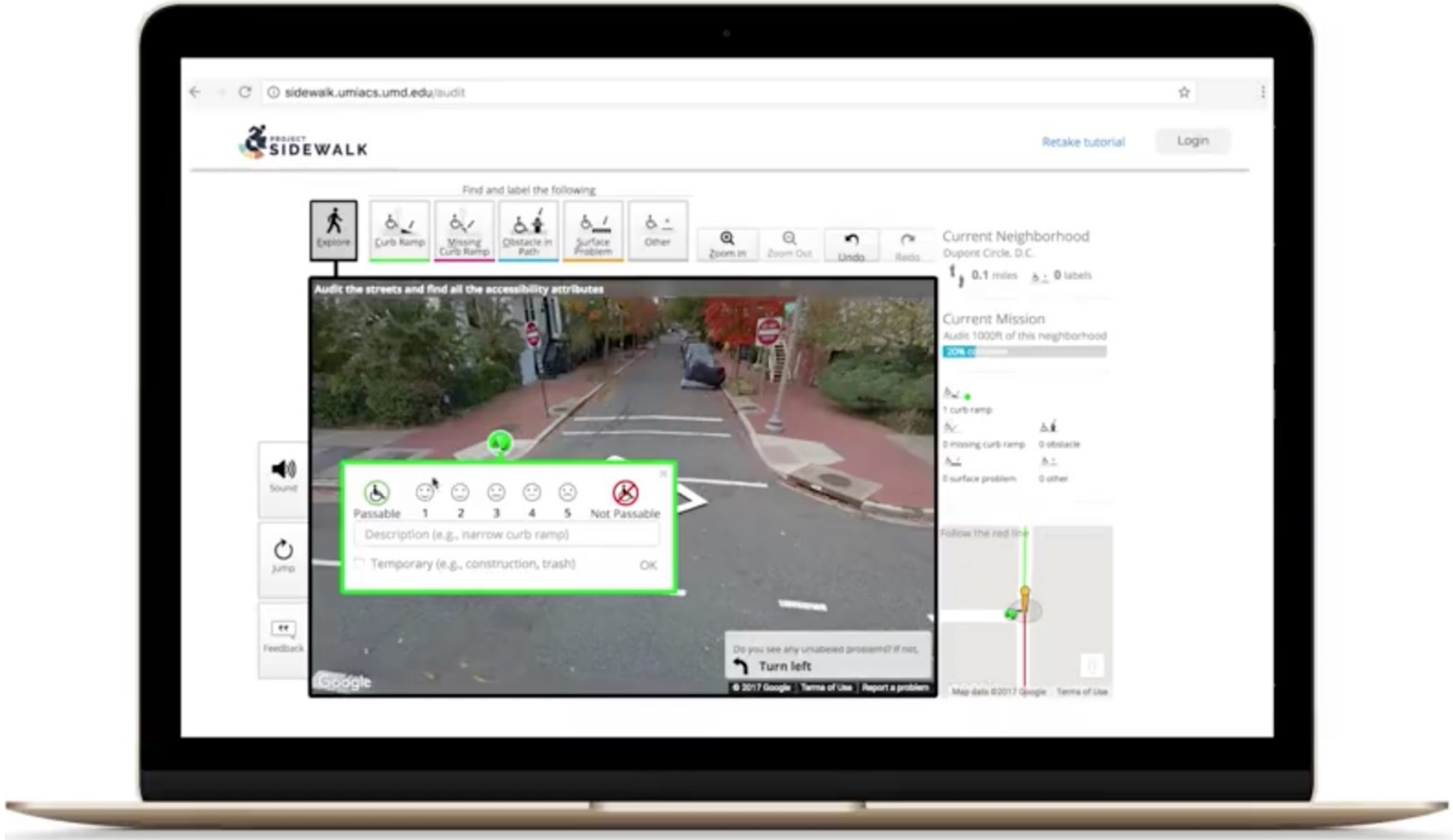
ASSESS SEVERITY



01
EXPLORE

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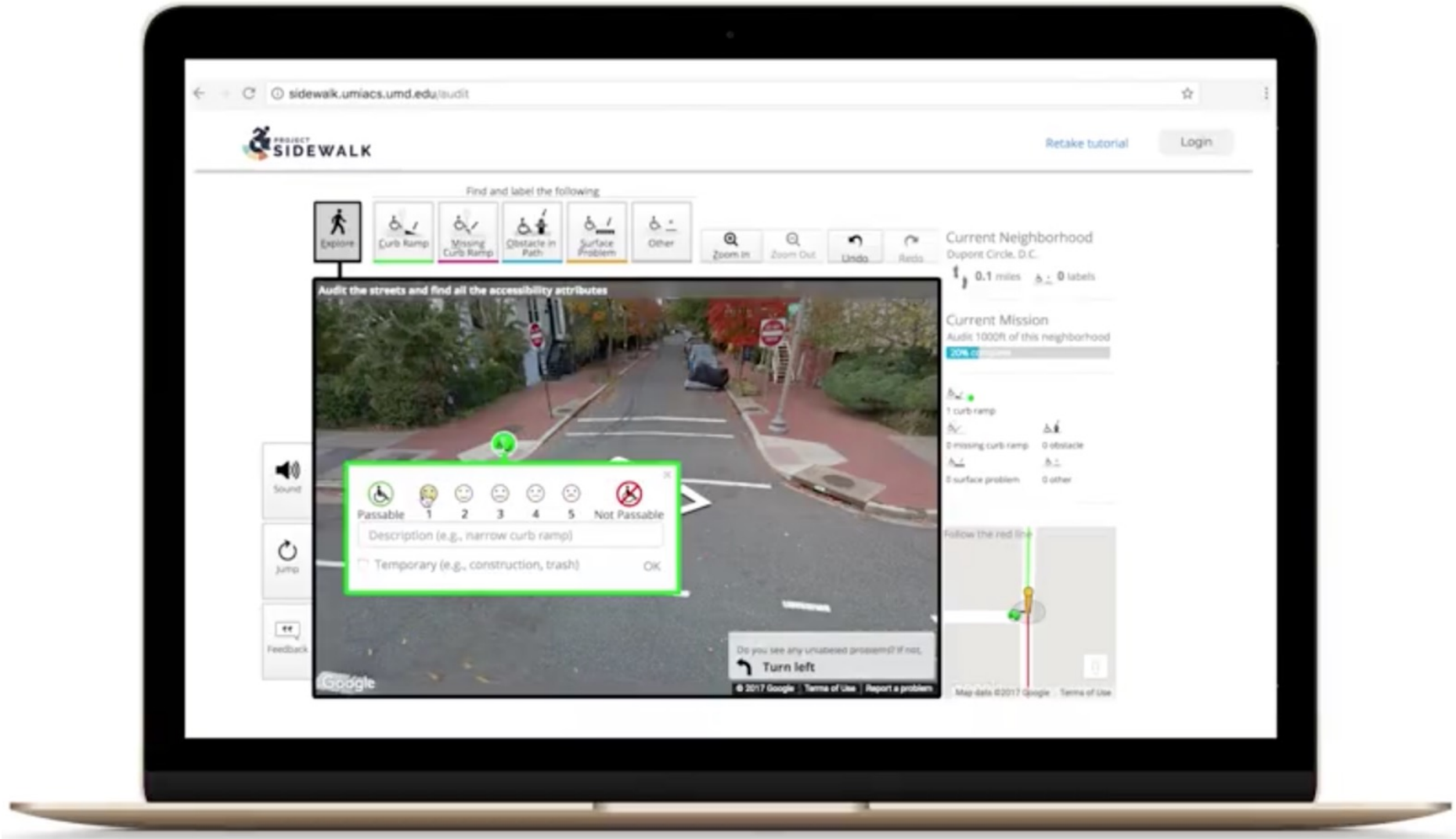
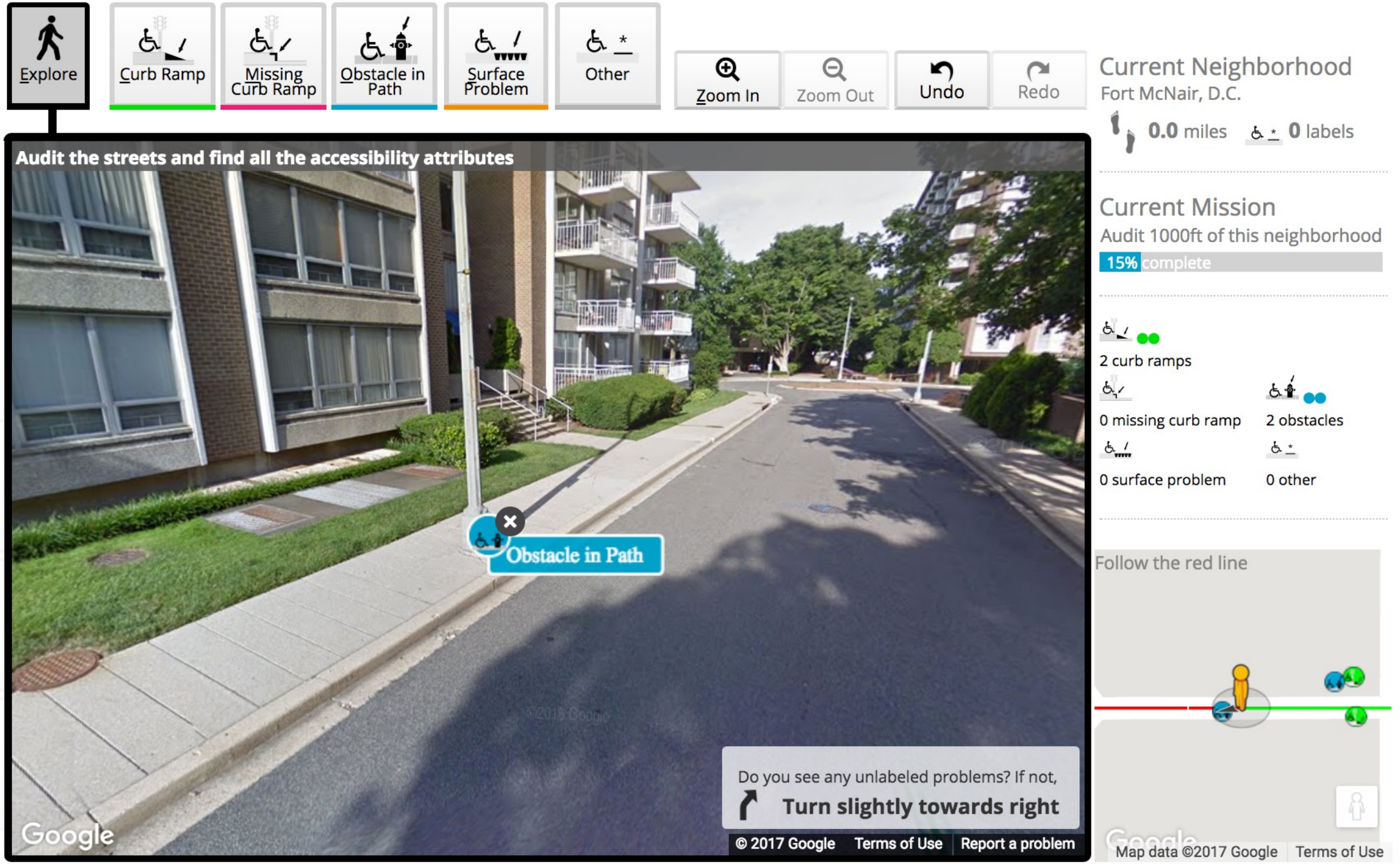
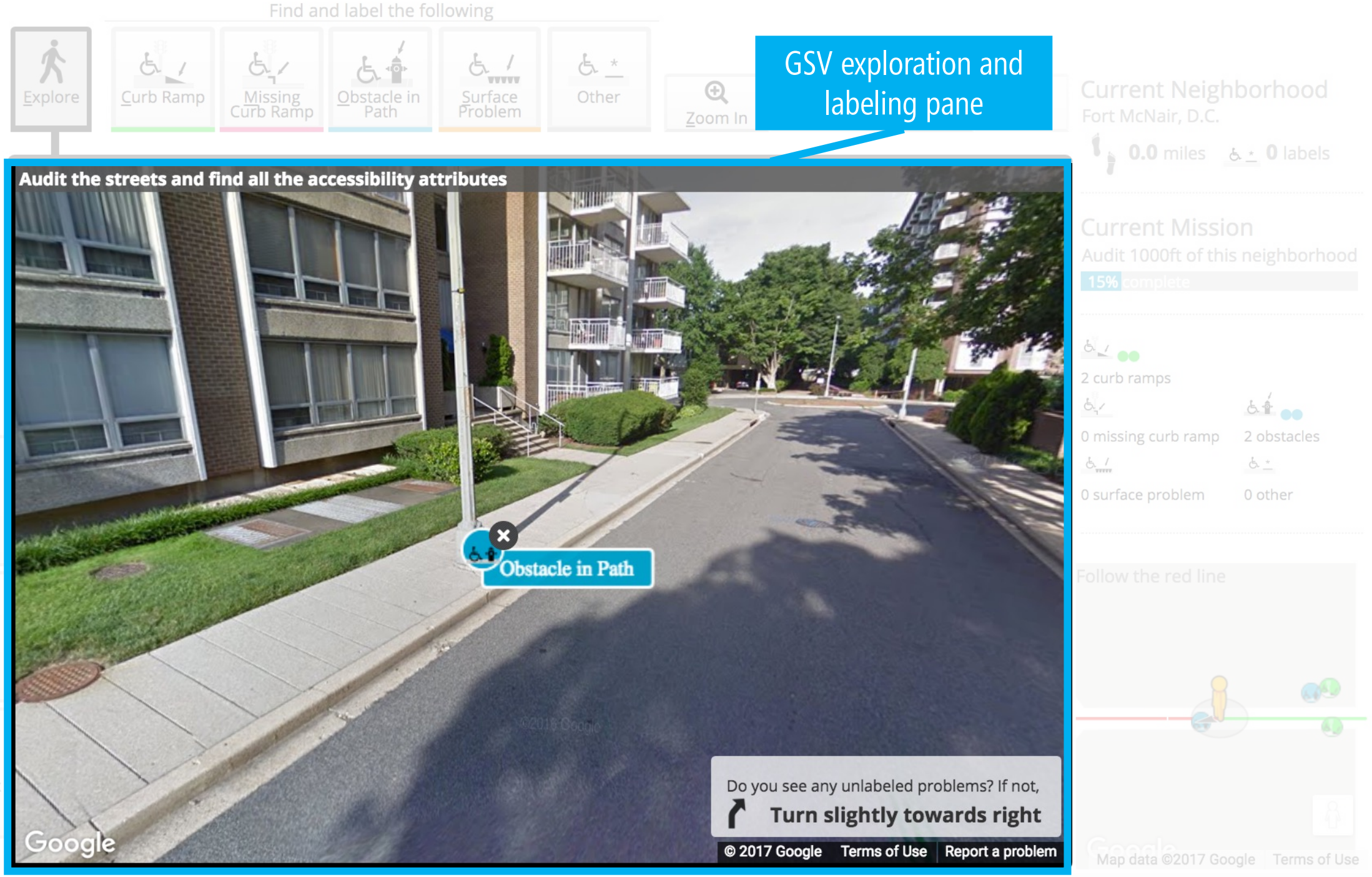


