Immersive Visualization of Multilayered Geospatial Urban Data

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Introduction

- Since 2017 doctoral student at Centrale Nantes with the Ambience, Architectures & Urbanités (AAU) lab

  ‣ Encadrement: Vincent Tourre

  ‣ (Original) topic: *Visualization of Multi-Layered Spatiotemporal 3D Urban Datasets*

  ‣ Motivation: *Create effective visualizations of spatiotemporal data for the urban design process, using recent advances in immersive technologies.*

Problem Statements

Urban Data Understanding

1. How can the *understanding of urban environments* be improved with *visualizing more available data*?

   ‣ What is *urban data?*
   ‣ What is *understanding urban environments?*

3D Urban Data Visualization

2. What are the benefits of *3D data visualization for urbanism?*

   ‣ How to preserve *legibility in (immersive) 3D views?*

Implementation

3. What are the most *useful views in 3D urban visualization?*

   ‣ Are *multi-view solutions* possible and desirable?
   ‣ How to *maximize data layer legibility, minimize interference?*

Urban Design: Two Definitions

"Urban design is concerned with the *physical form of cities*, buildings and the space between them. The study of urban design deals with the relationships between the physical form of the city and the social forces which produce it. It focuses, in particular, on the *physical character of the public realm but is also concerned with the interaction between public and private development* and the resulting impact on urban form."

From: Clara Greed and Marion Roberts. *Introducing urban design: interventions and responses*. Routledge, 2014

"...urban design should be taken to mean the relationship between different buildings; the *relationship between buildings and the streets, squares, parks and other spaces* which make up the public domain; the nature and quality of the public domain itself; the relationship of one part of a village, town, or city with other parts; and the *patterns of movement and activity* which are thereby established: in short, the *complex relationships between all the elements of the built and unbuilt space*."

Urban Design Process as a Visualization Challenge

- ***Visual Analytics in Urban Computing: An Overview*** (Yixian Zheng et al, 2016):

  ▸ With more data of higher complexity becoming available, human analysis is still indispensable

  ▸ Finding effective ways to present urban data is more important than ever

- ***In search of visualization challenges: The development and implementation of visualization tools for supporting dialogue in urban planning processes*** (Monica Billger et al, 2017):

  ▸ Urban data visualization is a great source for open research questions in visualizations

Challenge 1: Multilayer

- Multiple layers of information regarding different aspects of the city environment

- Difficulty in representing different parameters of geo-referenced data simultaneously in a comprehensible way
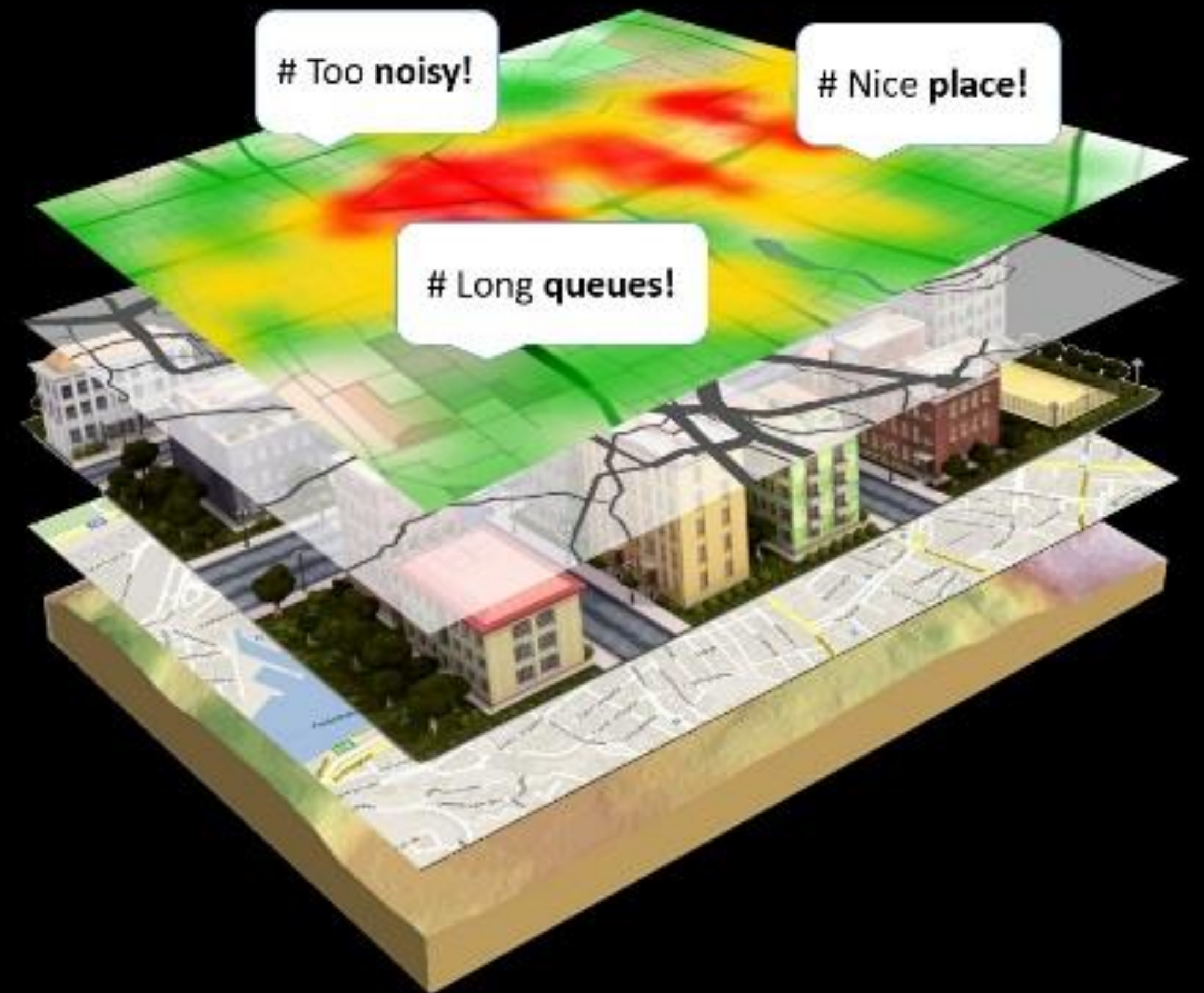
From *Visualizing environmental data for pedestrian comfort analysis in urban planning processes*, Wästberg et. al., 2017

Two-Layer Comparison

- Many ways exist to show **two** spatial layers simultaneously

- Work has been done in cartography to address comparing/understanding two map layers