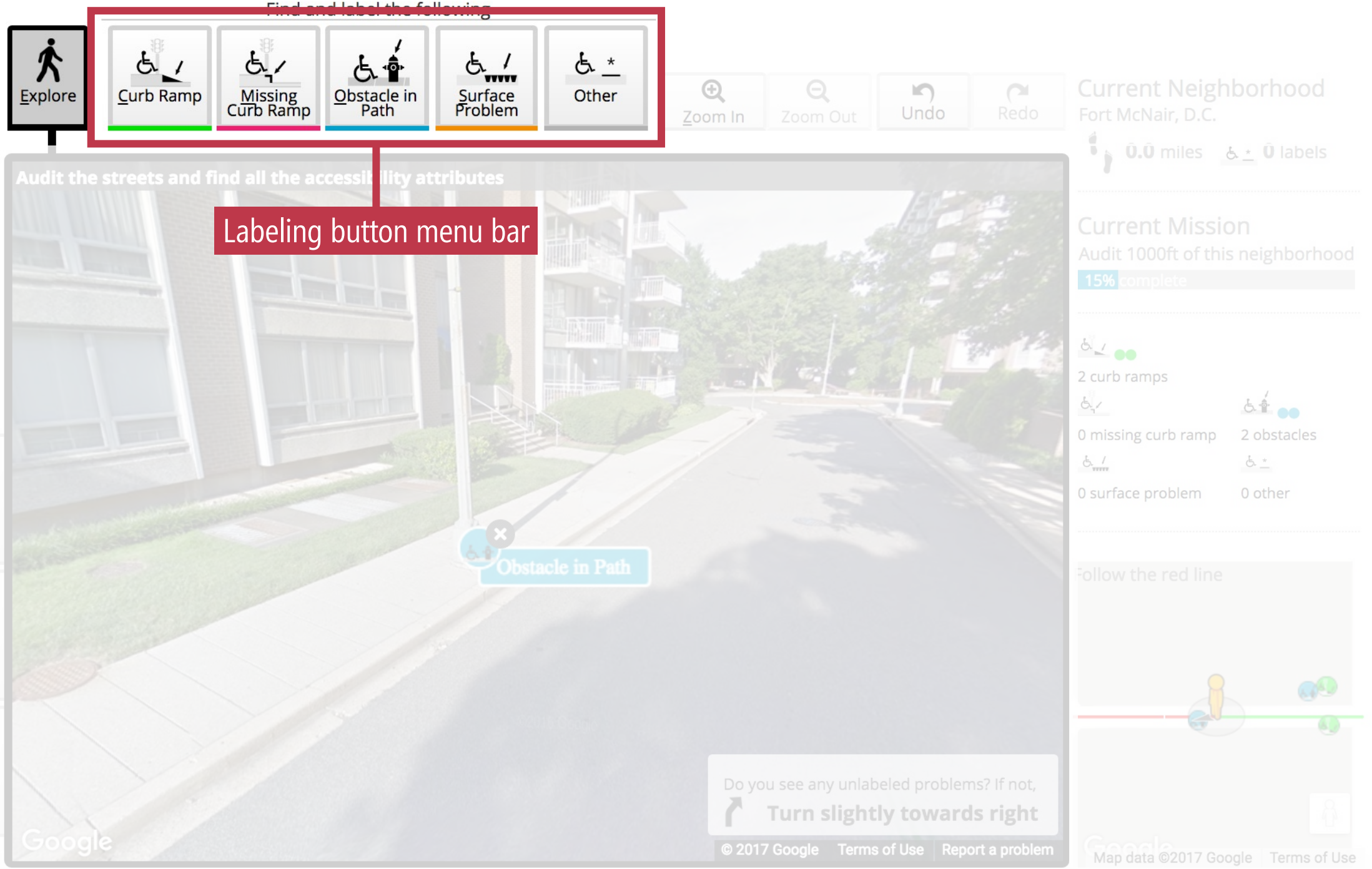
# TOOL WALKTHROUGH



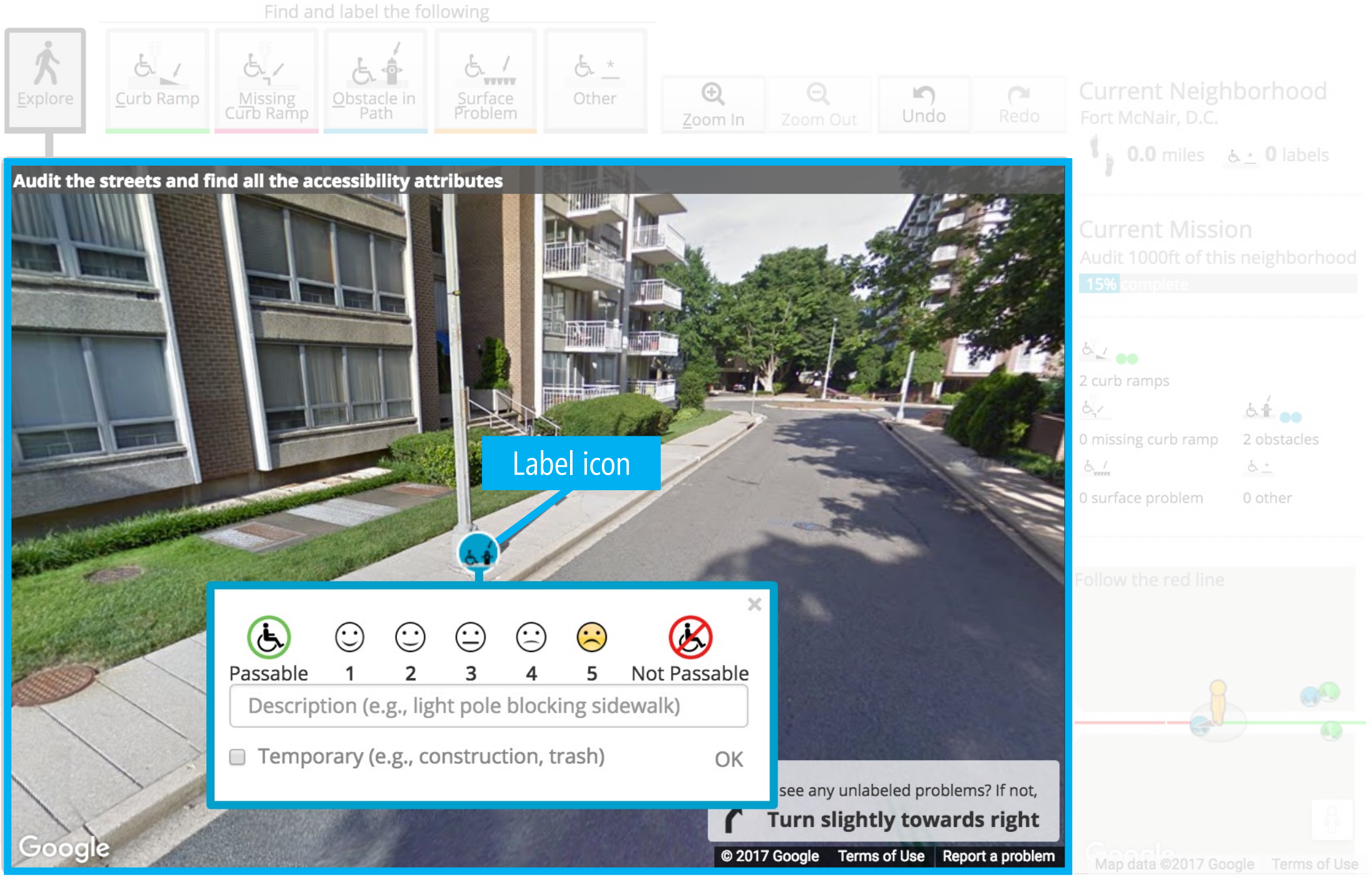
# TOOL WALKTHROUGH



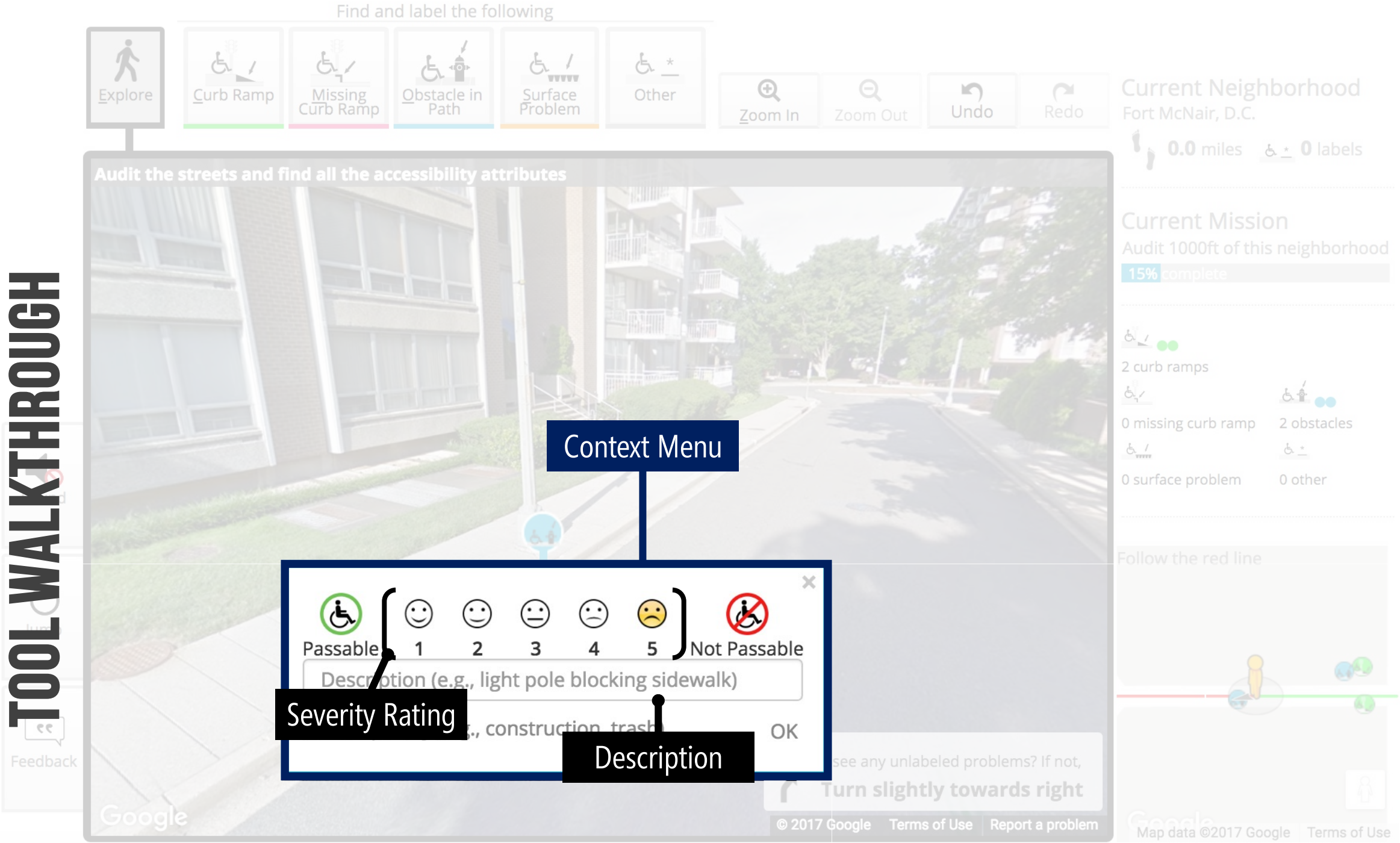
# TOOL WALKTHROUGH



# TOOL WALKTHROUGH



# TOOL WALKTHROUGH



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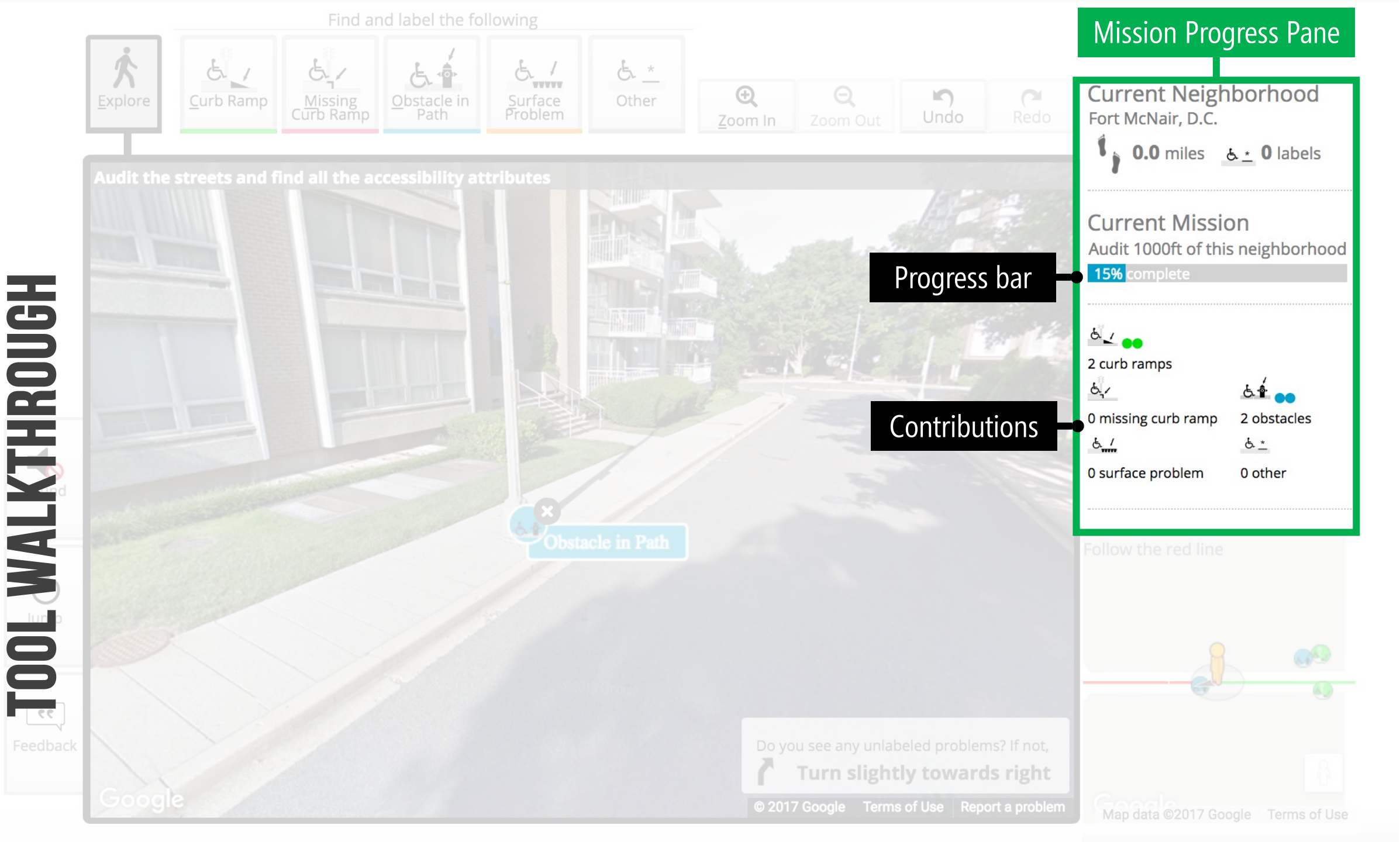
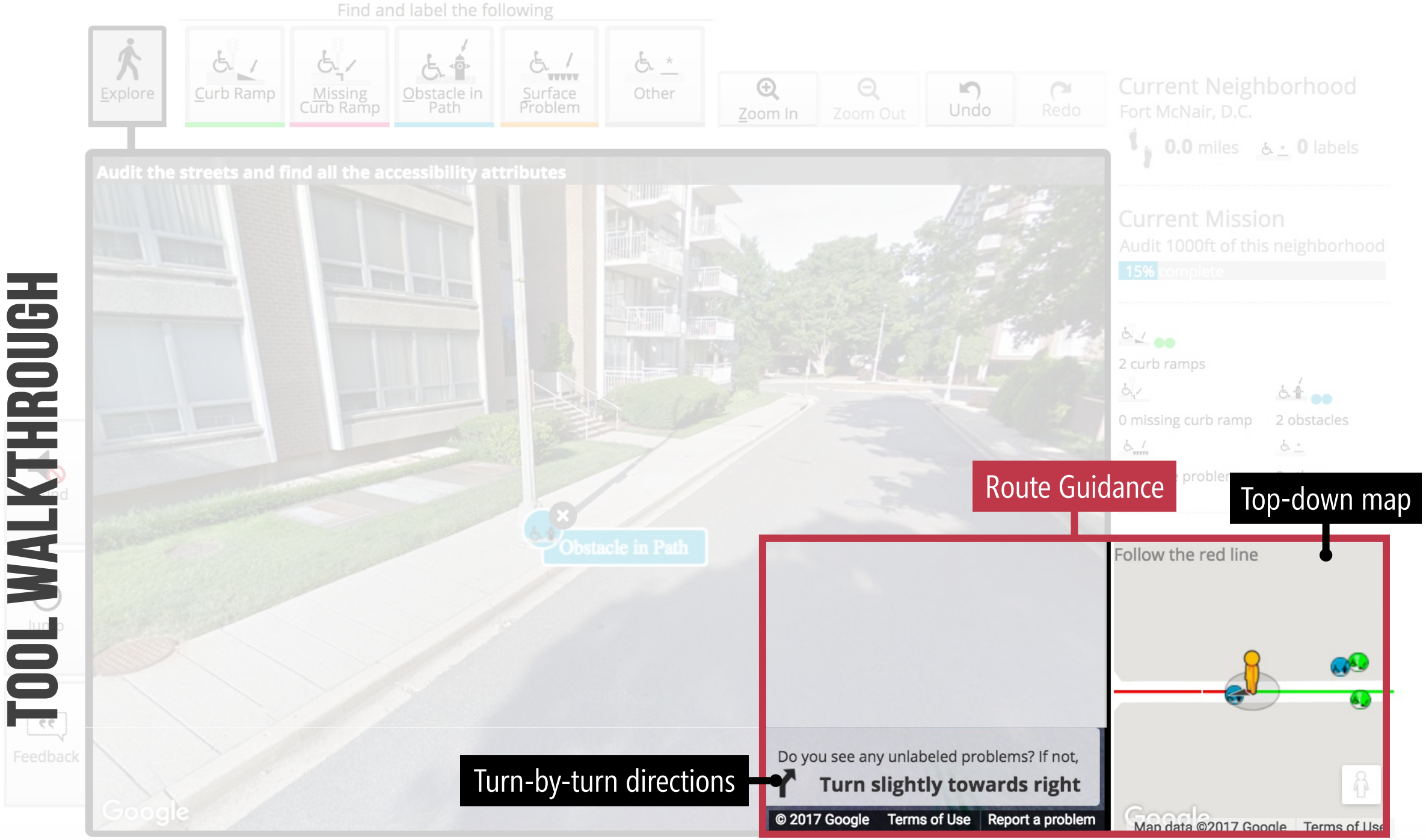


# TOOL WALKTHROUGH



PROJECT SIDEWALK SYSTEM

# INTERACTIVE TUTORIAL

Find and label the following

Explore | Curb Ramp | Missing Curb Ramp | Obstacle in Path | Surface Problem | No Sidewalk | Other

Zoom In | Zoom Out


Current Neighborhood

Woodridge, D.C.

0.0 miles | 0 labels

Current Mission

Complete the onboarding tutorial!