- Which of these are applicable to *more than two* layers?
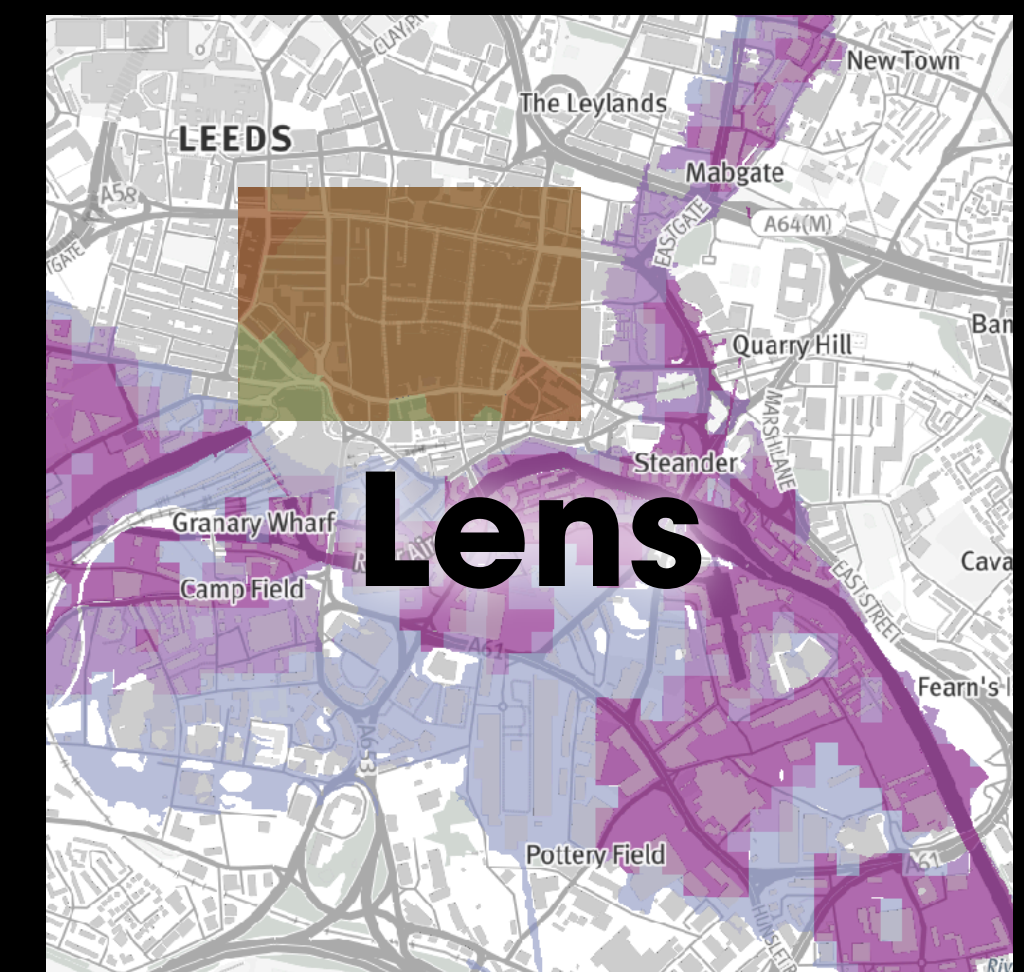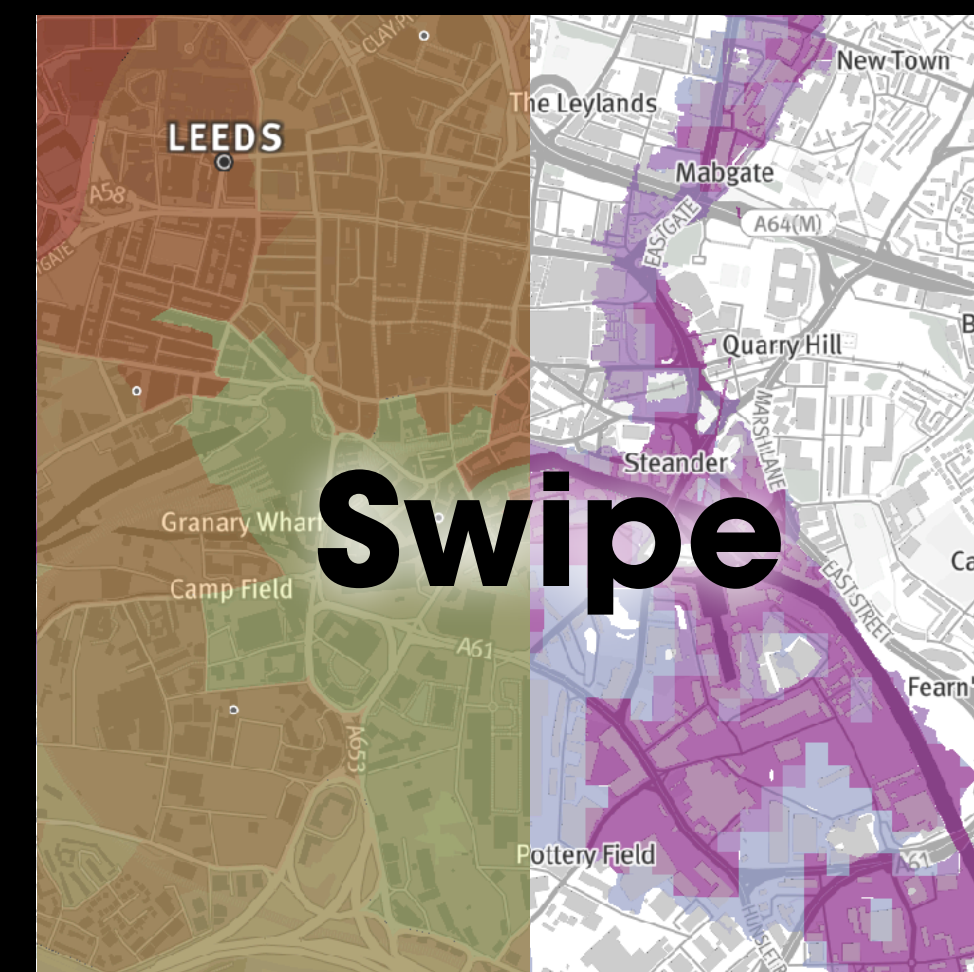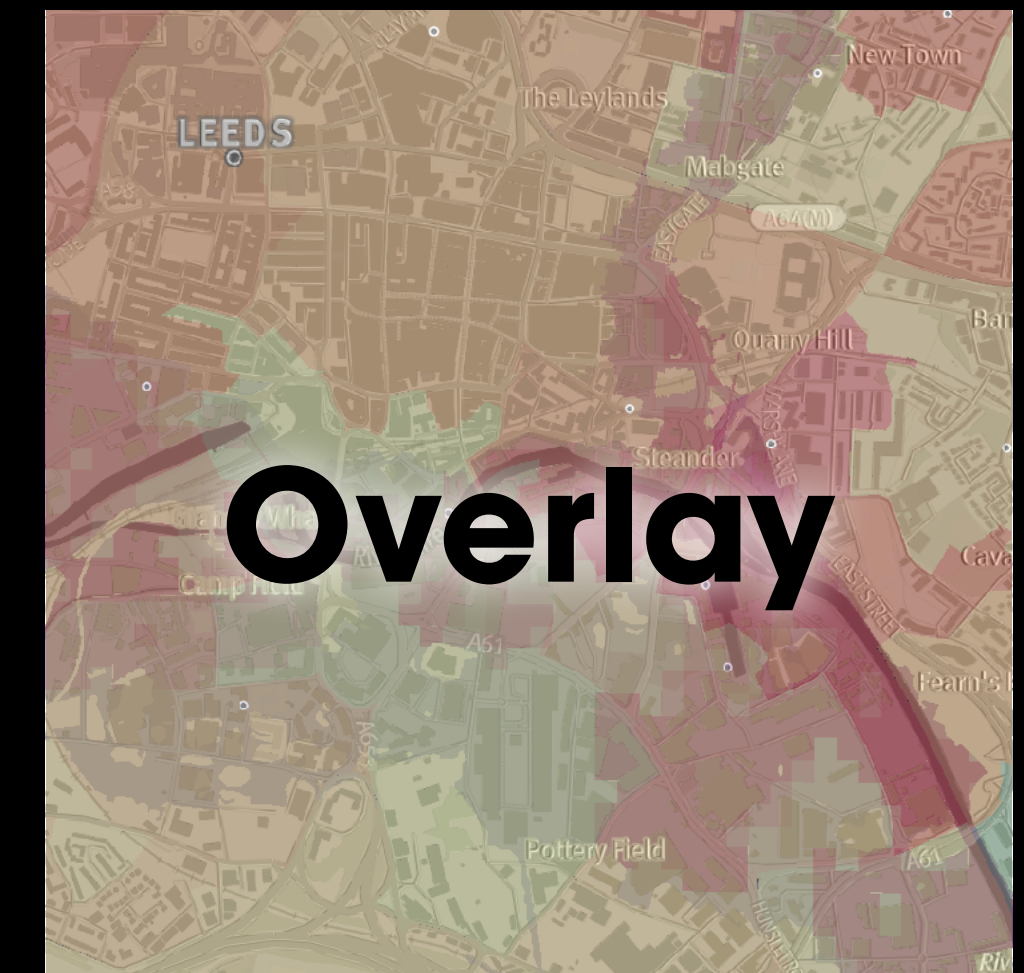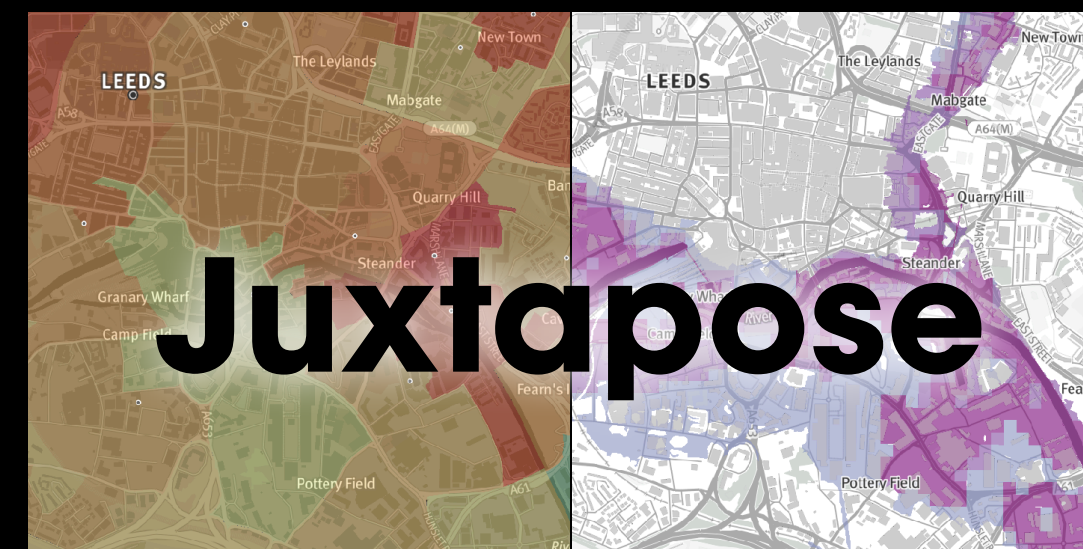
Example: *An Evaluation of Interactive Map Comparison Techniques,* Lobo et. al., 2015

Juxtapose

Overlay

Swipe

Lens

Multilayer: Space for Research

- *What about more than two layers?*

  ‣ Many applications require more than just two layers

  ‣ Many researched techniques don't apply well to more than two layers

- *Could immersive visualization offer advantages?*

  ‣ Theoretically infinite display size, with stereoscopic vision

  ‣ Direct interaction

  ‣ Immersion into the data

1. **Compare techniques applicable for more than two layers**

   Judge by subjective user ratings after completing tasks, qualitative interviews, and objective measurements

2. **Evaluate the techniques inside an immersive environment**

   By itself, XR offers advantages (large display size, interactivity), and since the *stack* appears to benefit most from stereoscopic display, the other methods had to be compared *on an equal footing*

Multilayer: Our Research

- Evaluate three compositing techniques in virtual reality

  ‣ *Blitting:* One big map, switching between layers

  ‣ *Grid:* Show all layers juxtaposed in a grid

  ‣ *Stack:* Show all layers juxtaposed in a stack

- Hypotheses:

  ‣ Juxtaposition beats blitting: less mental effort (all layers visible), faster, and less physical effort (no switching)

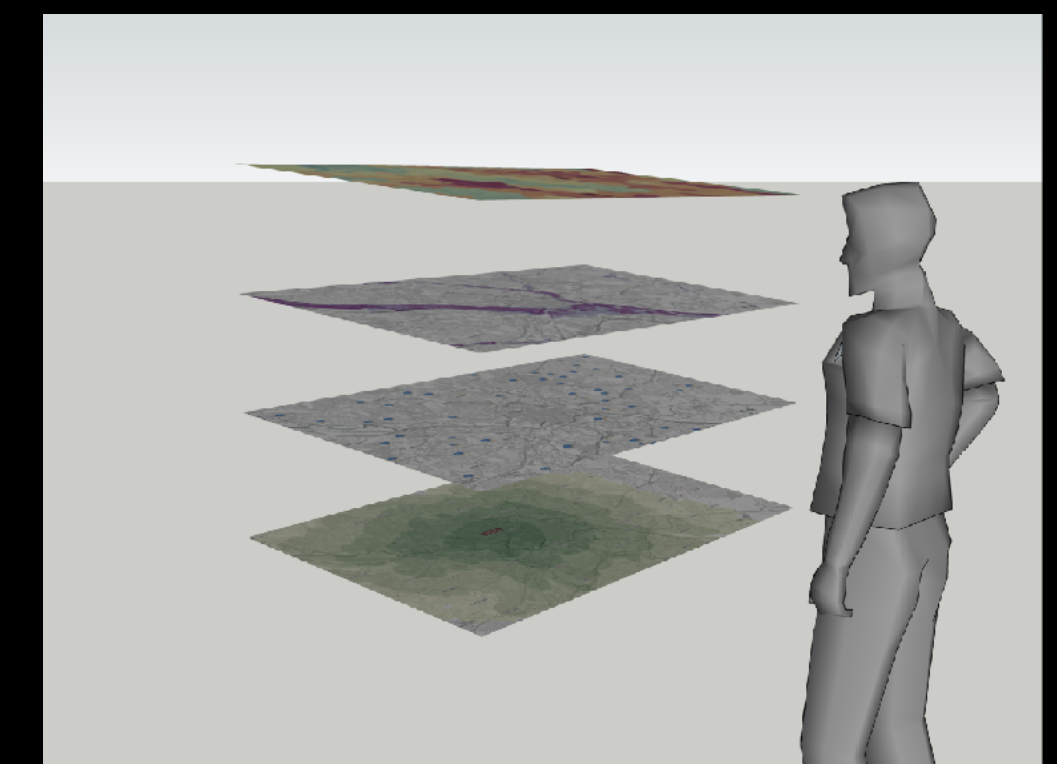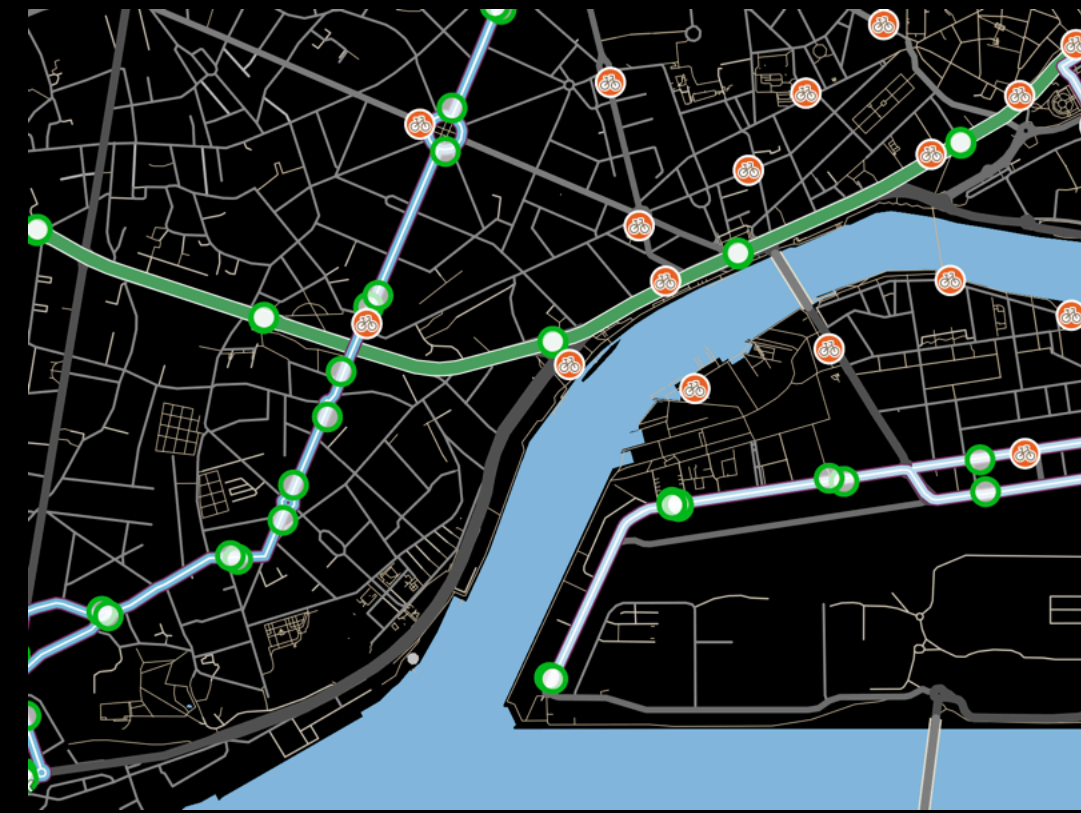 ‣ Stack beats grid: layers vertically aligned