0% complete

0 curb ramp | 0 surface problem

0 missing curb ramp | 0 no sidewalk

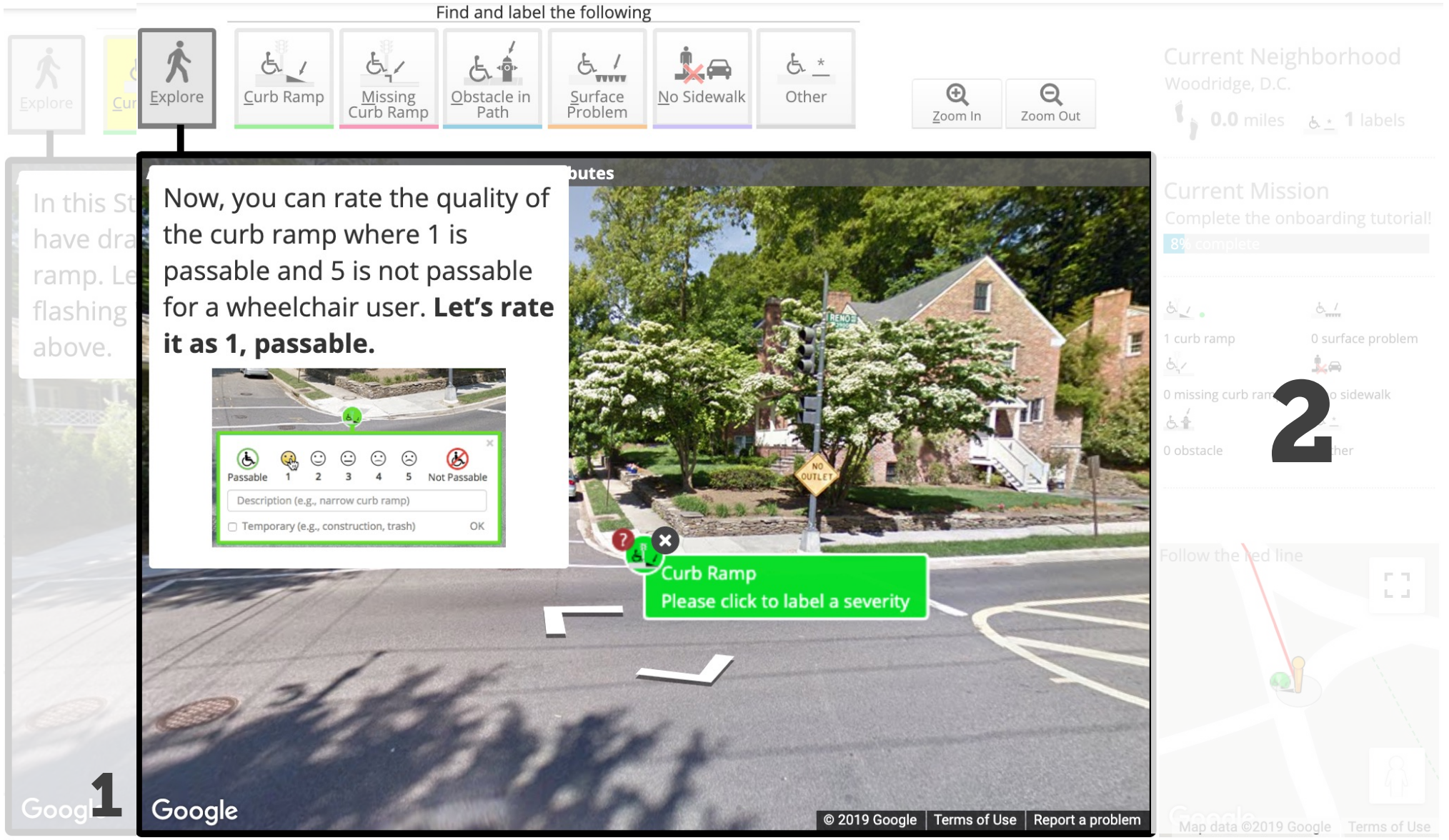
0 obstacle | 0 other

1

Follow the red line

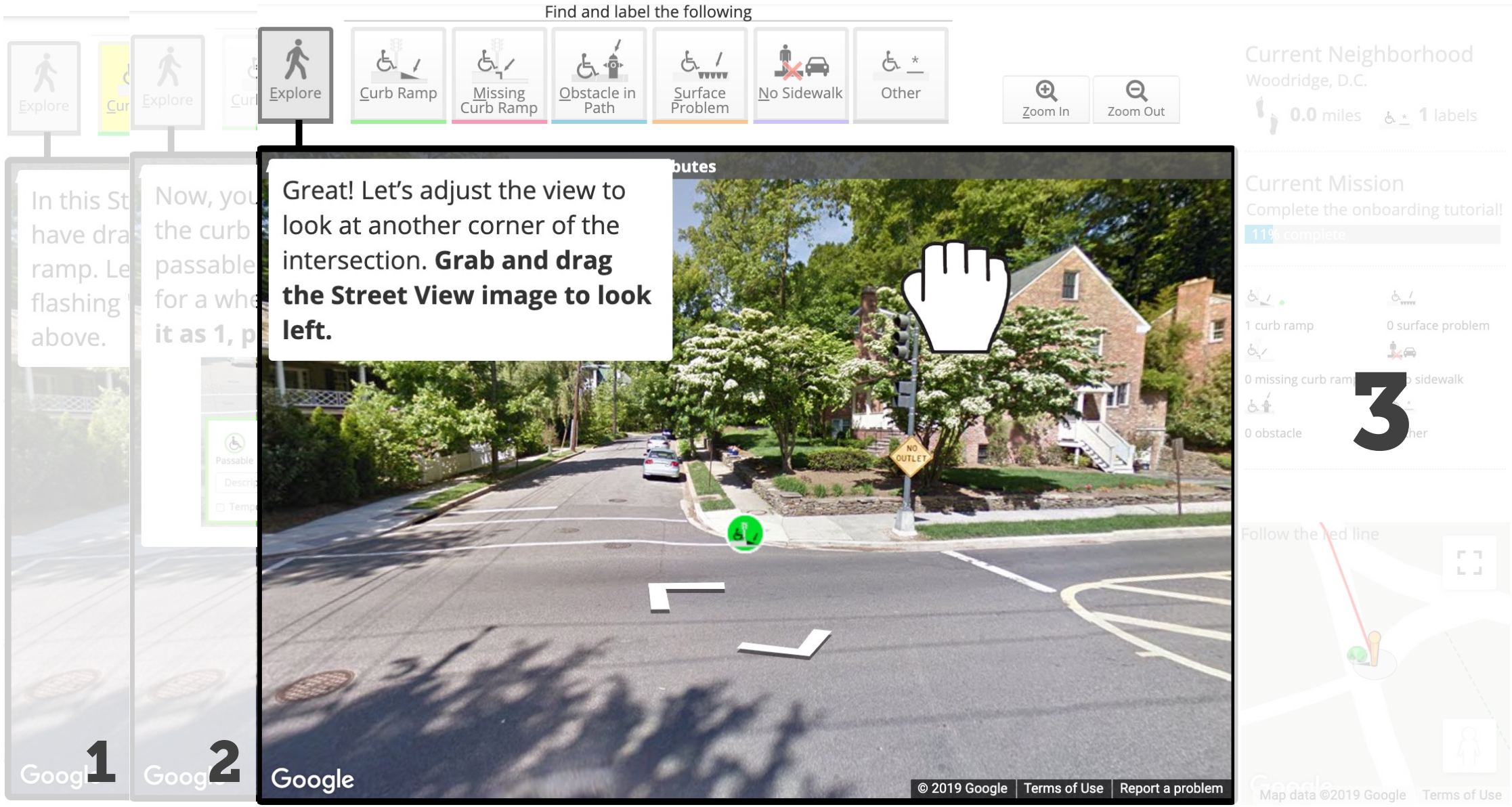
PROJECT SIDEWALK SYSTEM

# INTERACTIVE TUTORIAL



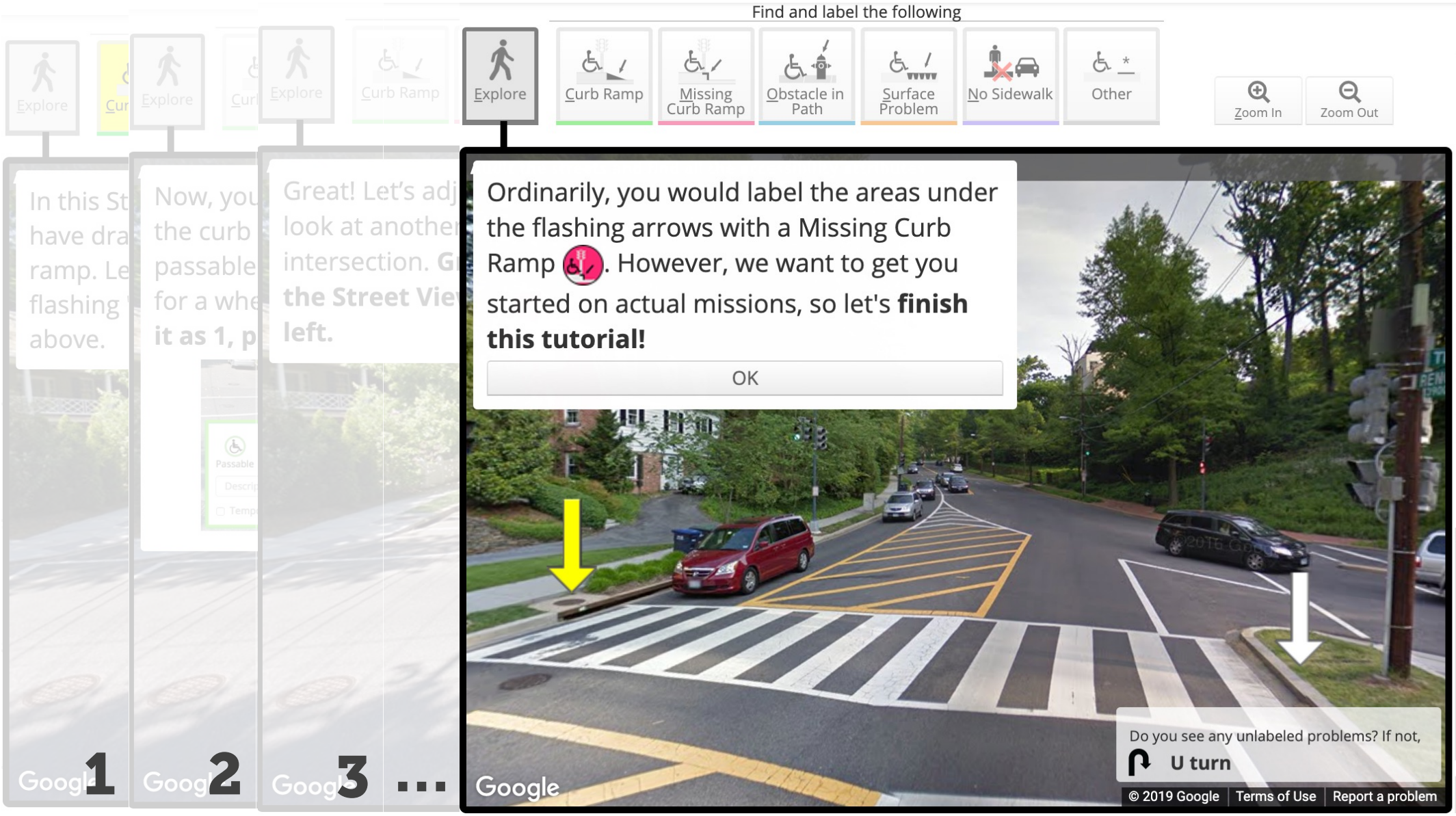
PROJECT SIDEWALK SYSTEM

# INTERACTIVE TUTORIAL



PROJECT SIDEWALK SYSTEM

# INTERACTIVE TUTORIAL



# STAKEHOLDER GROUPS VS CROWDWORKER GROUPS

## Stakeholder Groups = Data Benefiters

MI individuals

Caregivers

Advocates

Department Officials

DOTs

Policymakers

Elected Officials

## Crowdworkers Groups = Data Contributors

Anonymous Users

Registered Users

Volunteers

Paid crowdworkers

(Turkers)

# KEY RESEARCH QUESTIONS

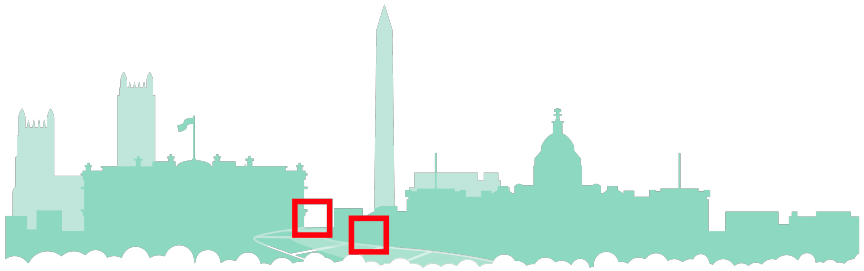
## User Behavior, Data Accuracy, and Data Utility

**RQ1** What are the **behavioral differences** between paid crowd workers and volunteers?

**RQ2** What are the **labeling quality differences** between paid crowd workers and volunteers and the **common mistakes** made?

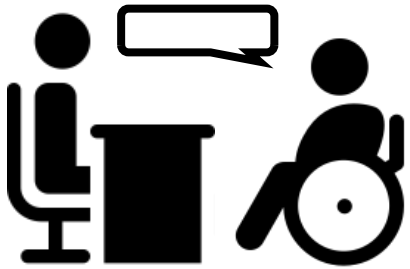
**RQ3** What are the **perceptions of utility** of crowdsourced accessibility data and concerns of **key stakeholder groups**?

# THREE STUDIES



**Deployment study**


**Data Validation Study**

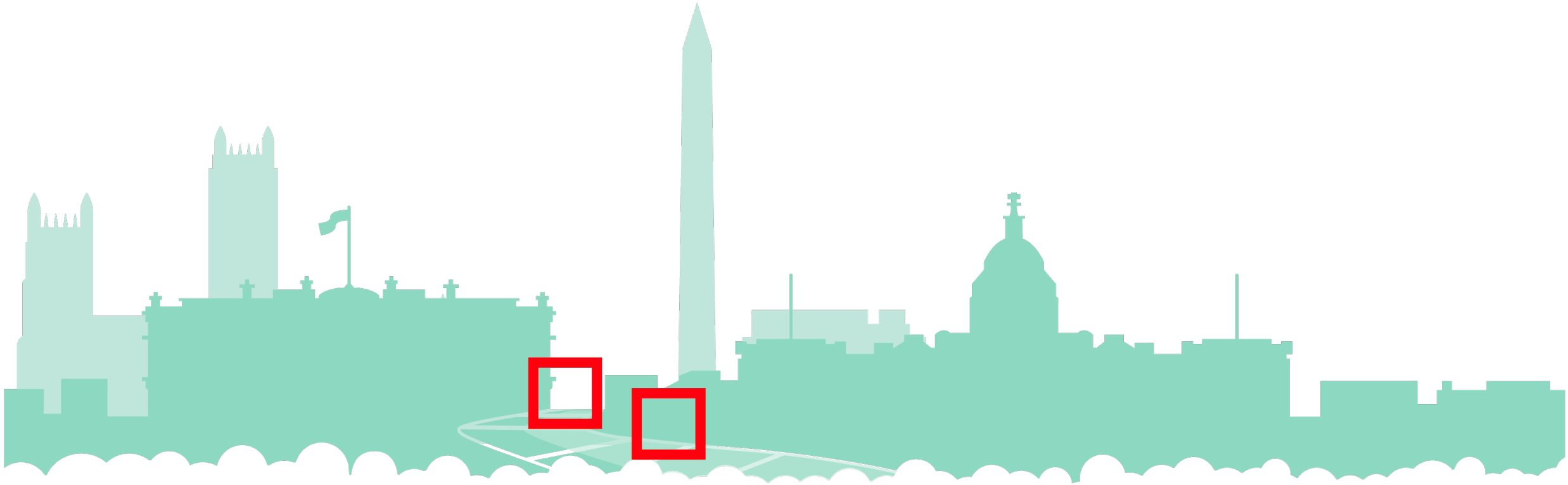


**Interview Study**

# DEPLOYMENT STUDY

CHI 2019, BEST PAPER

*Washington DC*



**18**-month deployment ~ Fall **2016** - Spring **2018**

PART 2: DATA PROBLEM : : DEPLOYMENT STUDY

# DATA COLLECTED

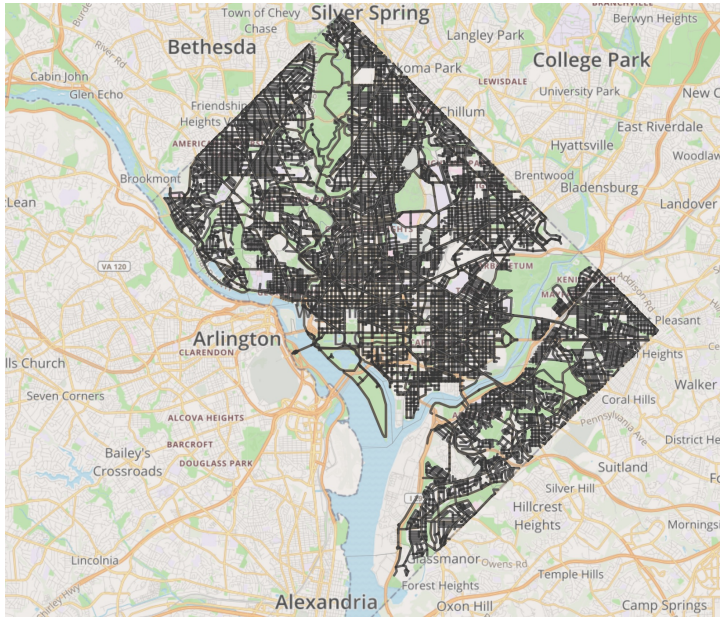
CHI 2019, BEST PAPER

PROJECT SIDEWALK
HTTP://PROJECTSIDEWALK.IO

**~800**

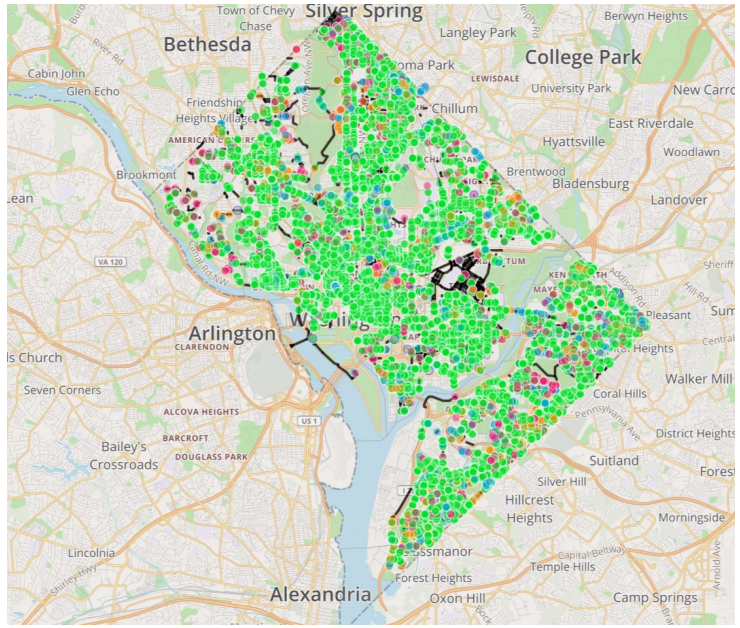
**USERS**

Volunteers | Turkers




**~3000**

**MILES**




**250,000+**

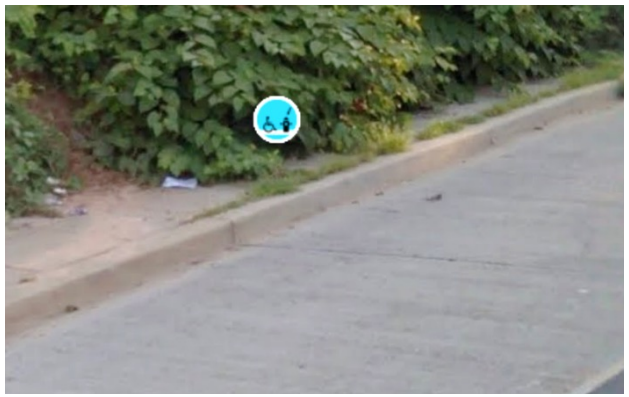
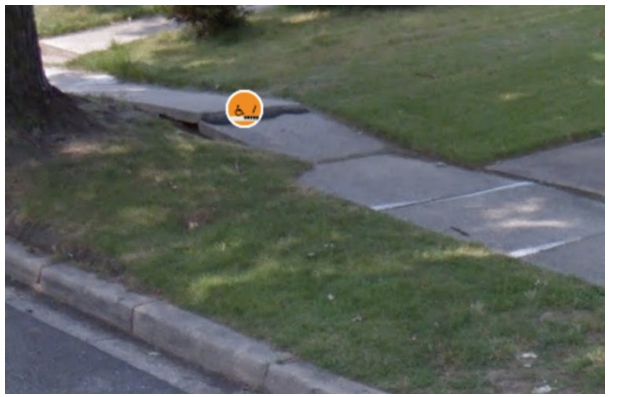
**LABELS**

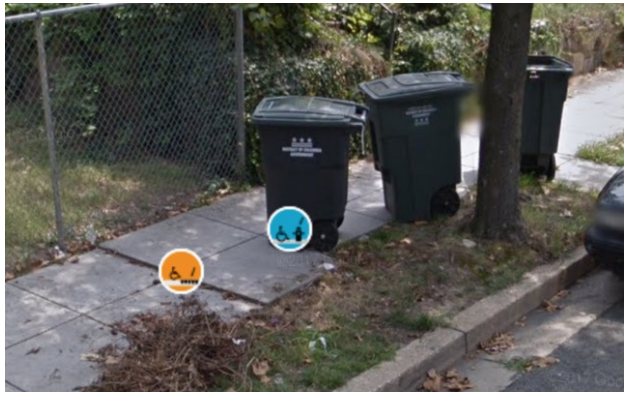
PART 2: DATA PROBLEM : : DEPLOYMENT STUDY

# LABEL EXAMPLES

CHI 2019, BEST PAPER




| 142,835 Curb Ramps | 18,719 Missing Curb Ramps | 21,736 Obstacles | 8309 Surface Problems |
|---|---|---|---|

# HOW ACCURATELY DID USERS PERFORM?

**~70%**

*raw accuracy across **all** user groups

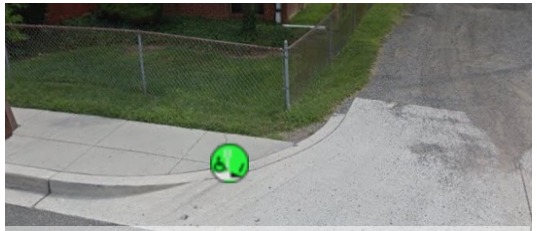
*Calculated on a subset of the dataset

PART 2: DATA PROBLEM : : DATA VALIDATION STUDY

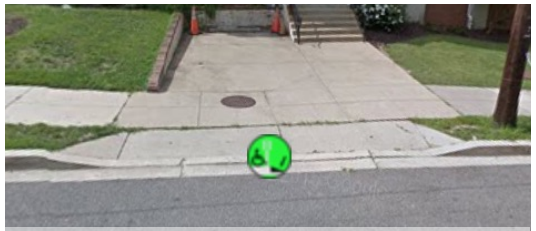
# WHAT ARE THE COMMON LABELING MISTAKES?