    • Stereoscopic VR makes stack readable

Blitting
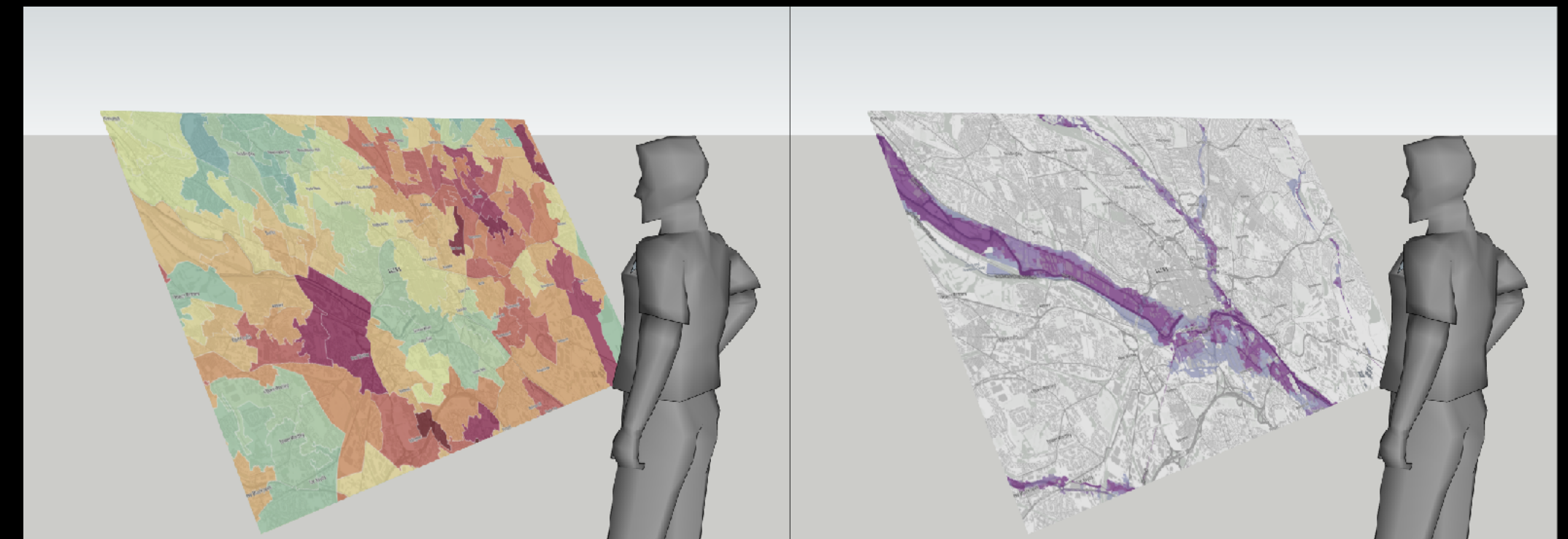
Grid
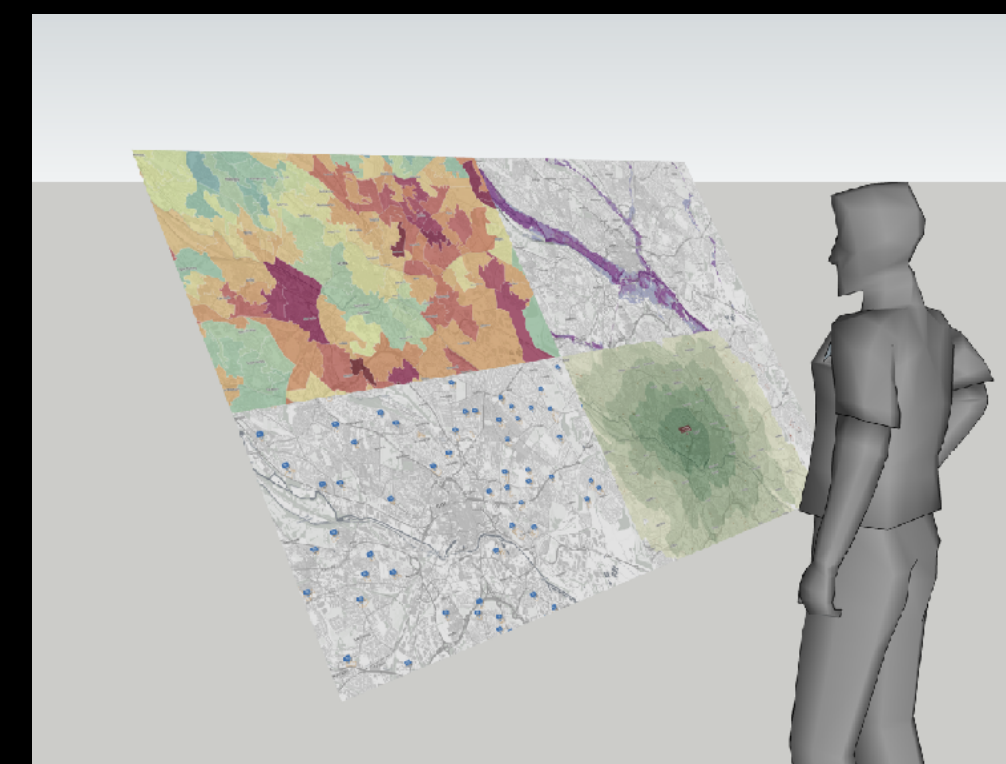
Stack

Research: Multilayer Data — City Illumination

Light pollution

Night transportation

Energy consumption

Night points of interest
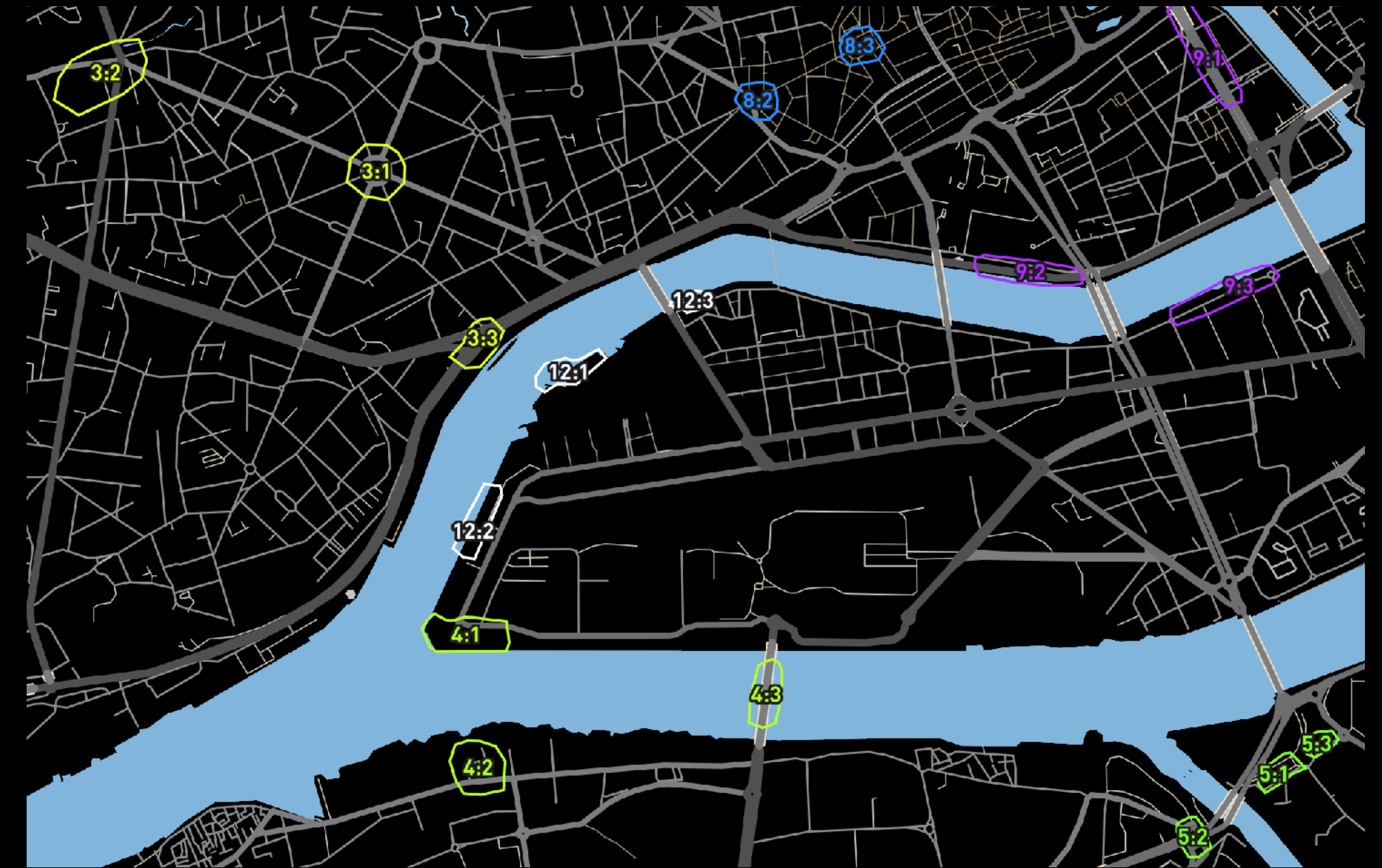
Evaluation requires a *task*; ideally a *use case*

- Decisions in urban public lighting are a natural multilayered problem
- Based on four layers, make a *choice* between three given areas: which one is the most "problematic," or most in need of change?
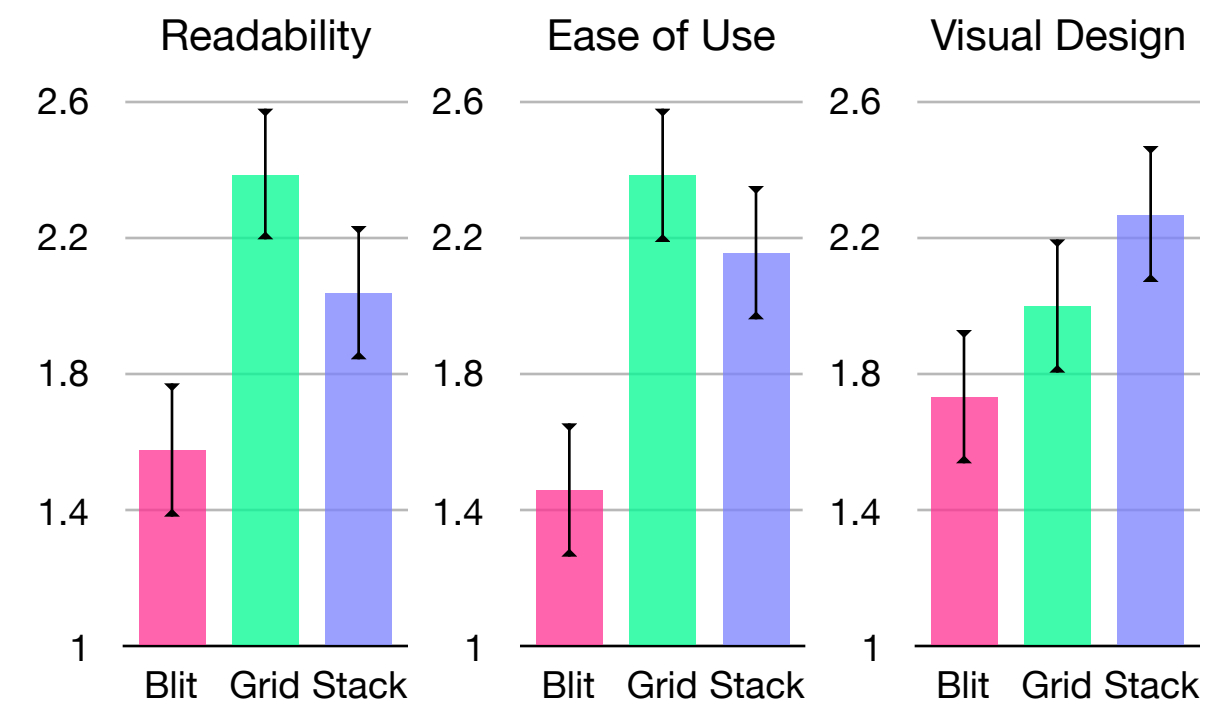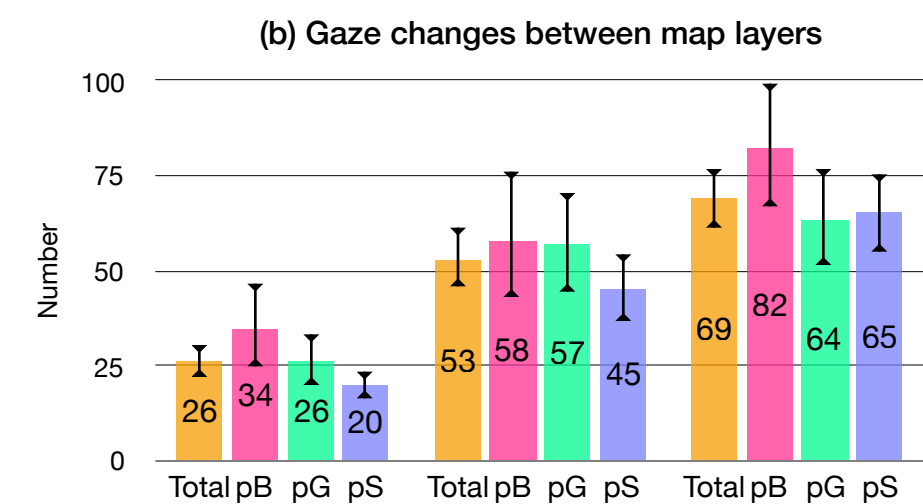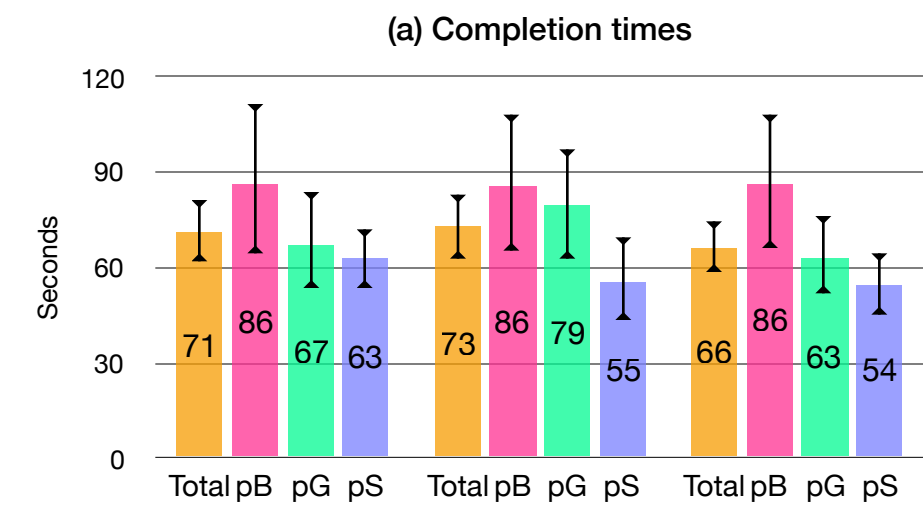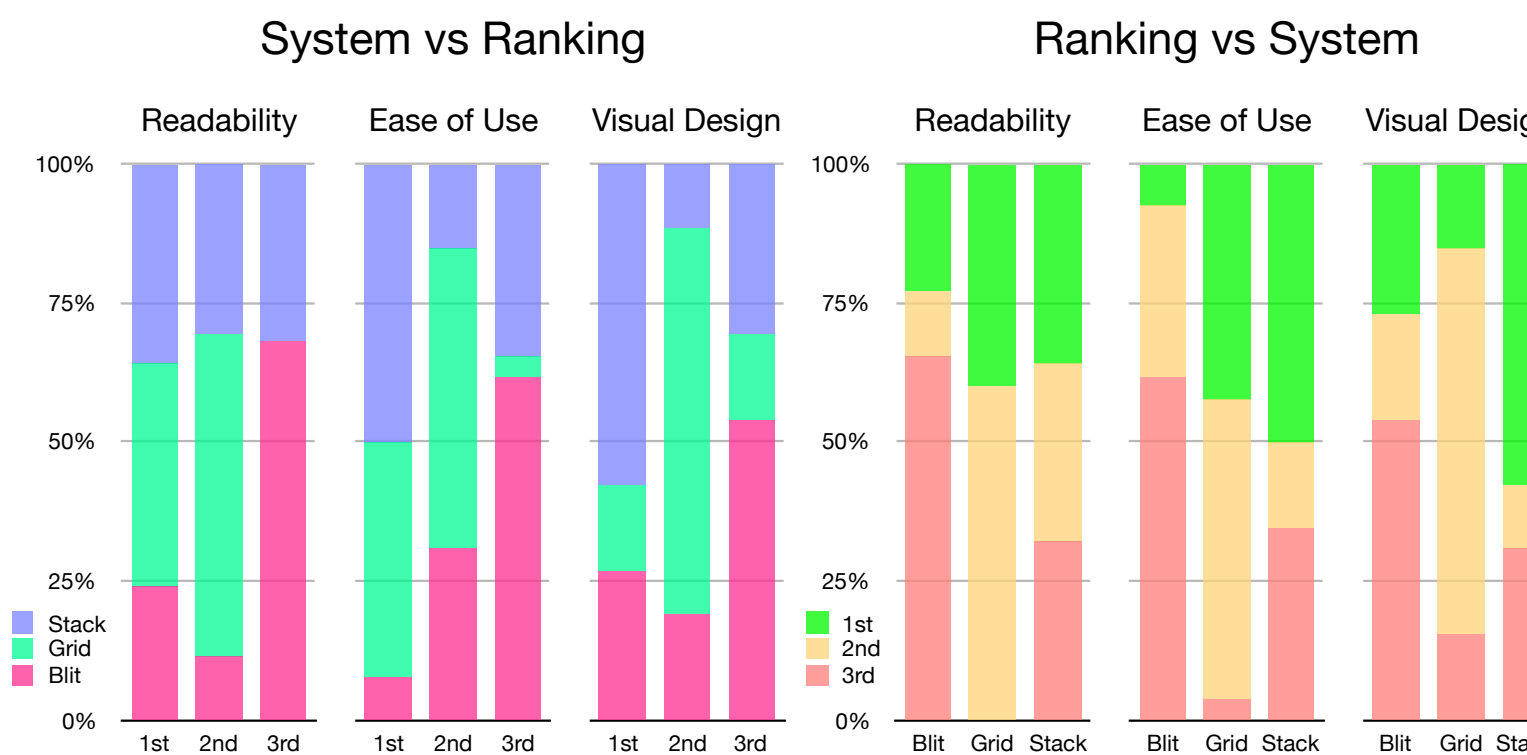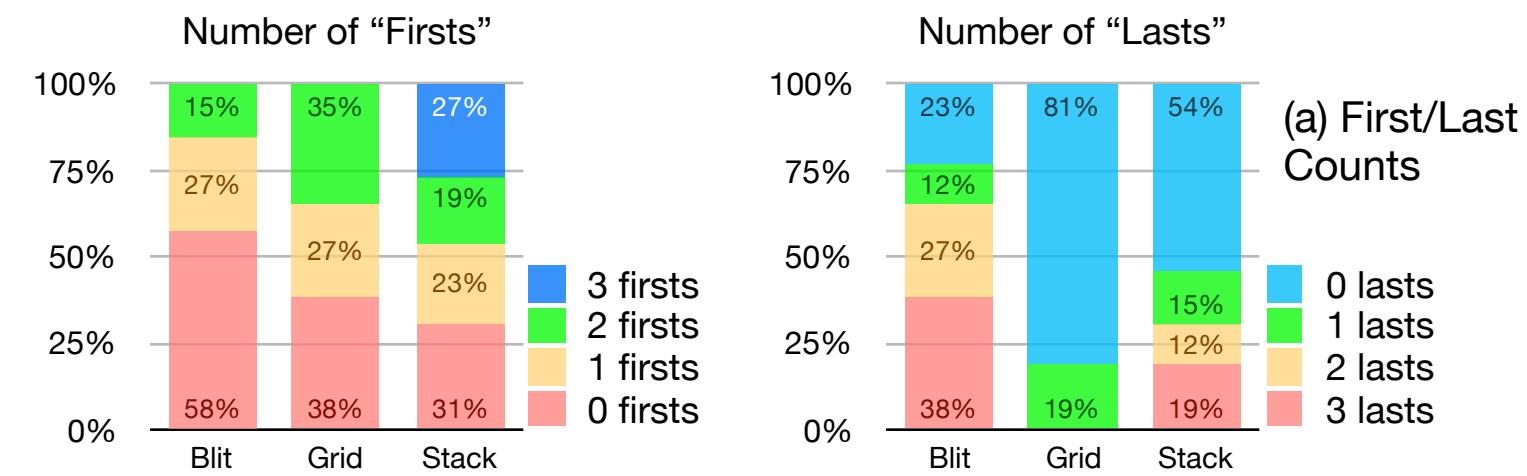
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Implementation: Screen Captures
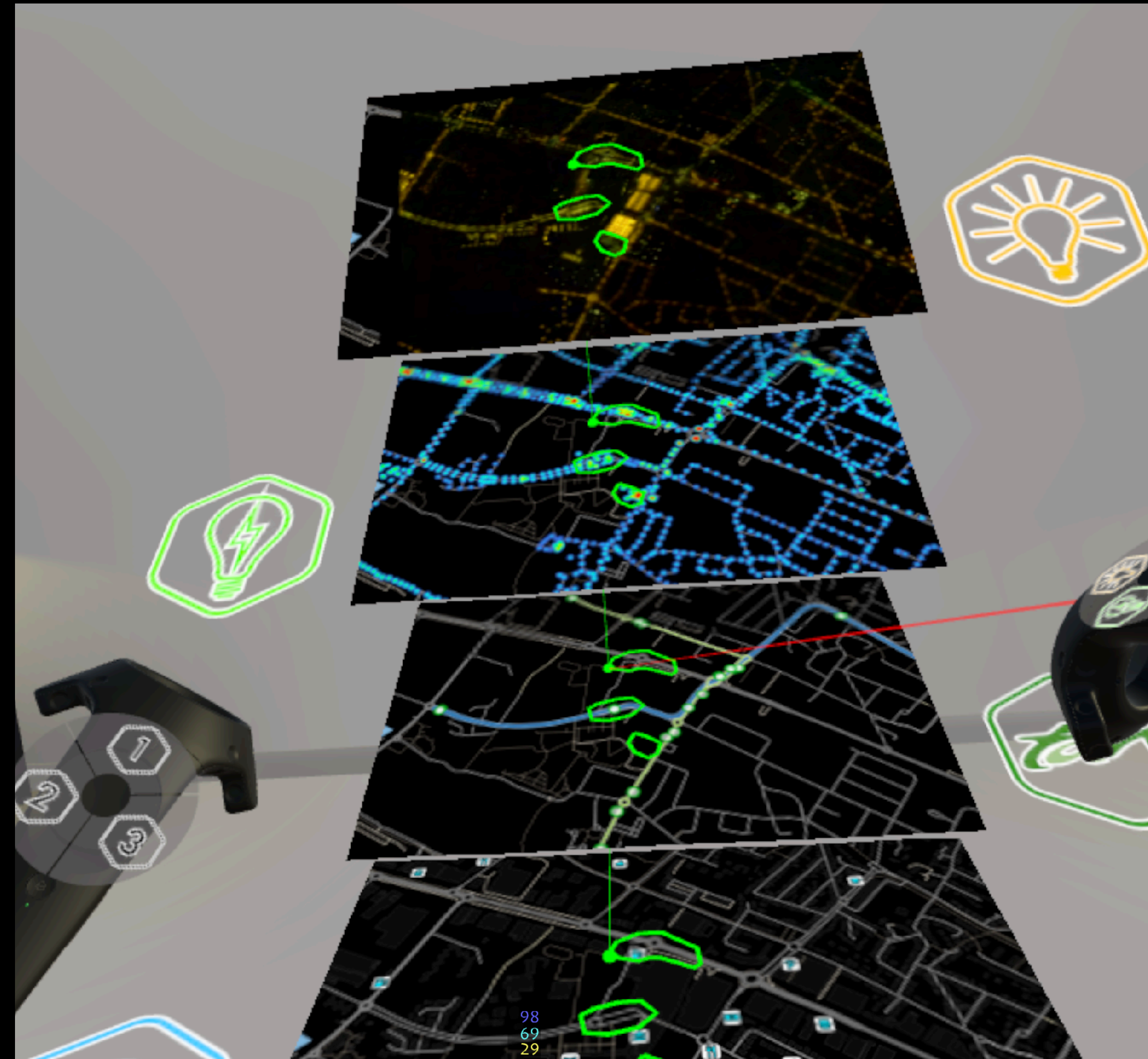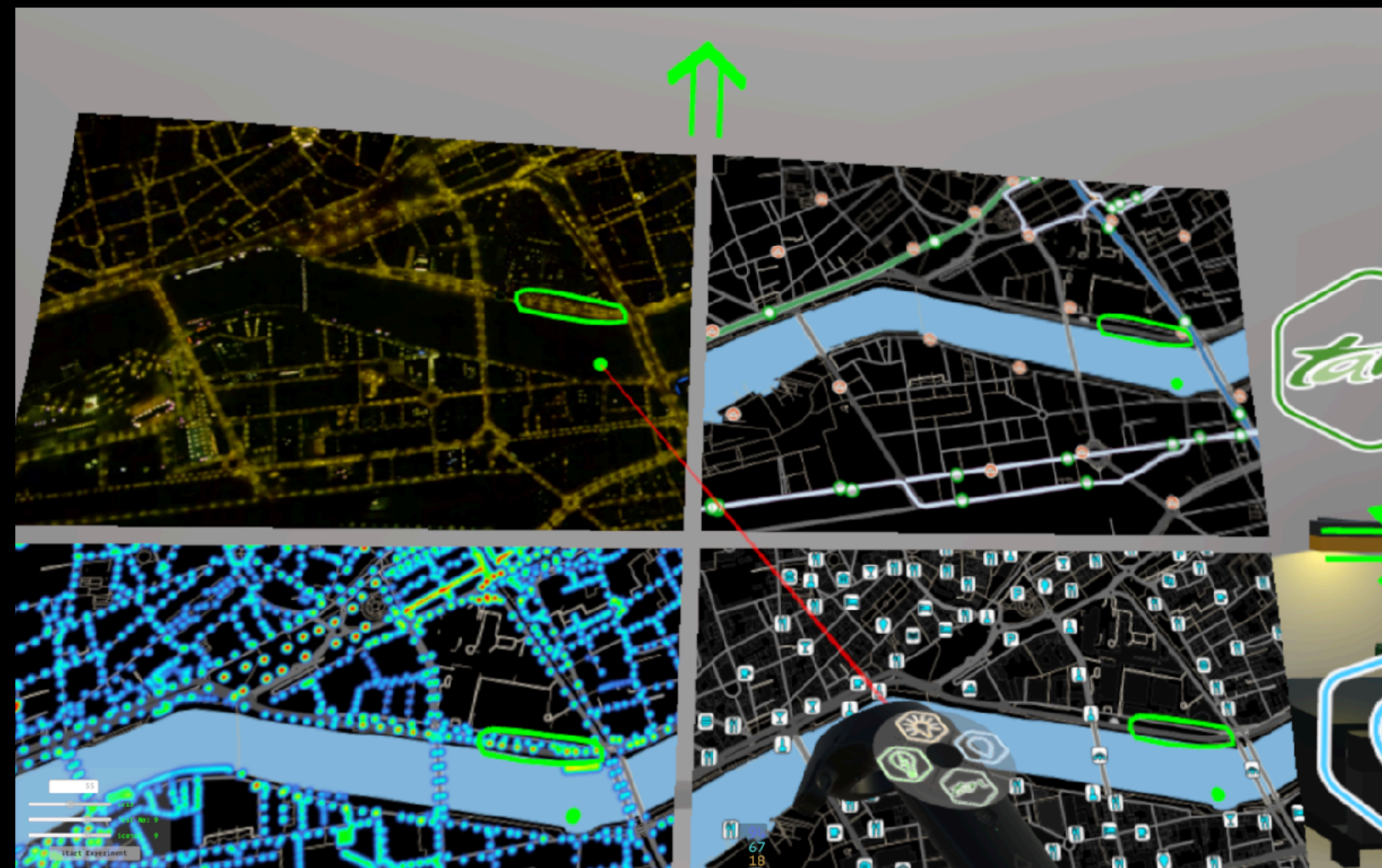
Implementation: Screen Recording