Randomly sampled 54 false positives and 54 false negatives for each label type (432 total error samples analyzed)

## Curb Ramps



**44.4%** driveway transition



**22.2%** driveways

**14.8%** random

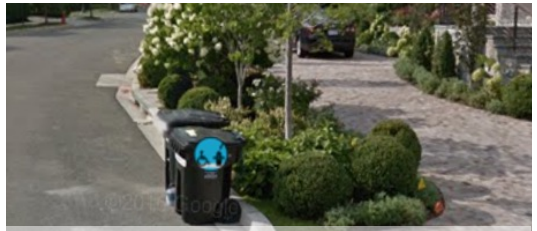
## Missing Curb Ramps

**29.6%** house-to-curb

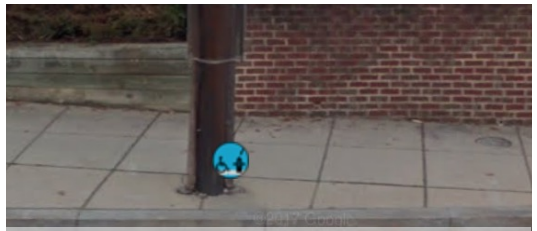
**25.9%** no pedestrian route

**24.1%** curb ramp exists

## Obstacles



**42.6%** not on pedestrian route



**37.0%** space to avoid obstacle

**9.3%** wrong label type

## Surface Problems

**46.2%** not on pedestrian route

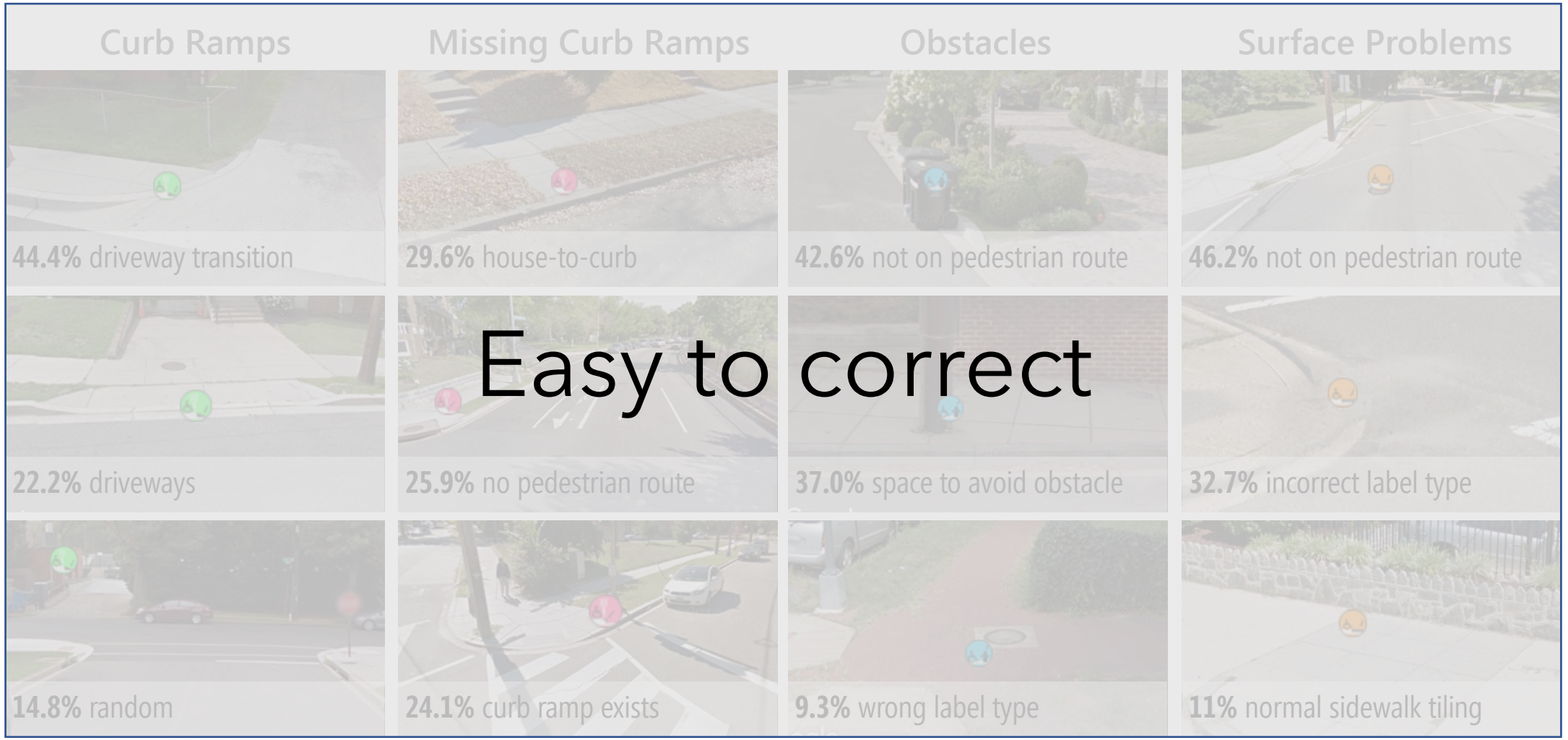
**32.7%** incorrect label type

**11%** normal sidewalk tiling

PART 2: DATA PROBLEM : : DATA VALIDATION STUDY

# WHAT ARE THE COMMON LABELING MISTAKES?

Randomly sampled 54 false positives and 54 false negatives for each label type (432 total error samples analyzed)



# KEY RESEARCH QUESTIONS

**RQ1** What are the **behavioral differences** between paid crowd workers and volunteers?

**RQ2** What are the **labeling quality differences** between paid crowd workers and volunteers and the **common mistakes** made?

**RQ3** What are the **perceptions of utility** of crowdsourced accessibility data and concerns of **key stakeholder groups**?

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Perceived Value

Usability

Concerns

Design Suggestions

Department Officials

DOTs

MI individuals

Caregivers

**N=14**

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Perceived Value

Usability

Concerns

Design Suggestions

Department Officials

DOTs

MI individuals

Caregivers

**N=14**

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

## Perceived Value

Enabled rapid data collection

Gathered diverse perspectives about accessibility

Helped engage citizens in thinking about urban design

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

## Perceived Value

> *It's really good for a starting point. This is a first observation, and when you send somebody out in the field, they can see those observations and pick up more information. It's just neat!*
>
> ~G4

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

## Concerns

Data age i.e., outdated GSV imagery or labels

Data reliability

Conflicted data

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

## Concerns

> *I would have more confidence if different people did it, did the same street.*
>
> ~G4

# WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

## Concerns

> *My concern as a user [is that] someone said this was accessible and I got there and it wasn't accessible, because everyone has different opinions on accessibility.*
>
> ~MI1

PART 2: DATA PROBLEM

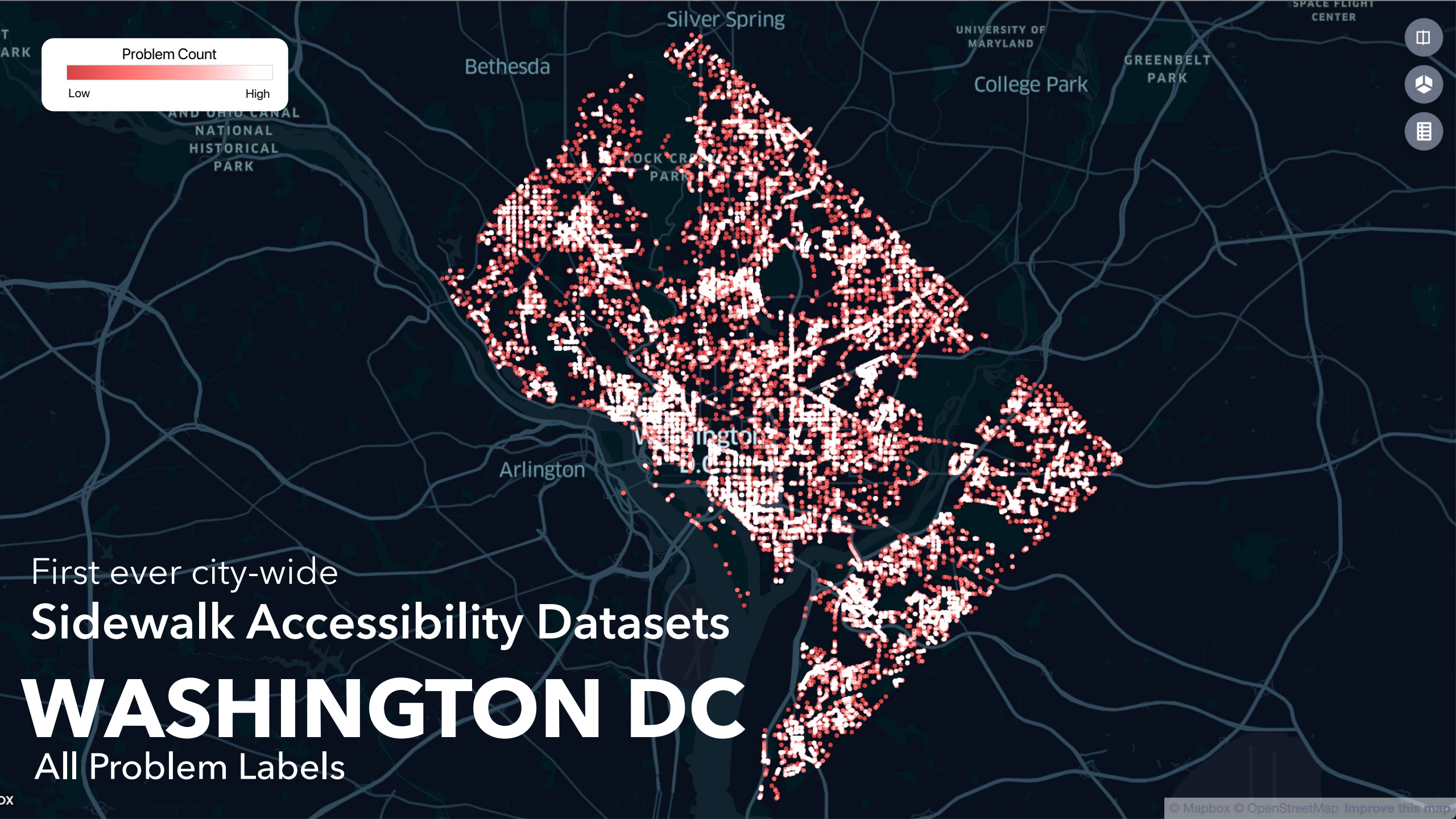
# RESEARCH OUTCOMES

Lots of **feature improvements** to Project Sidewalk tool (e.g., **data validation** by multiple users)

**Lessons** learnt for future deployments

# REAL WORLD IMPACT

# WASHINGTON D.C.


Problem Count
Low
High
Silver Spring
Bethesda
College Park
UNIVERSITY OF MARYLAND
GREENBELT PARK
SPACE FLIGHT CENTER
NATIONAL HISTORICAL PARK
Arlington
First ever city-wide
Sidewalk Accessibility Datasets
WASHINGTON DC
All Problem Labels
© Mapbox © OpenStreetMap Improve this map


NEWBERG

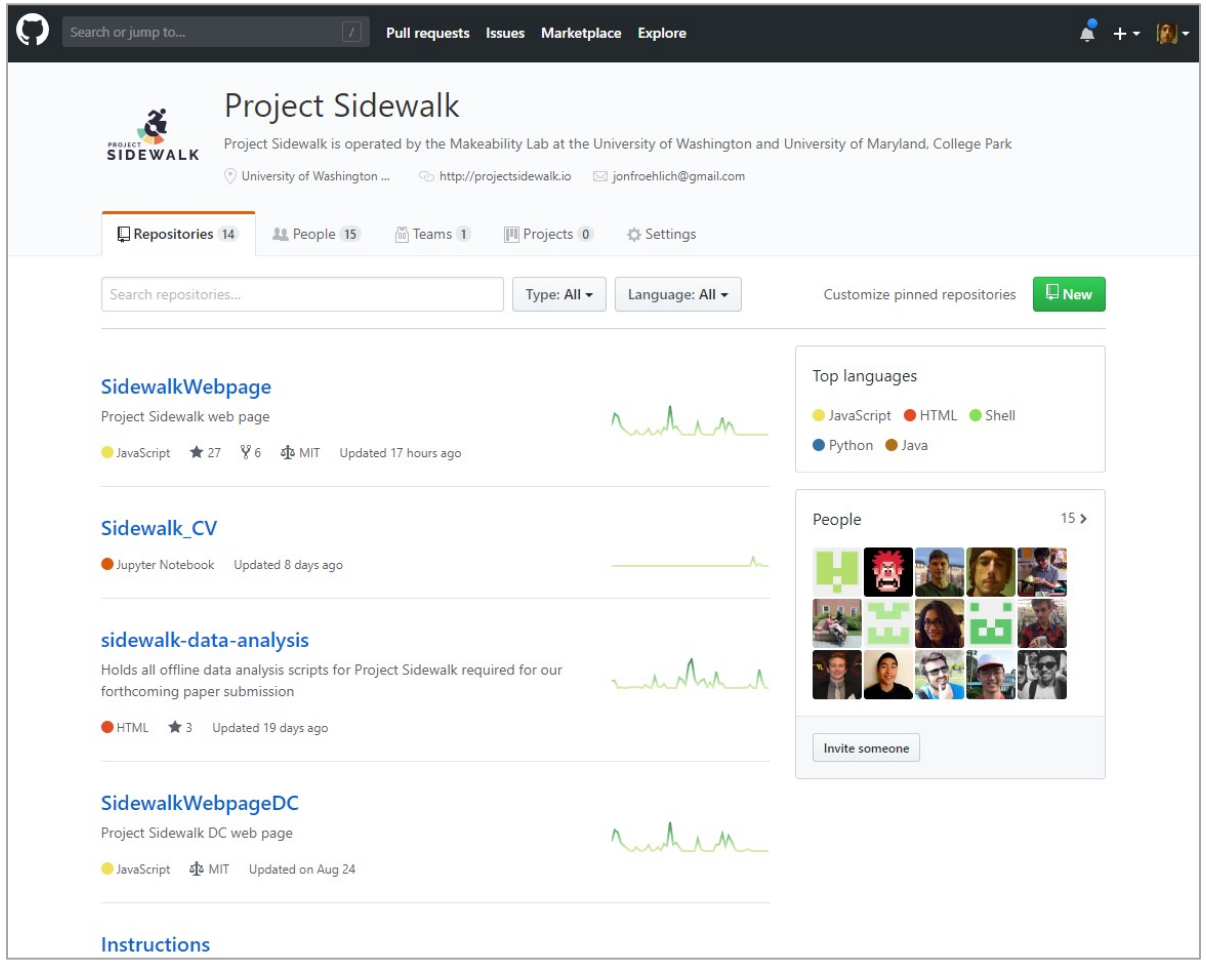

SEATTLE


COLUMBUS

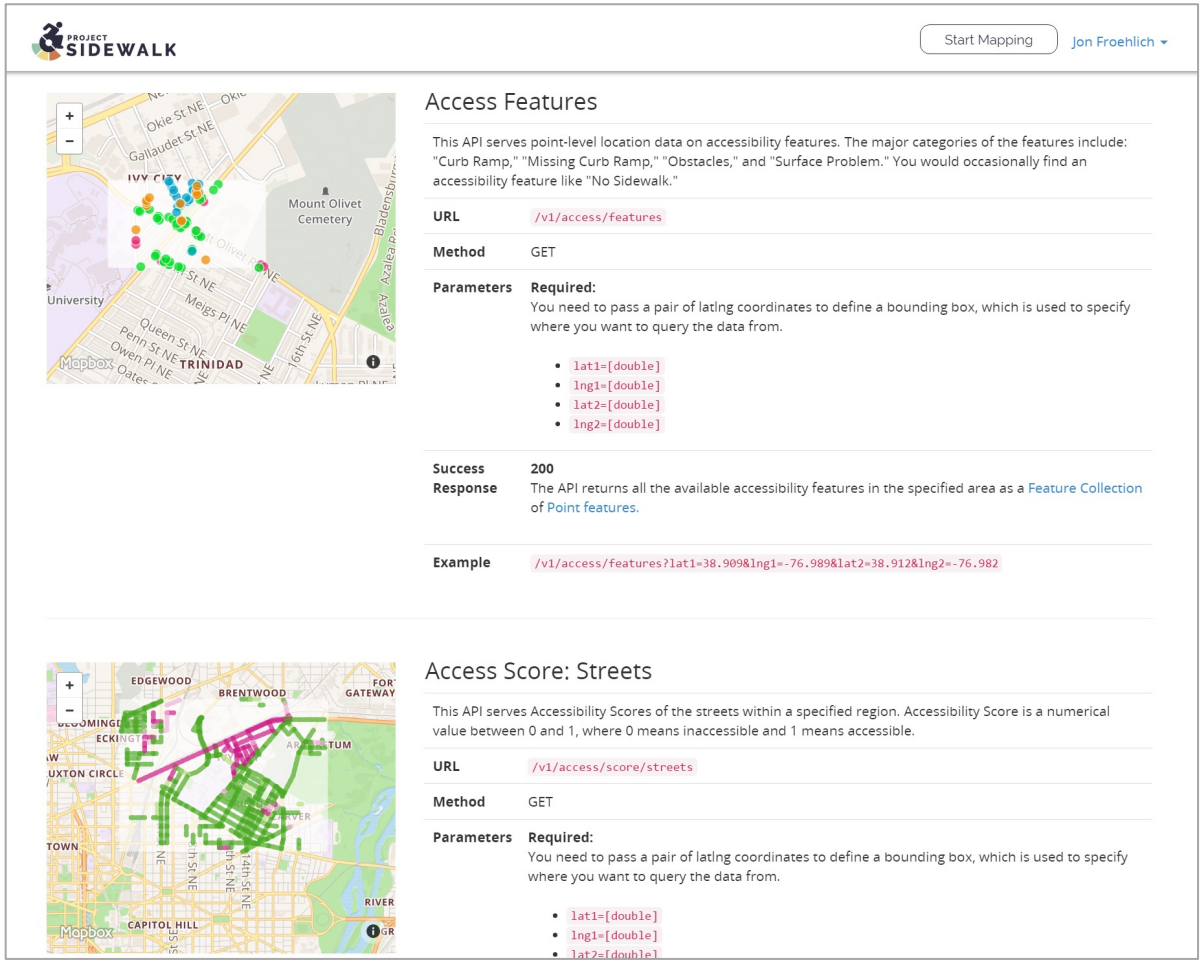

MEXICO CITY

PART 2: DATA PROBLEM : : REAL WORLD IMPACT

# OPEN SOURCE & OPEN DATA




https://github.com/ProjectSidewalk




http://projectsidewalk.io/api

PART 2: DATA PROBLEM : : REAL WORLD IMPACT

# AUTOMATING DATA COLLECTION USING COMPUTER VISION

CVPR 2017, ASSETS 2019

# CONTRIBUTIONS

Developed a web-based crowdsourcing tool for **remote** data collection of accessibility data **at scale**