Experiments

- 26 (28) Participants

- Data gathered with questionnaire, user interaction and eye-tracking

- Results show strong preferences, and data hints at explanations for those
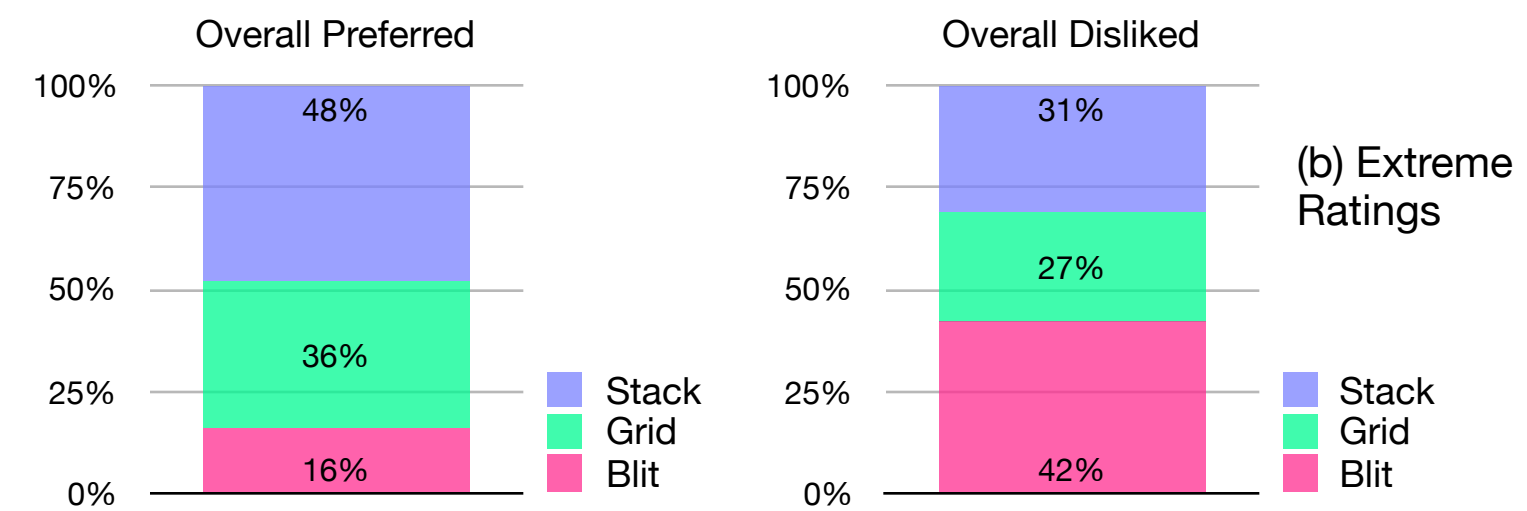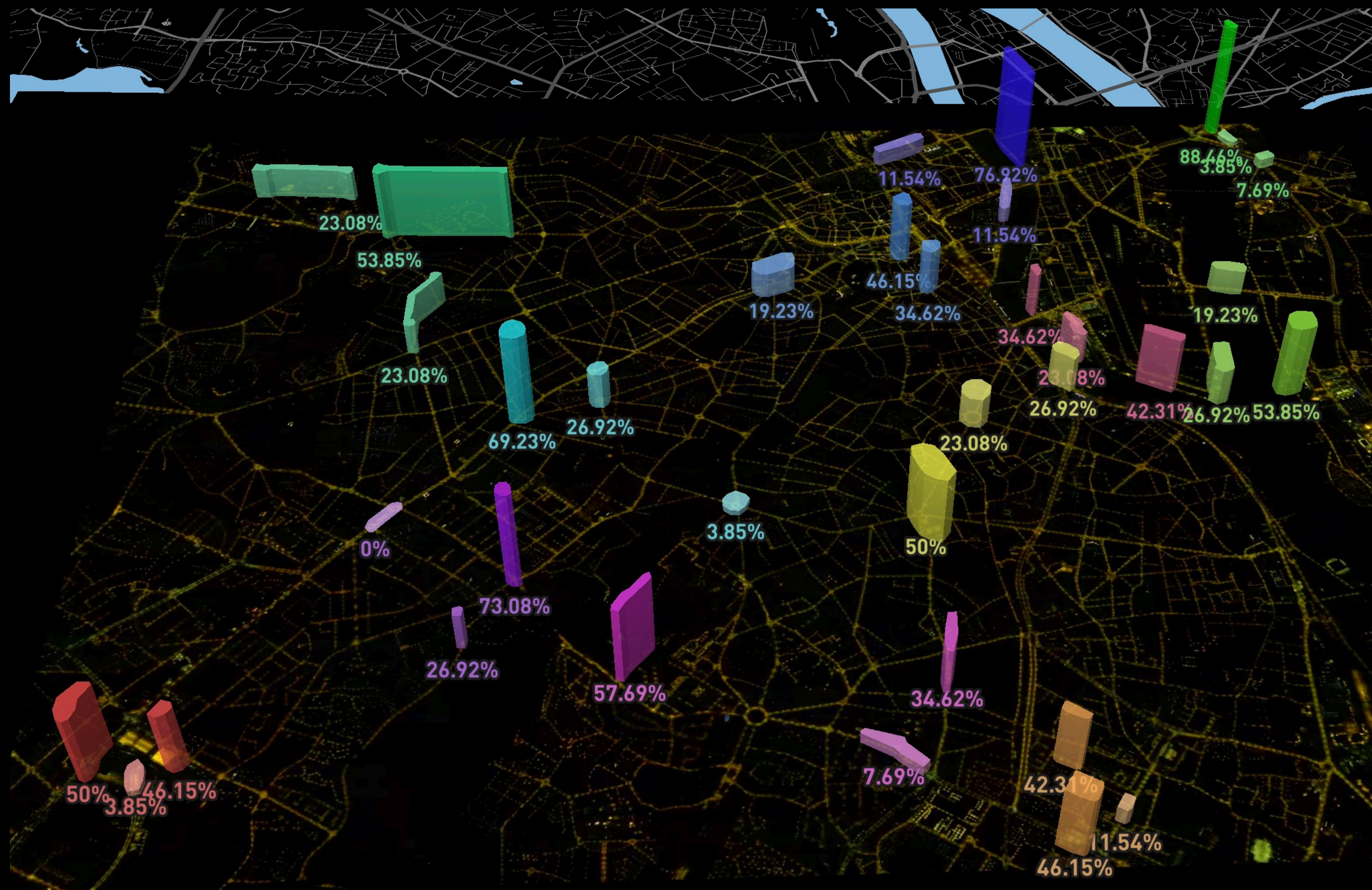
Experiment: First Results — Oculometry

Search behavior very different between users

▸ Avenues for further exploration?

Test Subject No.18

Test Subject No.16
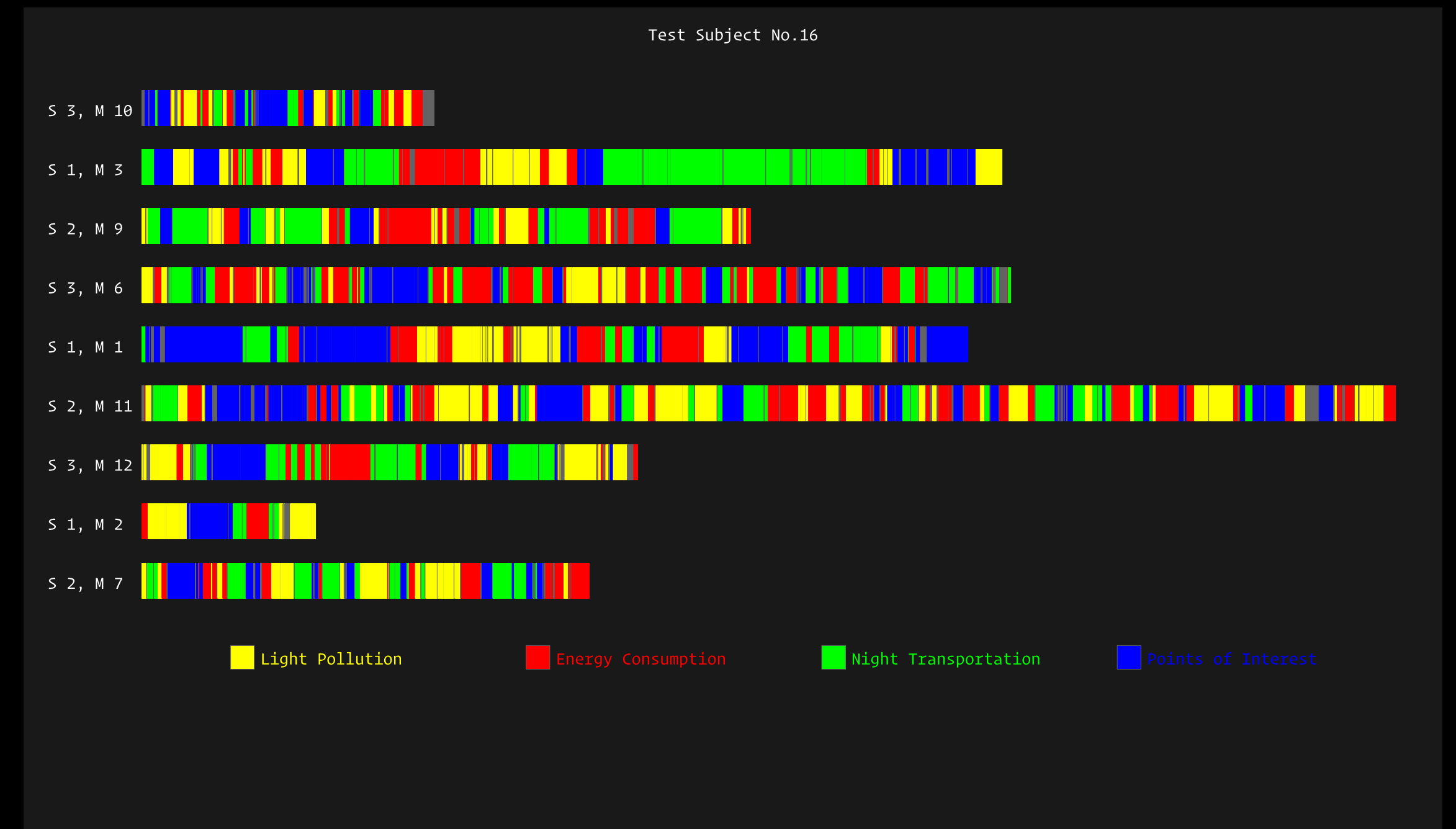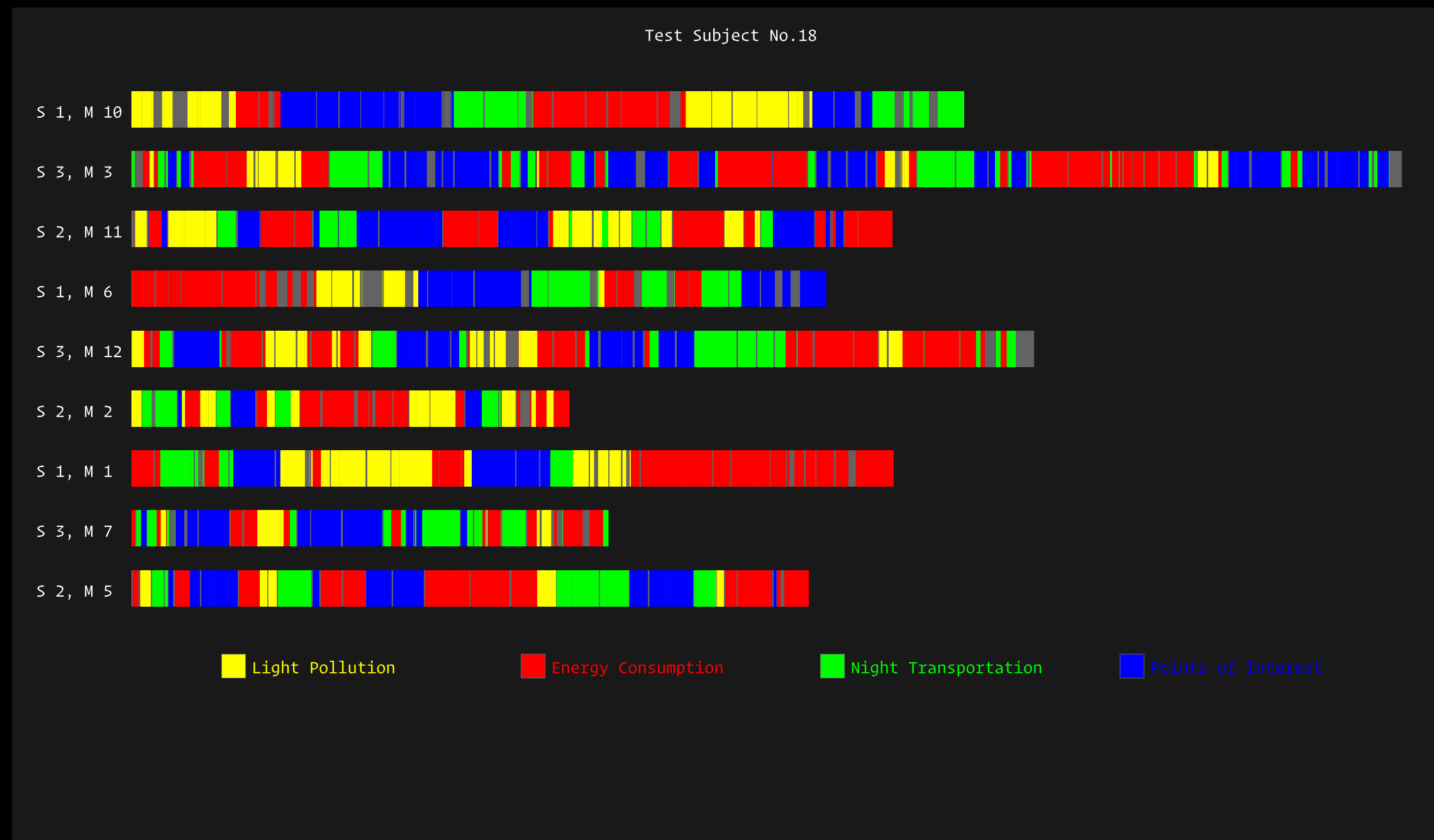
Experiment & First Results — Choices

Results from the tasks also interesting to urbanism research

Challenge 2: Immersion, Focus + Context

- Urban visualization mostly uses top-down, planar views

- Desire exists to move to more immediate views for better *urban immersion*

  ‣ Requires a detailed view of a focussed area *and* an overview of the surrounding context

- Existing solutions to combine both:

  ‣ Superposition of multiple views (minimap)