Demonstrated **feasibility** of remote data collection approach

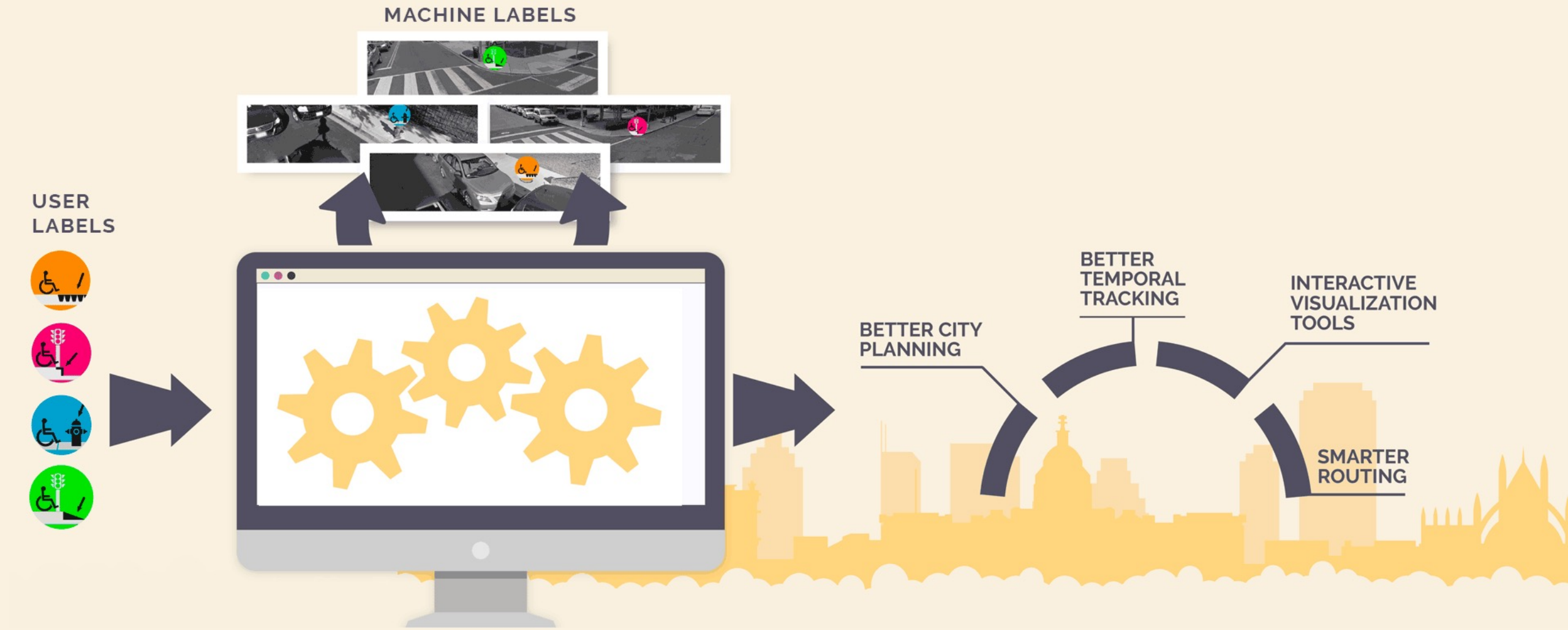
Generated first-ever **city-wide accessibility datasets**

Published at **CHI 2019**: Saha, M., Saugstad, M., Maddali, H. T., Zeng, A., Holland, R., Bower, S., ... & Froehlich, J. (2019, May). ***Project Sidewalk: A web-based crowdsourcing tool for collecting sidewalk accessibility data at scale***. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-14).

USER
LABEL

**DATA**

Crowdsourced
Data Collection




## DATA

Crowdsourced Data Collection

## COMPUTER VISION + MACHINE LEARNING

(Semi) Automatic Data Collection

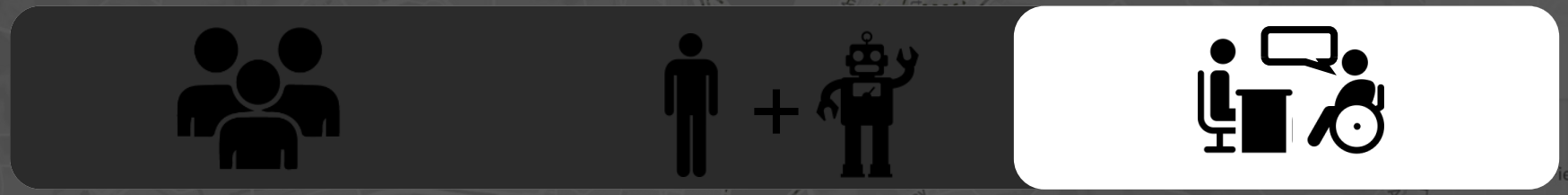
## INTERACTIVE APPLICATIONS

Accessibility-ware Application Design

# Tool Problem: Geovisual Analytics

RQ3: How might we utilize interactive visualizations of sidewalk data to facilitate effective decision-making, communication, and advocacy?

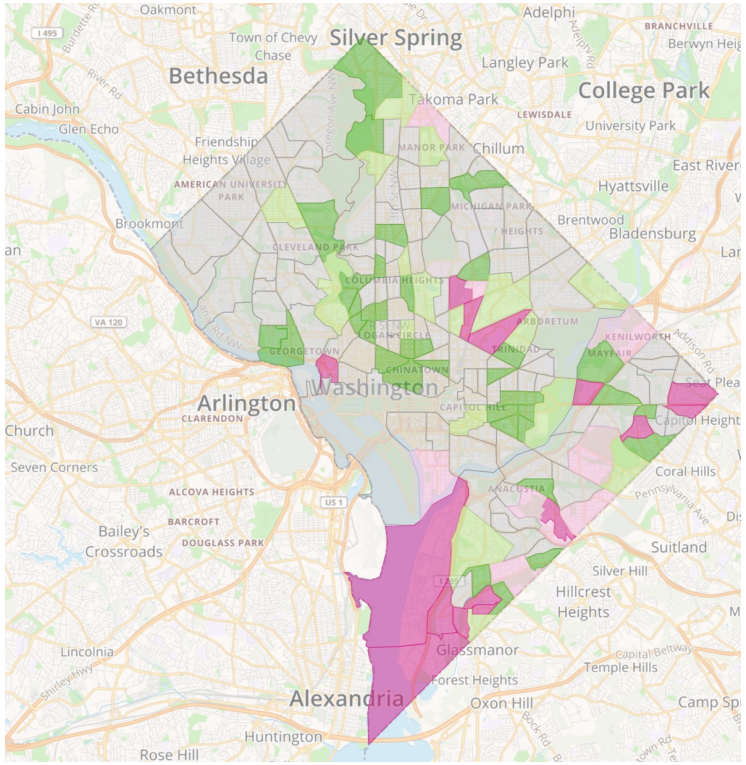
*Ongoing + Proposed Work*



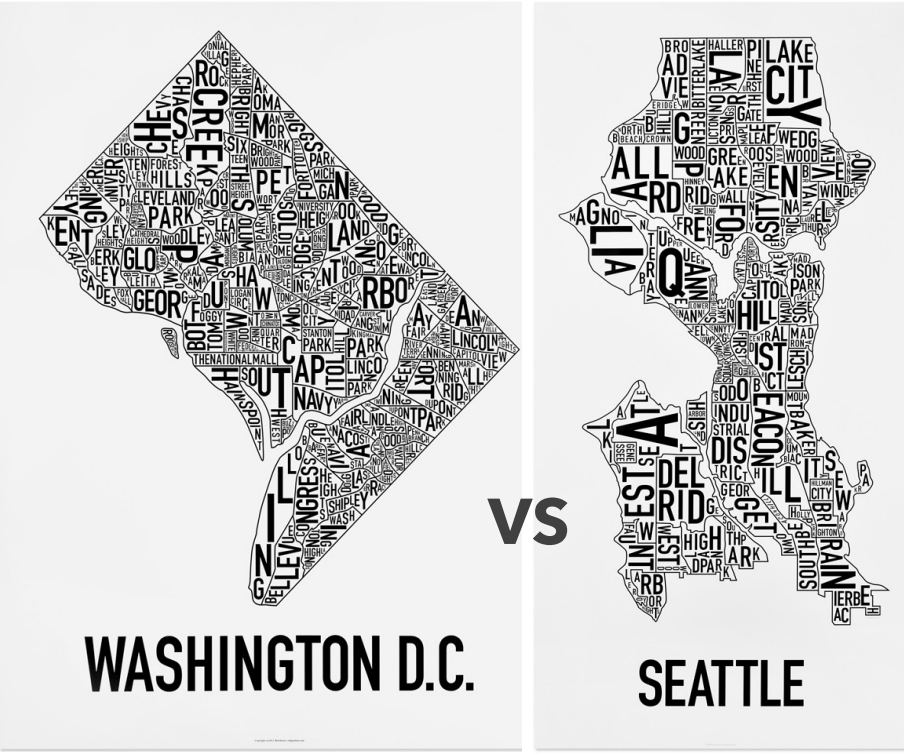
PART 3: TOOL PROBLEM : : MOTIVATION

# ACCESSIBILITY-AWARE APPLICATIONS


Smart routing for people with mobility impairments




Urban accessibility visualizations



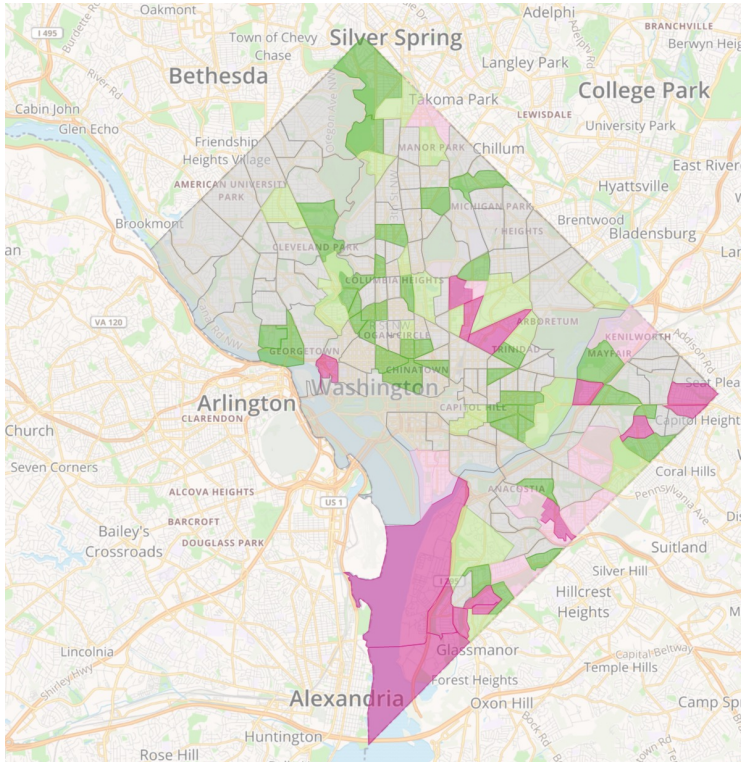

Cross-city comparison tools

PART 3: TOOL PROBLEM : : MOTIVATION

# ACCESSIBILITY-AWARE APPLICATIONS: MY FOCUS




Smart routing for people with mobility impairments



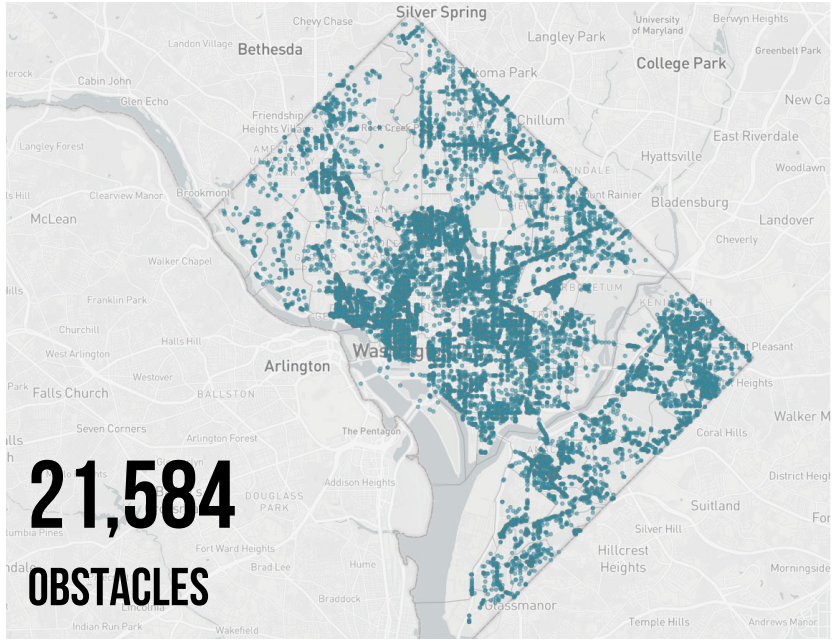

Urban accessibility visualizations

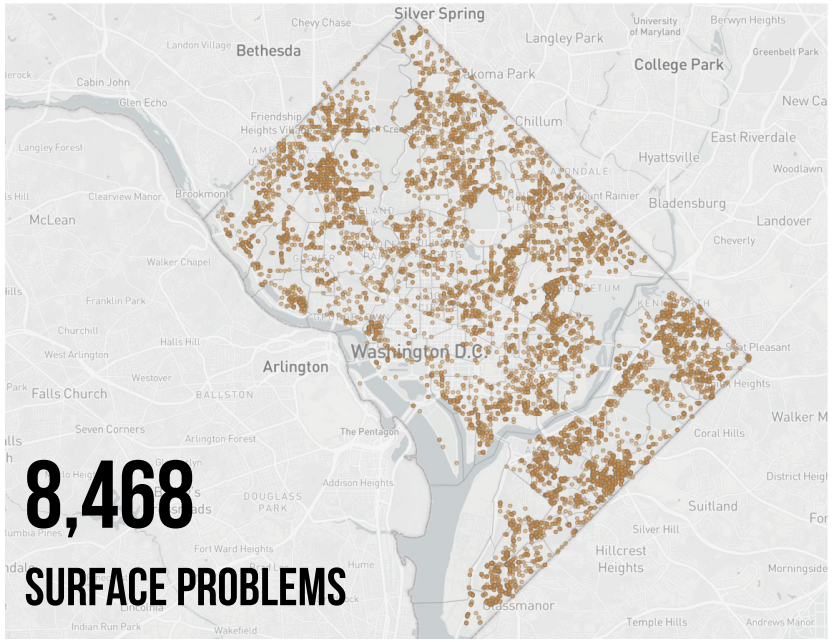


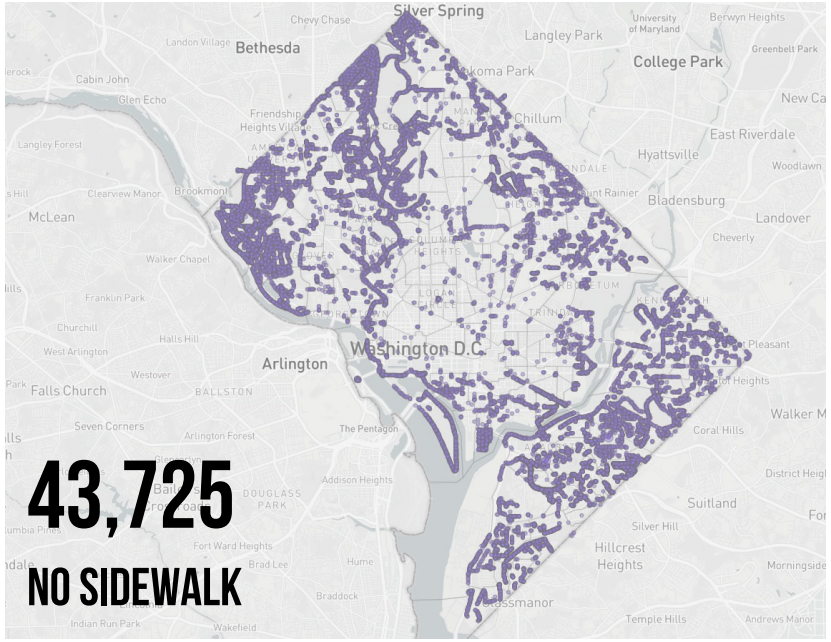

Cross-city comparison tools

PART 3: TOOL PROBLEM : : MOTIVATION

# URBAN ACCESSIBILITY VISUALIZATIONS




What are the (in)accessible areas of the city?

Why are they (in)accessible?

Where are the areas with highest repair needs?

# STAKEHOLDER-DEPENDENT DATA QUESTIONS

## What are the (in)accessible areas in my neighborhood?

**People with Mobility Impairments**

**Caregivers**

**Accessibility Advocates**

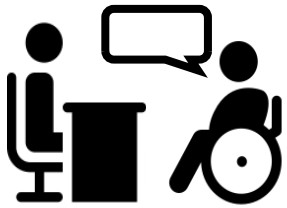

**Government Officials**

Elected Officials
and other policymakers

DOTs

## Where are the areas with highest repair needs?

How do we design **accessibility–aware** **interactive tools** for **urban accessibility**?