  ‣ Transformation of one view to show both (deformation)
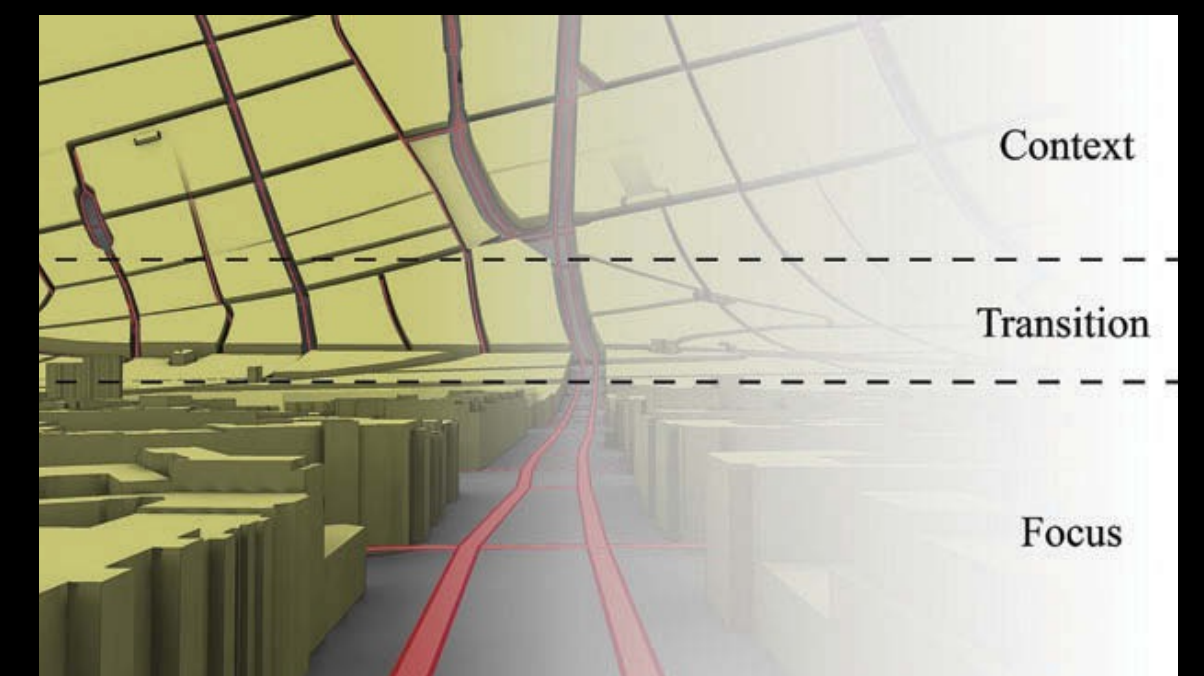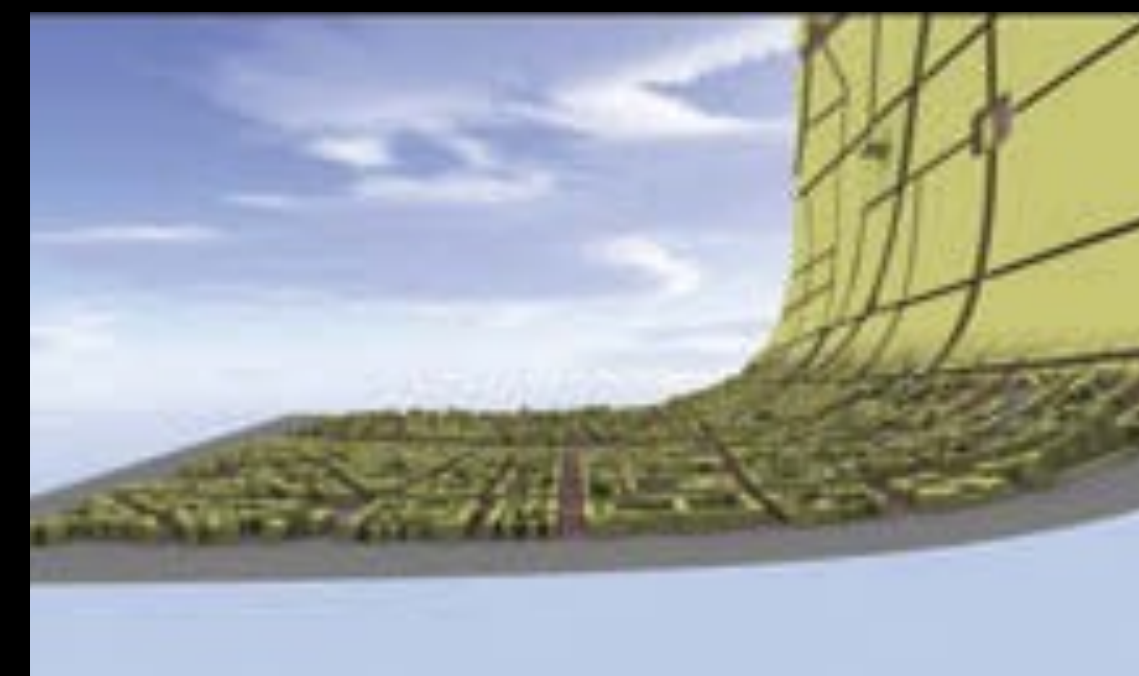
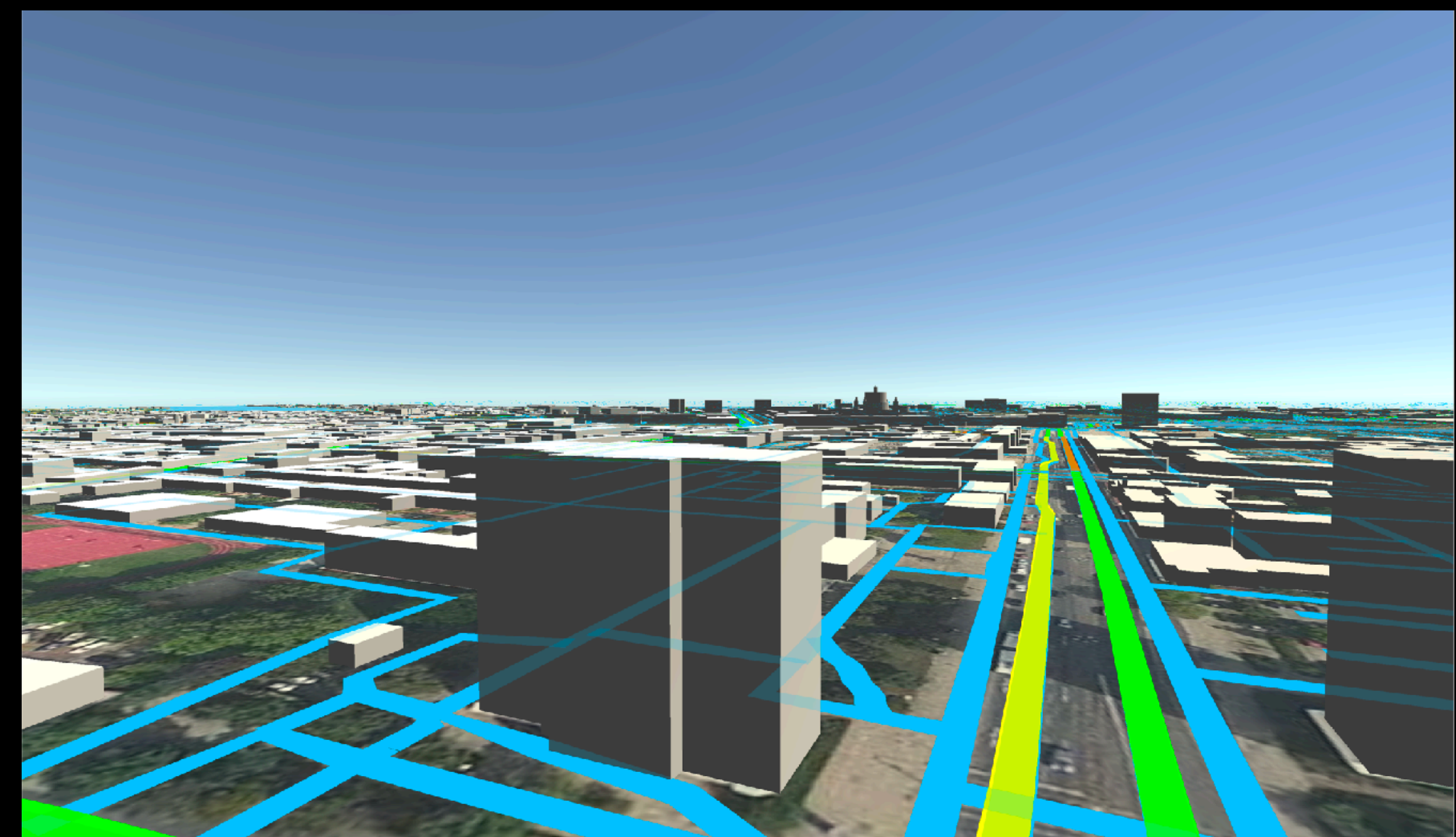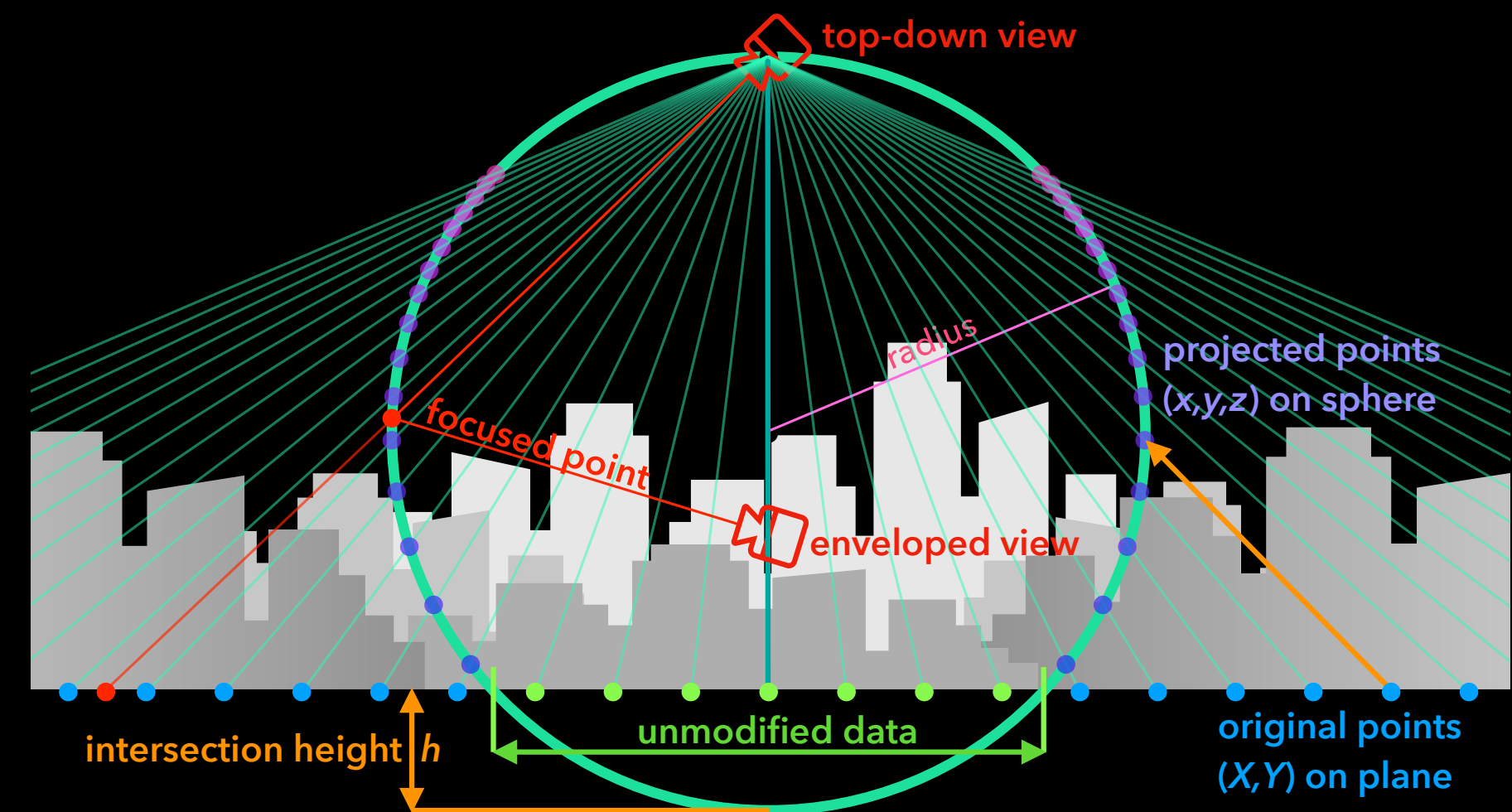From *Multi-Multi-Perspective 3D Panoramas,* Pasewaldt et. al., 2014