# TWO STEPS

Study 1

## [ONGOING]

**Paper prototype** design study to understand visualization and decision-making needs of our stakeholders

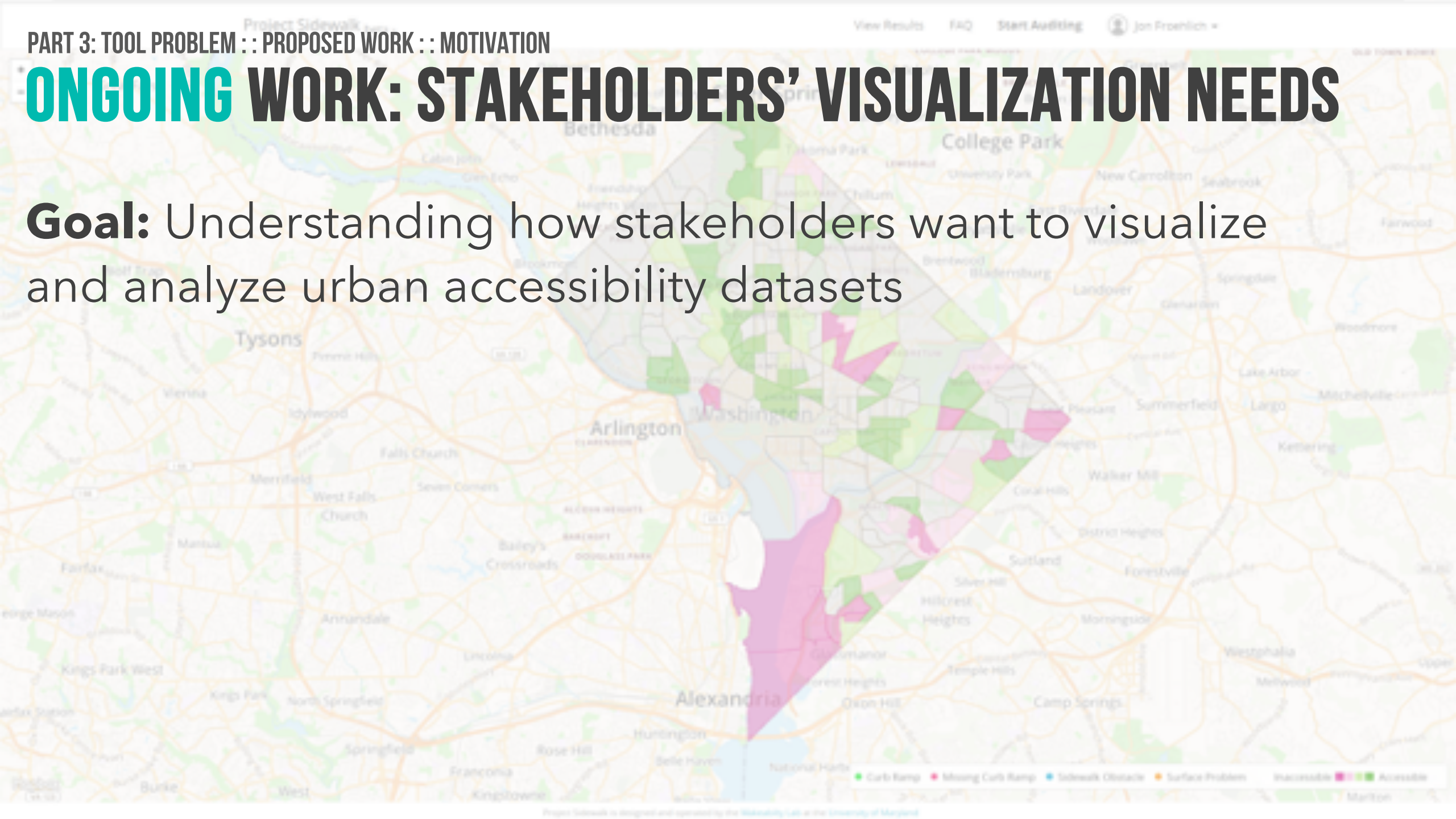
Study 2

## [PROPOSED]

**Interactive prototype** design study to investigate how to design interactive visualization tools, specifically focusing on supporting advocates and activists

# ONGOING WORK: STAKEHOLDERS' VISUALIZATION NEEDS

**Goal:** Understanding how stakeholders want to visualize and analyze urban accessibility datasets

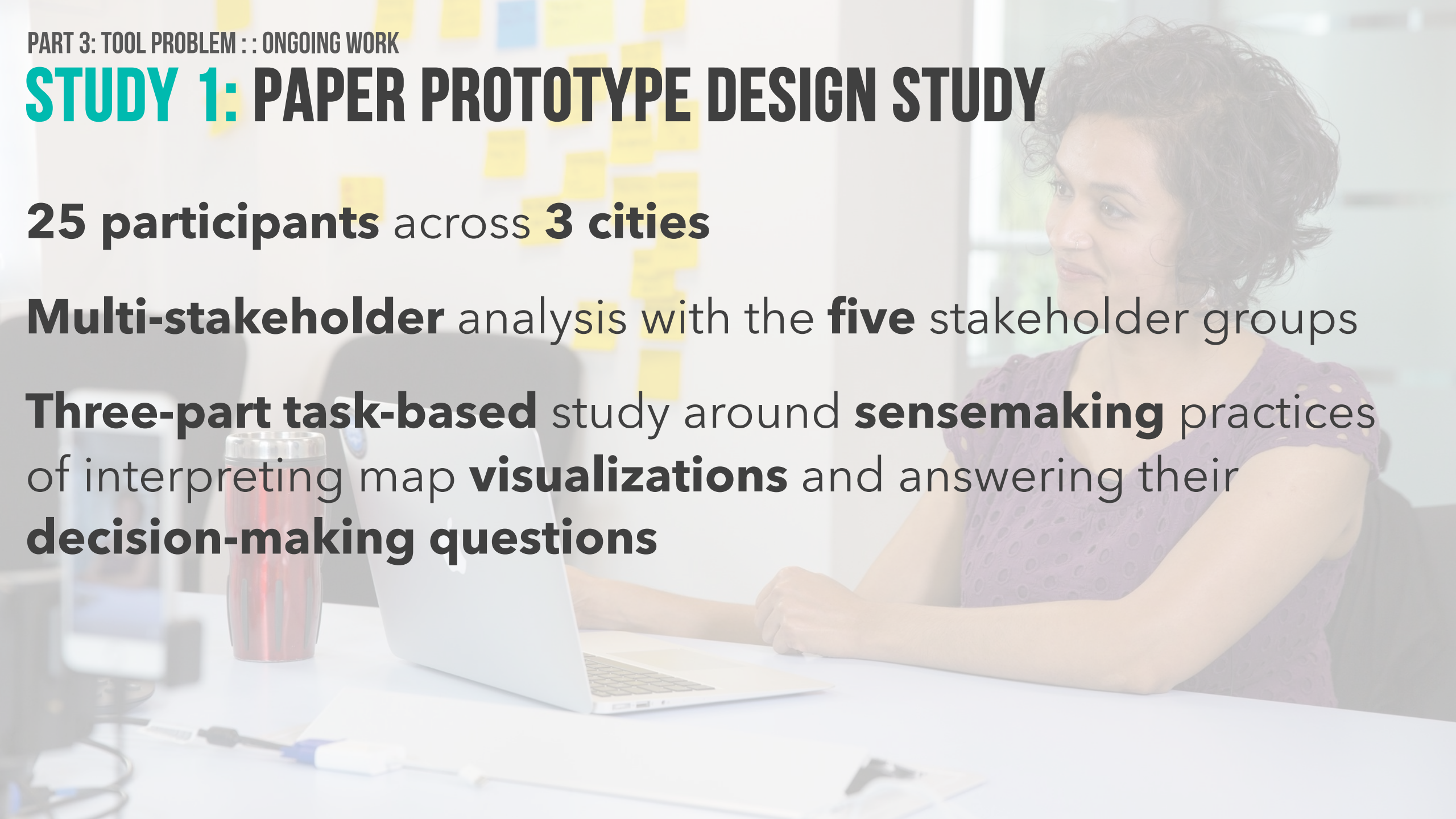


# STUDY 1: PAPER PROTOTYPE DESIGN STUDY

**25 participants** across **3 cities**

**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**



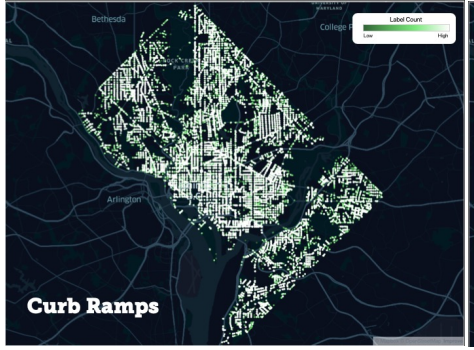
# STUDY 1: RESEARCH QUESTIONS

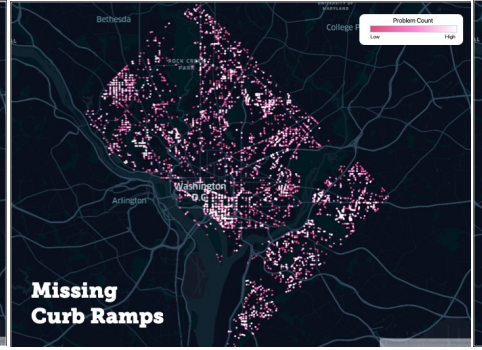
**RQ1** What are the design goals and guidelines to visualize accessibility to support the stakeholders' decision-making questions?

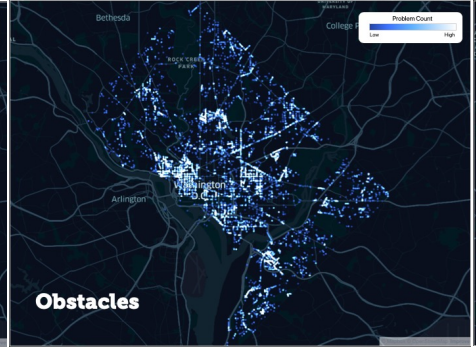
**RQ2** What are the unique perspectives and differences across stakeholder groups in terms of information needs and visual perception ?

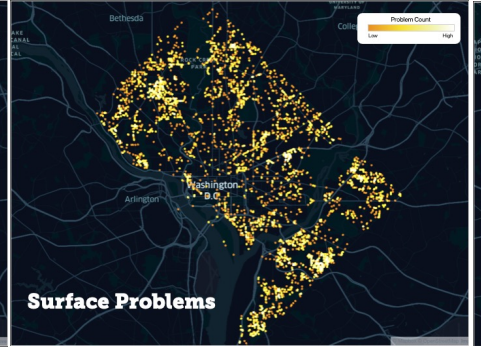

# Map Visualizations as Design Probes

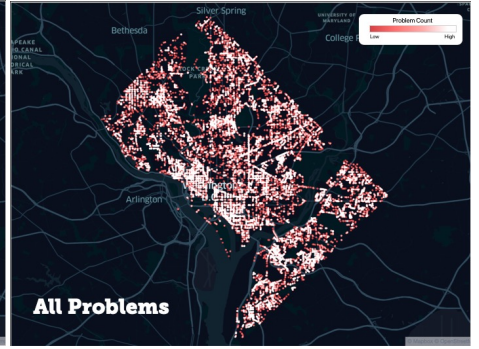
Type 1: Point-based



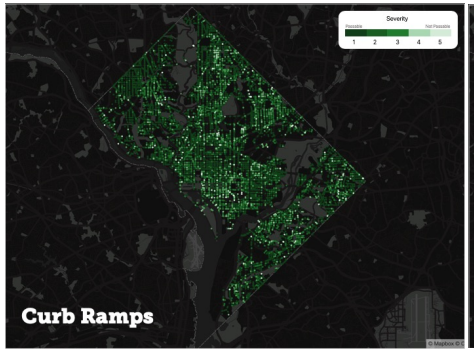



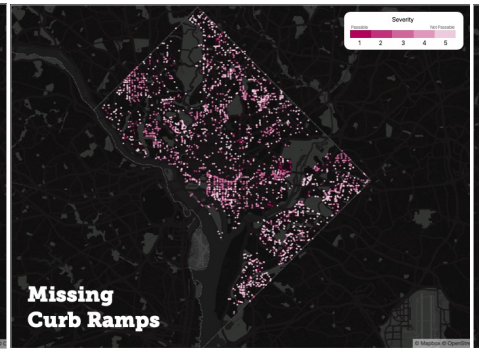



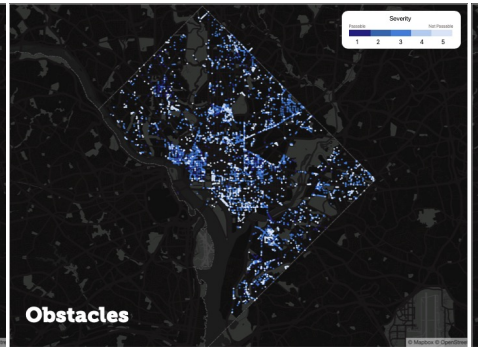



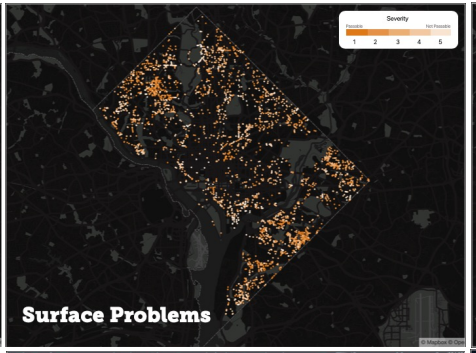



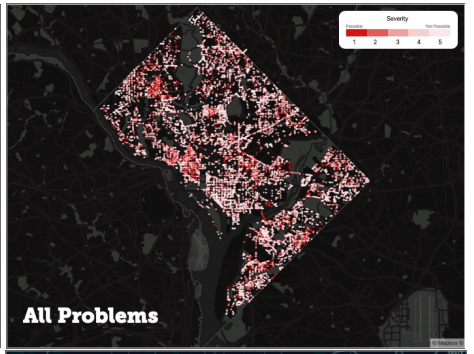

Type 2: Severity Point-based



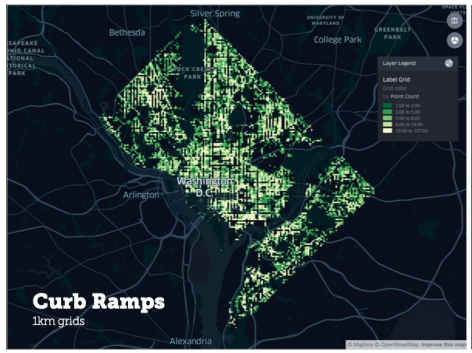



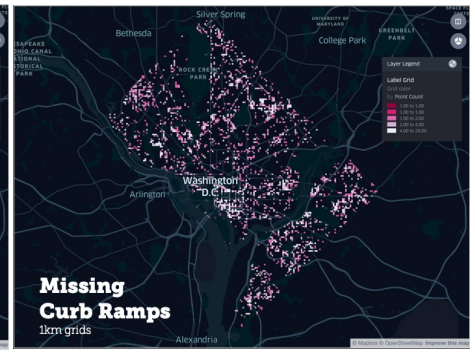



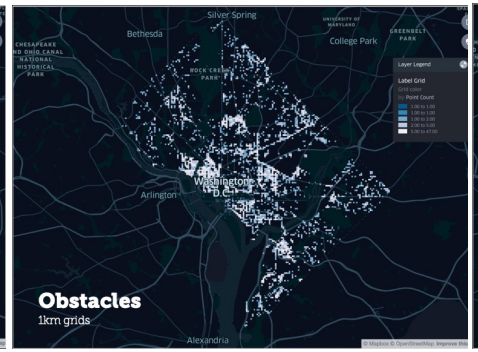



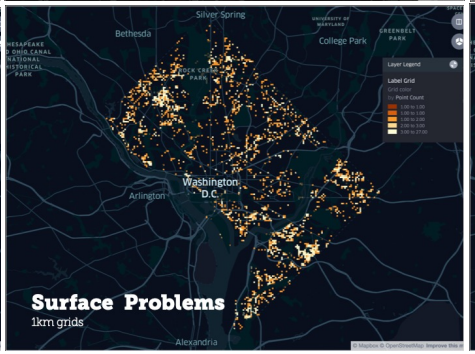



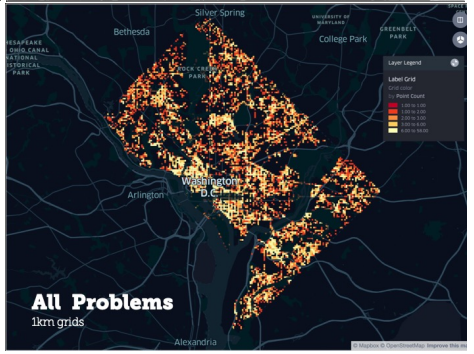

Type 3: Grid Maps



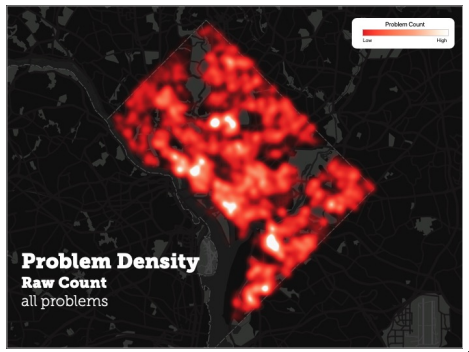



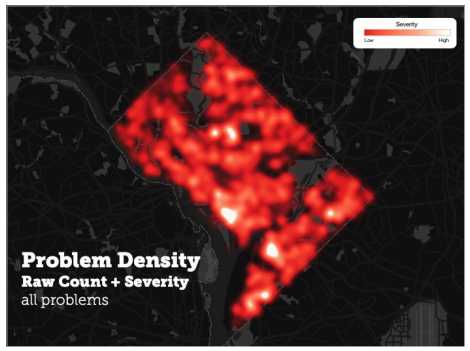



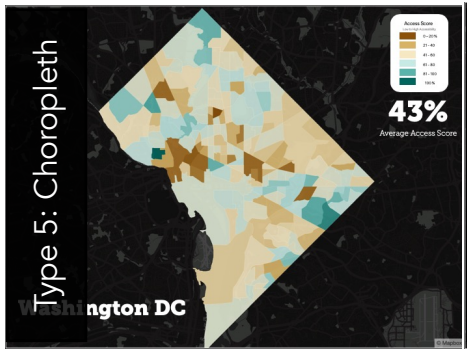




Type 4: Heatmaps

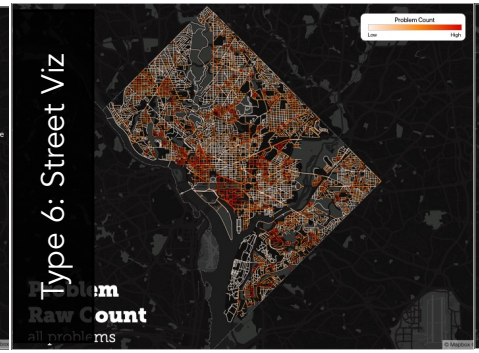


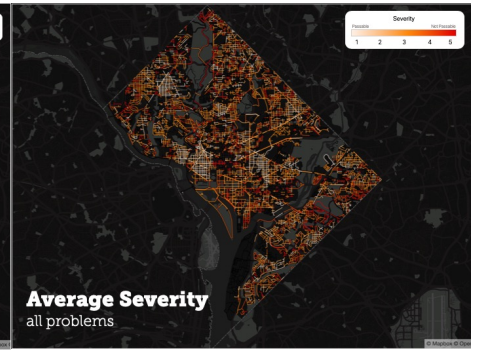




Type 5: Choropleth




Type 6: Street Viz









# ACCESS SCORE: PERSONALIZED ACCESSIBILITY MODEL

## Interactively Modeling and Visualizing Neighborhood Accessibility at Scale: An Initial Study of Washington DC

**Anthony Li[1], Manaswi Saha[2], Anupam Gupta[2], Jon E. Froehlich[2]**
[1]University of Maryland, College Park, [2]University of Washington, Seattle
antli@umd.edu, {manaswi, anupamg, jonf}@cs.washington.edu

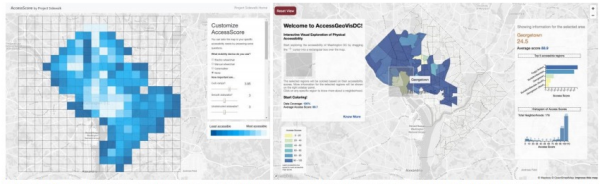


**Figure 1.** In this poster paper, we explore the initial design and implementation of two interactive geo-visualizations of neighborhood accessibility for people with mobility impairments: **(a)** *AccessScore* and **(b)** *AccessVisDC*. Both prototypes model and visualize accessibility using Project Sidewalk's API [9].

**ABSTRACT**
Walkability indices such as walkscore.com model the proximity and density of walkable destinations within a neighborhood. While these metrics have gained widespread use (*e.g.*, incorporated into real-estate tools), they do not integrate accessibility-related features such as sidewalk conditions or curb ramps—thereby excluding a significant portion of the population. In this poster paper, we explore the initial design and implementation of neighborhood accessibility models and visualizations for people with mobility impairments. We are able to overcome previous data availability challenges by using the Project Sidewalk API, which provides access to 255,000+ labels about the accessibility and location of DC sidewalks.

**Author Keywords**
Urban accessibility; geo-visualization; walkability indices

**ACM Classification Keywords**
H.5.m. Information interfaces and presentation (e.g., HCI)

**INTRODUCTION**
Websites such as walkscore.com model and visualize the "walkability" of neighborhoods by measuring the proximity and density of walkable destinations (*e.g.,* grocery stores, parks, and restaurants). While recent work suggests that neighborhood walkability correlates with real estate value, lower crime rates, and more walking trips for non-work purposes [3, 7], these metrics do not incorporate accessibility-related features such as sidewalk conditions, the presence of curb ramps, and road grade. One key challenge has been data availability.

Enabled by *Project Sidewalk's* API (projectsidewalk.io/api), which provides access to 255,000+ labels describing the accessibility and location of Washington DC sidewalks [9], we designed and implemented two interactive geo-visualizations of neighborhood accessibility for people with mobility impairments (Figure 1). While recent work has explored accessibility-aware pedestrian routing algorithms and tools [1, 11], these systems are focused on *wayfinding* rather than modeling and visualizing higher-level abstractions of accessibility. Our aim is complementary: to provide personalizable, interactive, and glanceable visualizations of city-wide accessibility.

As early work, our research questions are exploratory: how can we develop algorithmic models that accurately describe the accessibility of streets and sidewalks? How can we make these models and resulting visualizations parameterizable to meet the needs of different users (*e.g.,* manual *vs.* electric wheelchair users)? How can we make our visualizations responsive and interactive over the web (even with 100,000+ data points)? To begin addressing these questions, we report on the initial development of two open-source prototype visualization tools: *AccessScore* and *AccessVisDC*[1].

[1] Source code and live demos for AccessScore: https://goo.gl/doMR3G and AccessVisDC: https://goo.gl/yn93RZ.



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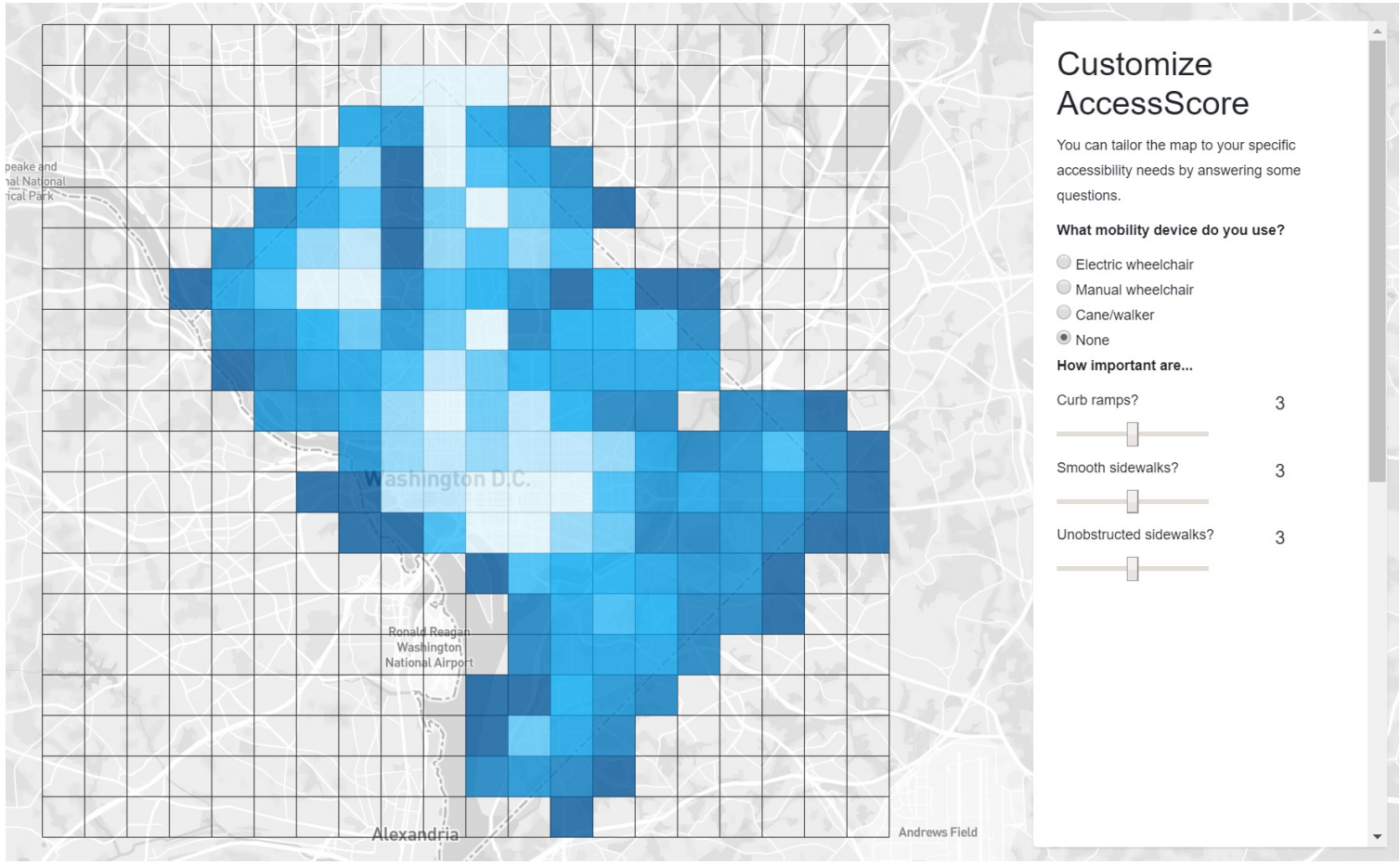
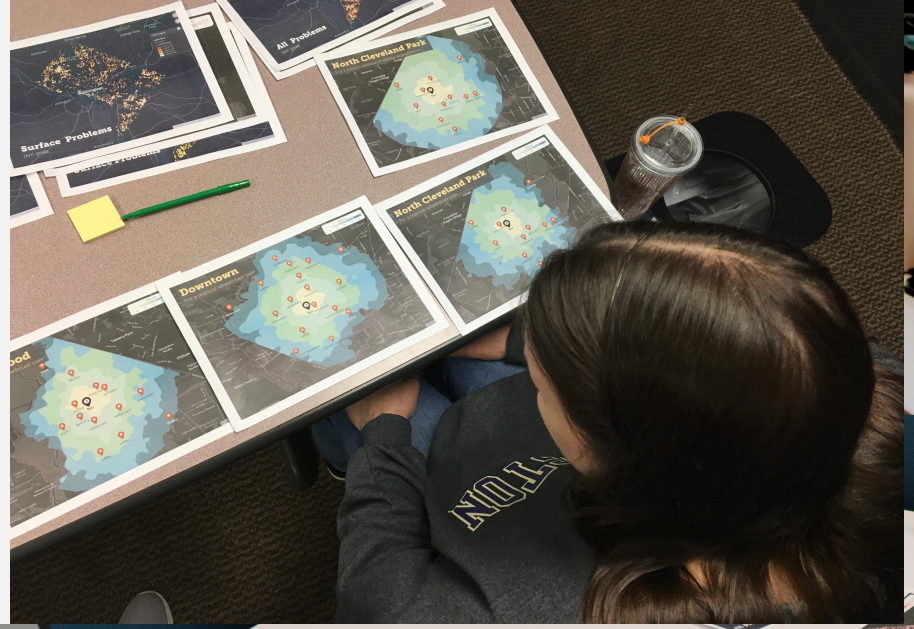


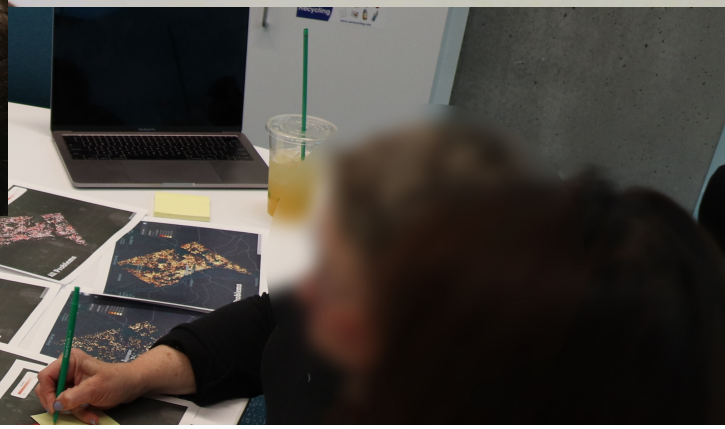

[ASSETS'18 Poster]

# DESIGN INTERVIEWS

## N=25

Department officials
City elected officials
Accessibility advocates
People with mobility disabilities
Caregivers





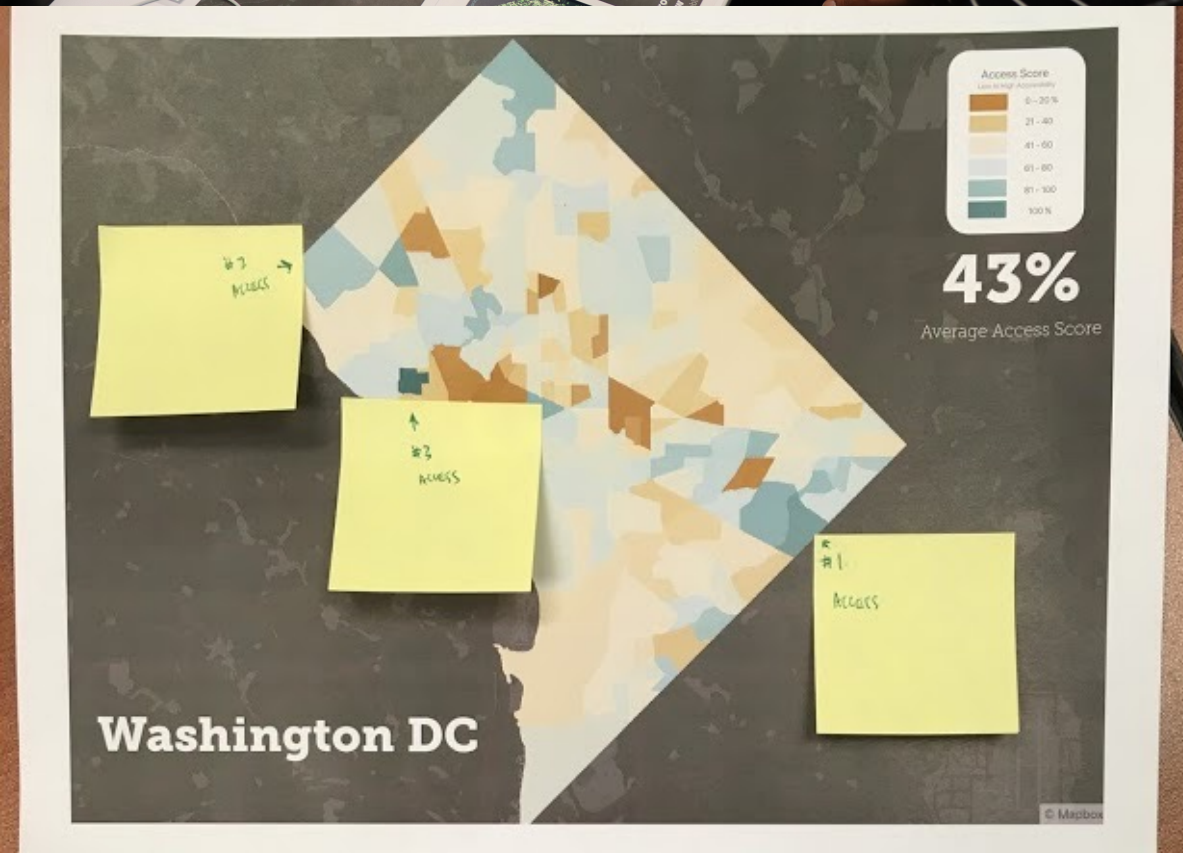
1. Initial Exploration of Maps
2. Visual Sensemaking Tasks
3. Future Interactive Vis Tools

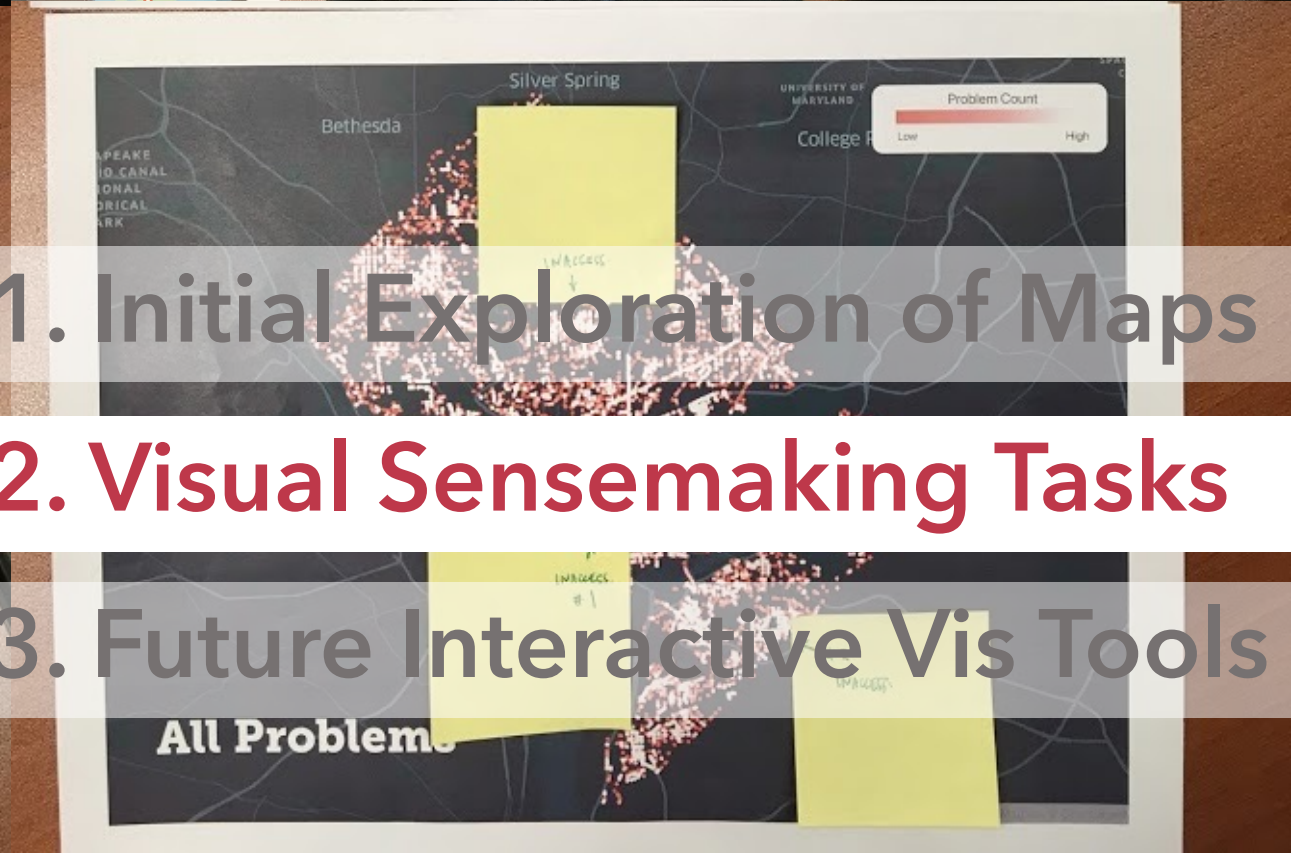

1. Initial Exploration of Maps

2. Visual Sensemaking Tasks

3. Future Interactive Vis Tools



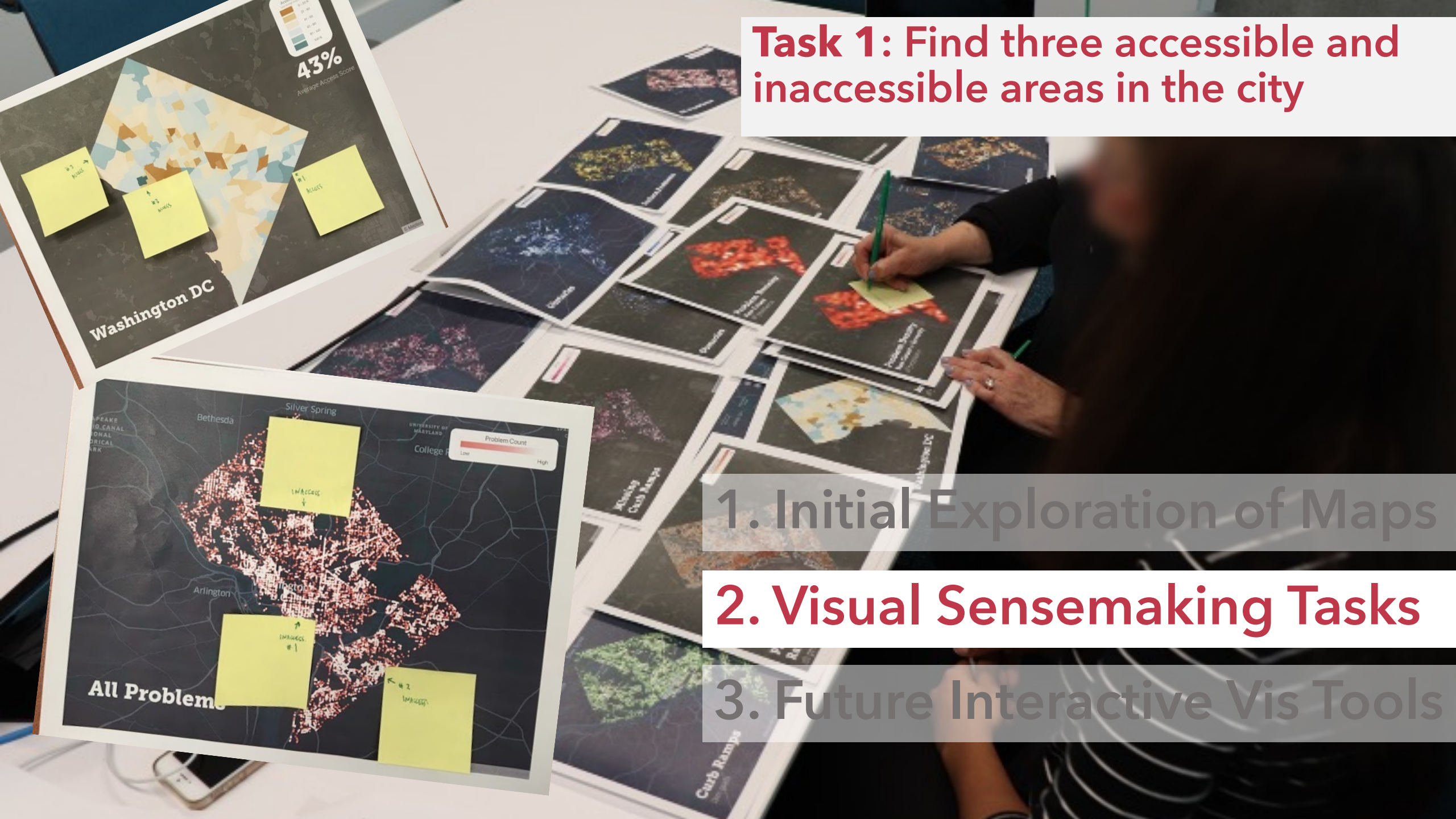


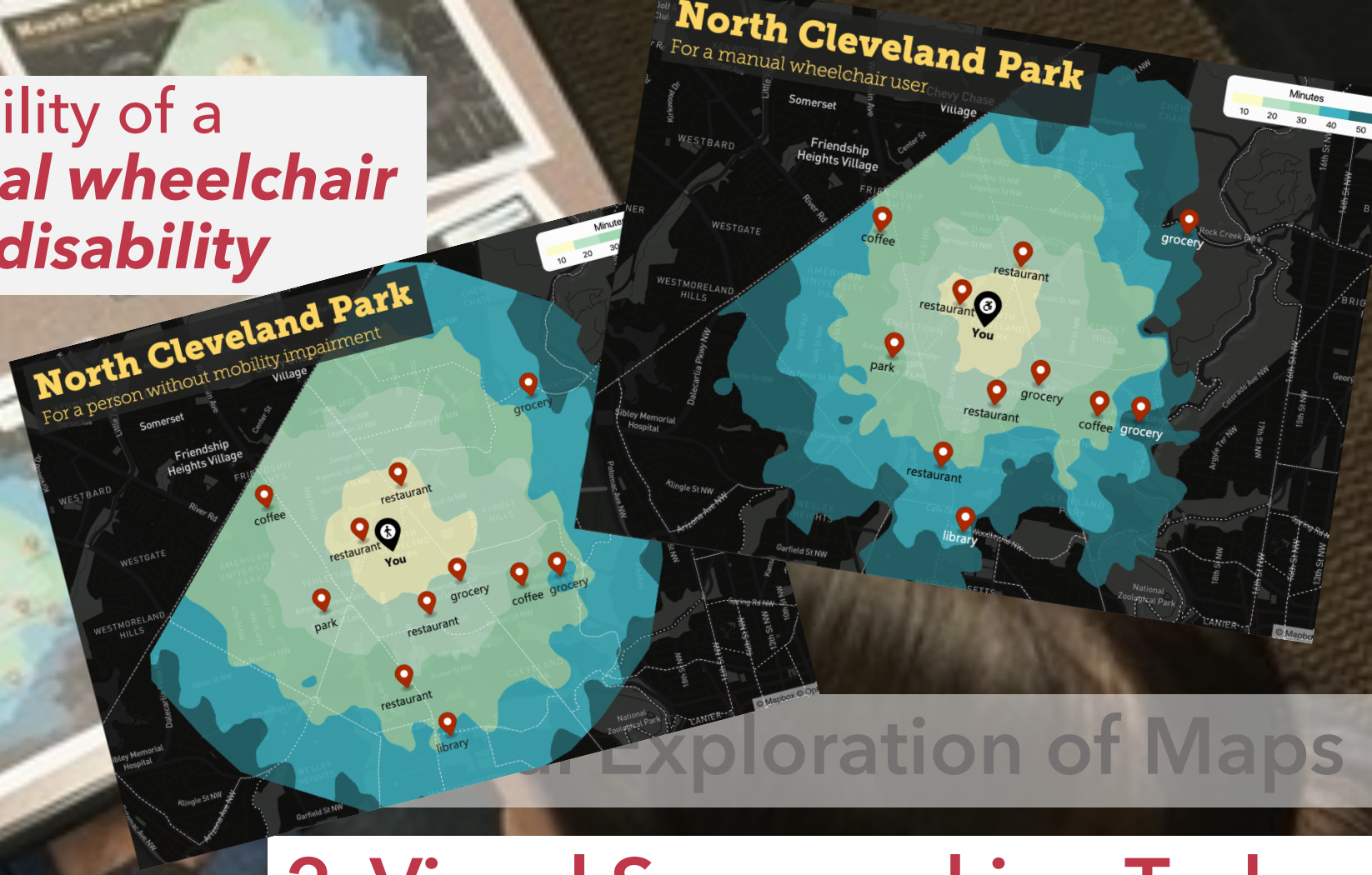

1. Initial Exploration of Maps

2. Visual Sensemaking Tasks

3. Future Interactive Vis Tools


Task 1: Find three accessible and inaccessible areas in the city
43%
Average Access Score
Washington DC
Silver Spring
Bethesda
Arlington
Problem Count
Low
High
All Problems
Curb Ramps
1. Initial Exploration of Maps
2. Visual Sensemaking Tasks
3. Future Interactive Vis Tools

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



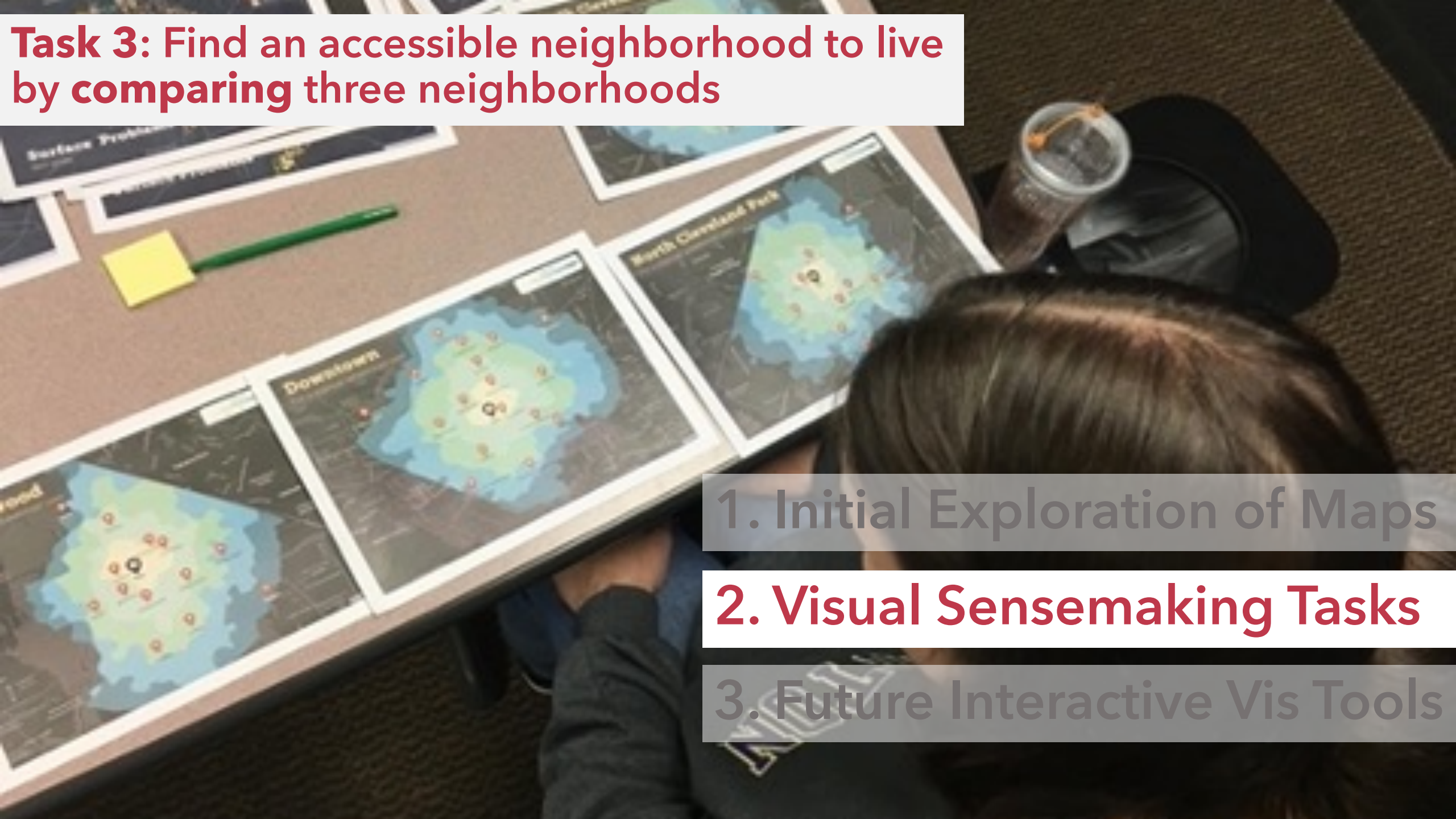


1. Exploration of Maps

2. Visual Sensemaking Tasks

3. Future Interactive Vis Tools

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




1. Initial Exploration of Maps

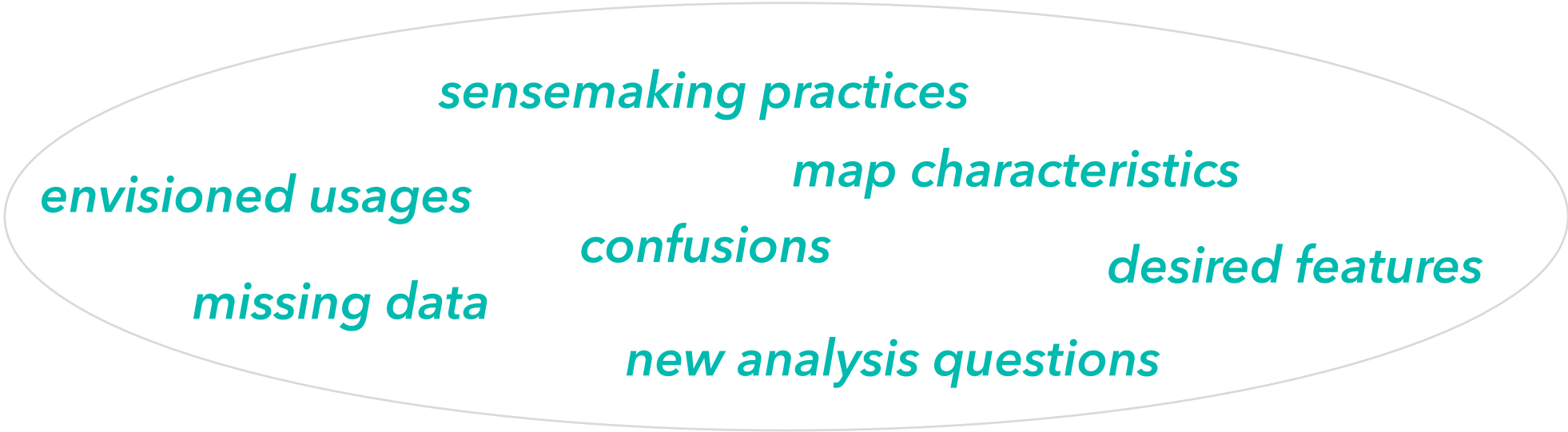
2. Visual Sensemaking Tasks

3. Future Interactive Vis Tools

# EXPECTED FINDINGS

**One-size-fits-all** for a visualization tool would **not** work

Emerging **themes** include




**Expected** higher level themes include data and information granularity needs, interactivity needs, and prioritization needs for acquiring actionable insights

# PROPOSED WORK: DESIGN NEEDS FOR ADVOCACY

**Advocates**

**Unique** group that sits between government and citizens whose **decision-making needs** have **not yet well-studied**

Targeting advocates who are **novices** in tech-driven data analytics

**Goal:** Address the tool gap geared towards social advocacy needs for urban accessibility

# ADVOCACY PERSPECTIVE: TWO IMPORTANT FACTORS

**Analyzing data** inline with perspectives of both government and citizens

Creating a strong **compelling evidence-based narrative**

# STUDY 2: RESEARCH QUESTIONS

## Supporting interactivity needs

**RQ1** How do we design intuitive interaction patterns to make geovisual data analysis accessible to novices?

## Supporting information needs

**RQ2** How do we augment visualizations with contextual data to answer advocates' data analysis questions and create strong narratives?

# STUDY 2: INTERACTIVE PROTOTYPE DESIGN PROBE STUDY

**Two-part** task-based qualitative study

**Part A:** investigate *interaction patterns* to support probing the datasets, finding patterns, and building insights

**Part B:** investigate *contextual data types* to augment visualizations for maximizing insight building

**Goal**: To generate design guidelines for building geovisual analytical tools for novice users, particularly advocates

# STUDY 2: PART A PROTOTYPE DESIGN IDEAS

**Goal**: To investigate **interactions** patterns that help **guide advocates** to move between different stages of their analysis journey: from exploratory analysis to target question-driven analysis.

**Prototypes**: Examples of interactions include

- contextual data on the sidebar triggered by **direct map manipulations**
- **switching map types** based on **zoom levels** to show different data views for the task question
- showing **linked side-by-side maps** with each map showing different factors of the task question

# STUDY 2: PART B PROTOTYPE DESIGN IDEAS

**Goal:** To investigate how best to guide users with **contextual data** from finding a pattern to building an insight to creating a **compelling story** for advocacy efforts

**Prototypes**: Examples of contextual data/vis widgets include,

- GSV images
- Region's accessibility statistics
- GSV images with statistics
- External information such as curated news articles

PART 3: TOOL PROBLEM : : PROPOSED WORK : : STUDY 2

# ACCESSVIS: INTERACTIVE VIS TOOL PROTOTYPE

**Interactive Visual Exploration of Physical Accessibility**

Start exploring the accessibility of Washington DC by dragging the + cursor into a rectangular box over the map.

The selected regions will be colored based on their accessibility scores. More information for the selected regions will be shown on the right sidebar panel.
Click on any specific region to know more about a neighborhood.

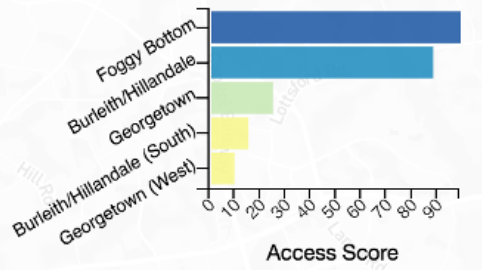
**Start Coloring!**

Data Coverage: 100%
Average Access Score: 89.7

Know More

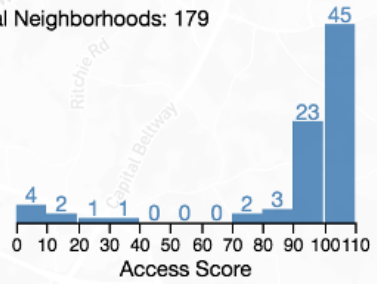
Georgetown
24.5
Average score 88.9

Top 5 accessible regions




Histogram of Access Scores

Total Neighborhoods: 179




Access Scores
0 - 20
20 - 40
40 - 60
60 - 80
80 - 90
90 - 100
Least accessible (low score) to most accessible (high score)


Showing information for the selected area
Howard University
57.6
Average street score 66.2


Showing information for the selected area
Cardozo/Shaw
99.9
Average street score 91.6

Andrews Field

© Mapbox © OpenStreetMap Improve this map

# PARTICIPANTS

## Accessibility advocates

Recruiting from

- NGOs and non-profits
- past participants
- partners of Project Sidewalk initiative

# EXPECTED CONTRIBUTIONS

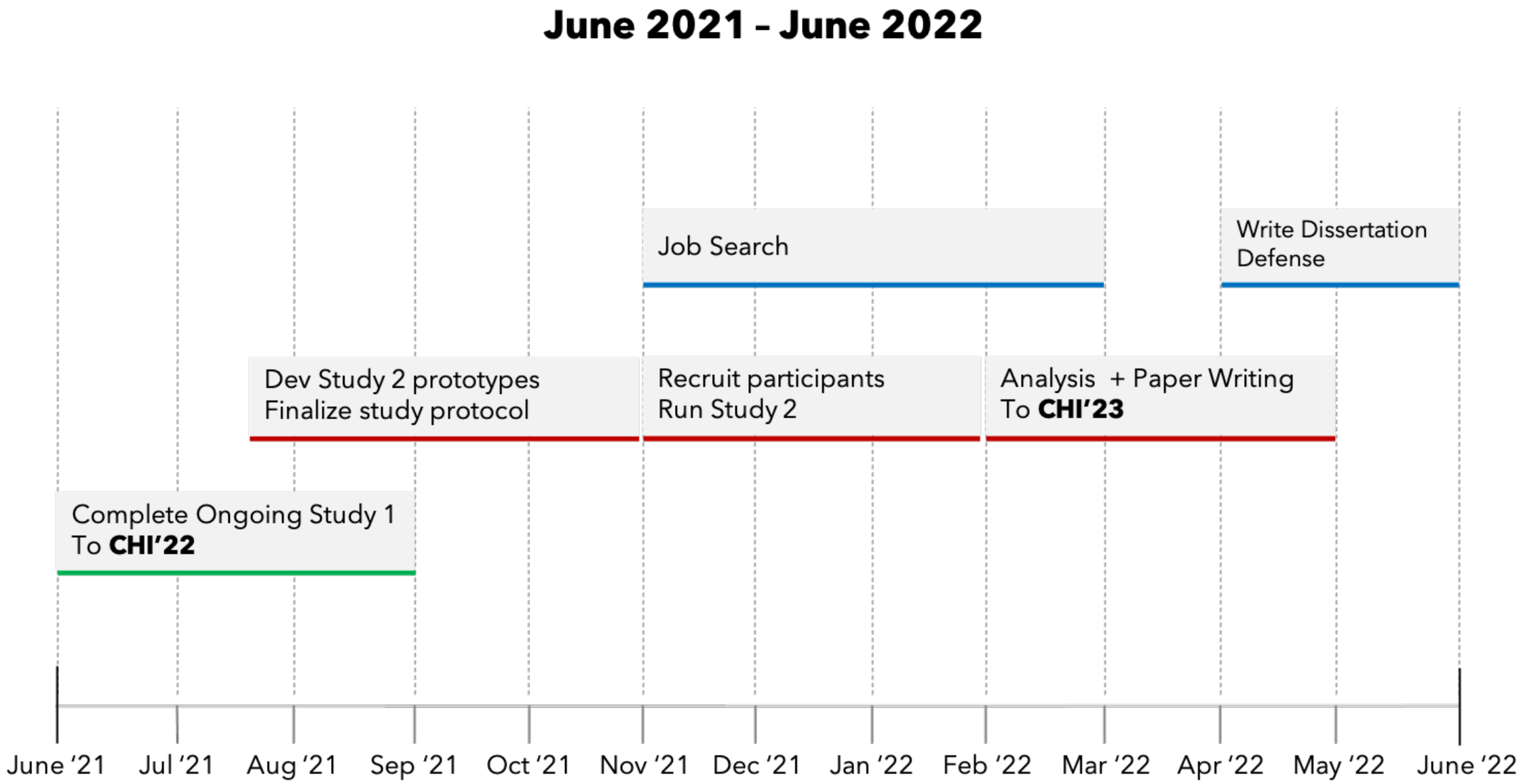
**Design needs** for supporting interactions and contextual information needs for **advocacy-based decision-making**

**Expected outcome** set of **design guidelines** for supporting advocates' data questions and decision-making goals.

**Larger implications** applicable to both urban accessibility and to the general field of **novice geovisual urban data analytics**

CONCLUSION

# PROPOSED TIMELINE



ACKNOWLEDGEMENTS

# TEAM

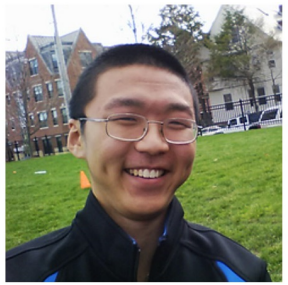
## Professors

Jon Froehlich

Jeffrey Heer

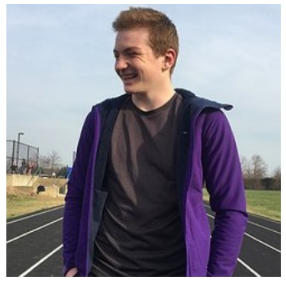
makeabilitylab.io

## Undergraduate & High School Students



Anthony Li

Steven Bower



Ryan Holland

Aditya Dash

Sage Chen

## Graduate Students

### PhD Students

Michael Saugstad

Hanuma Teja Maddali

Kotaro Hara

### Master Students

Devanshi Chauhan

Rachel Kangas

Siddhant Patil

Richard McGovern

Emily Cho

Evie (Yu-Yen) Cheng

Chris Horng

https://makeabilitylab.cs.washington.edu/people/

CONCLUSION

# TAKEAWAYS

## Any Questions?

Socio-political factors complicates things!

Facilitating civic interactions may hold the key!

Technology can play an important role to understand and facilitate effective decision-making for urban accessibility

Help make the world more **accessible** for everyone!

Join us. Contact manaswi@cs.uw.edu manaswisaha

https://github.com/ProjectSidewalk http://projectsidewalk.io/api

MAKEABILITY LAB
DESIGN USE BUILD
PAUL G. ALLEN SCHOOL OF COMPUTER SCIENCE & ENGINEERING
UNIVERSITY of WASHINGTON