Immersion, Focus + Context: Space for Research

- Focus on data visualization

- Maintain urban legibility

  ‣ No deformation of the city's geometry

- Utilize advantages of immersive environments

  ‣ Large field of view offers more visual space for context

- Transitions between top-down and immersive views

Immersion, Focus + Context: Our Research
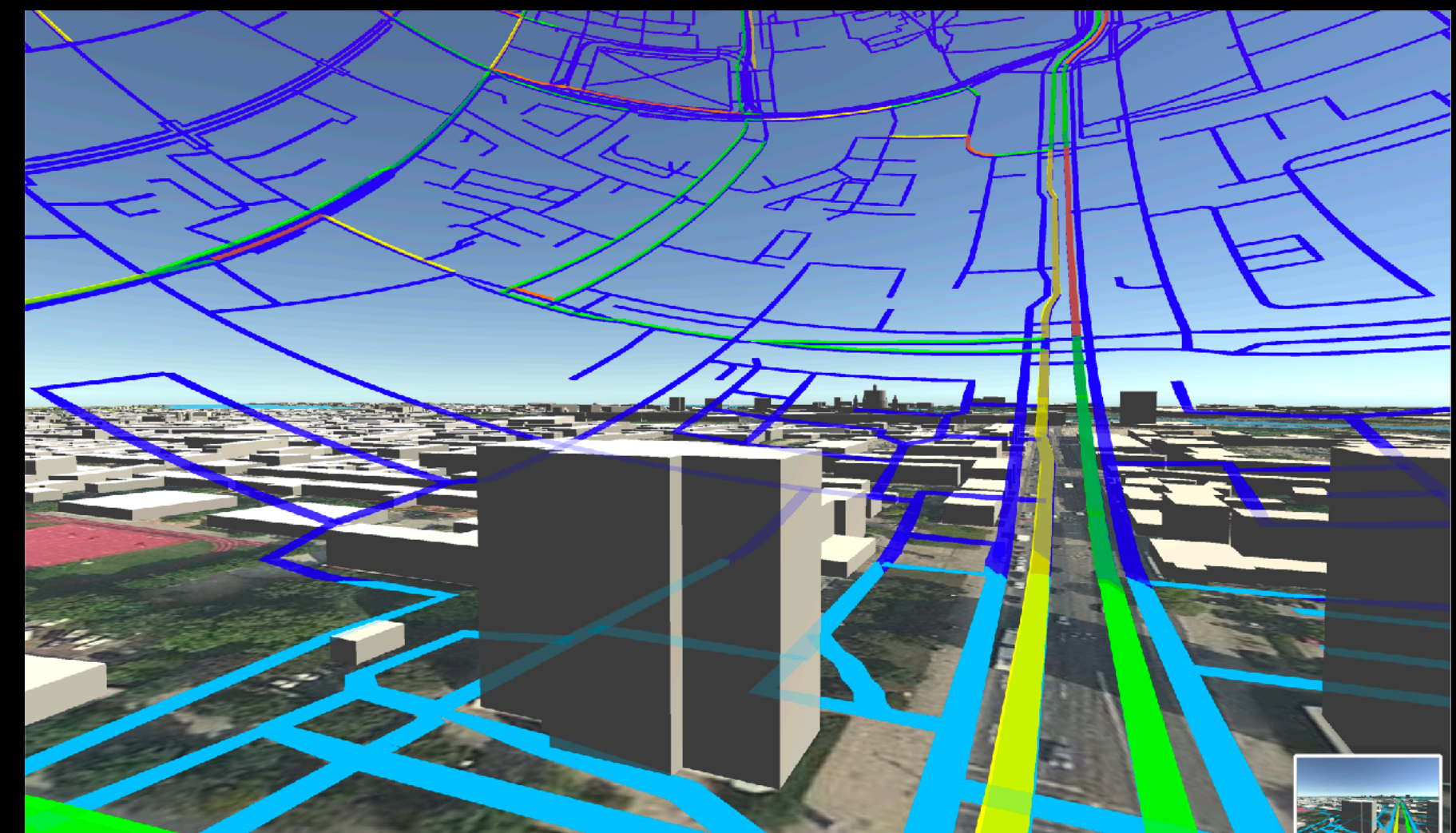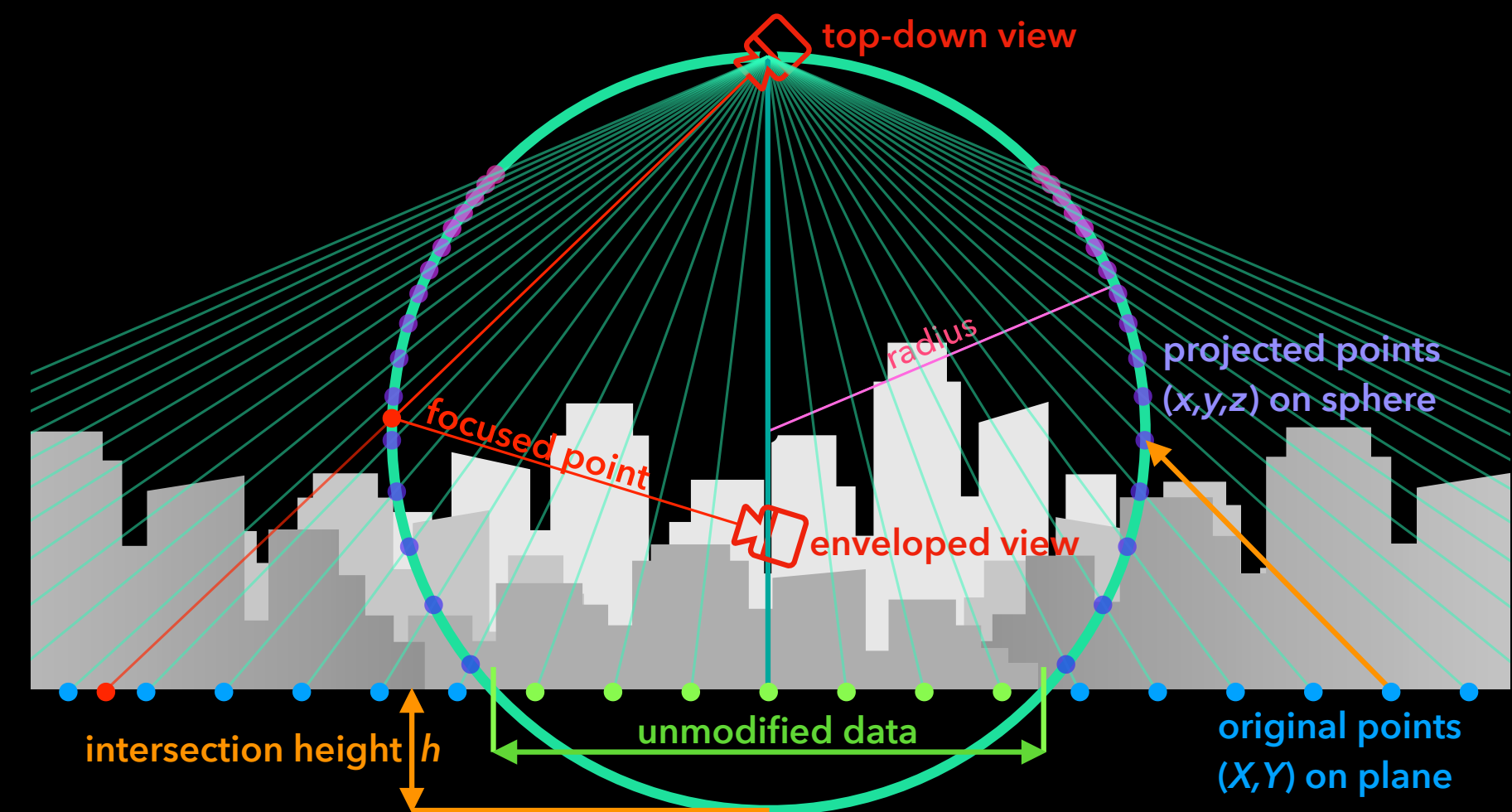
- *Urban DataSphere Prototype*

  ▸ Separates data from geometry; transforms data and keeps city shape intact

  ▸ Uses spherical (stereographic) projection for legible deformation in all directions

  ▸ Projects data or the city's geometry on the sky, which is usually unused otherwise

 ▸ Projection properties allow for smooth transition between planar and immersive view

# Immersion, Focus + Context: Our Research

- *Urban DataSphere Prototype*

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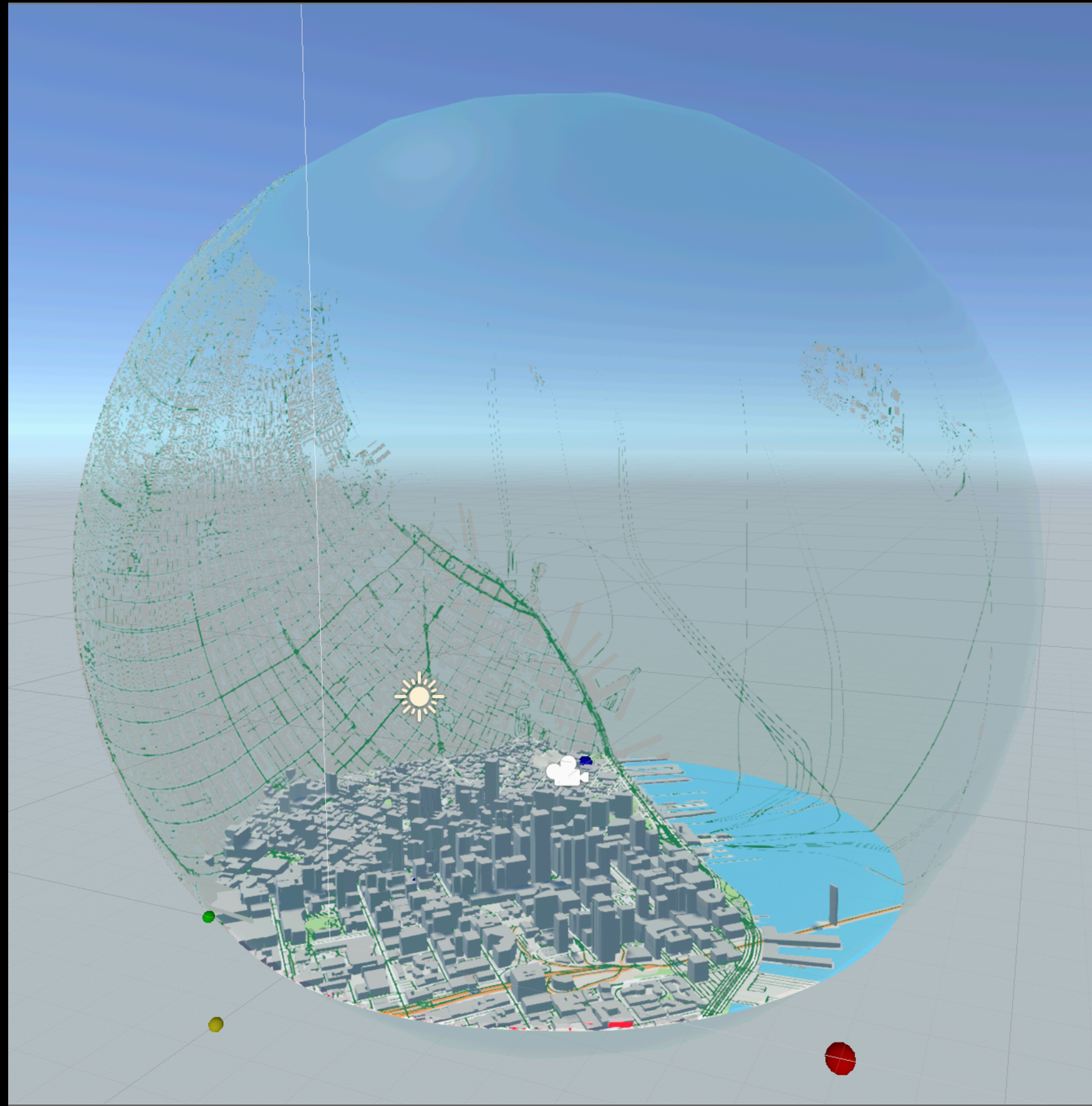 ‣ Projection properties allow for smooth transition between planar and immersive view
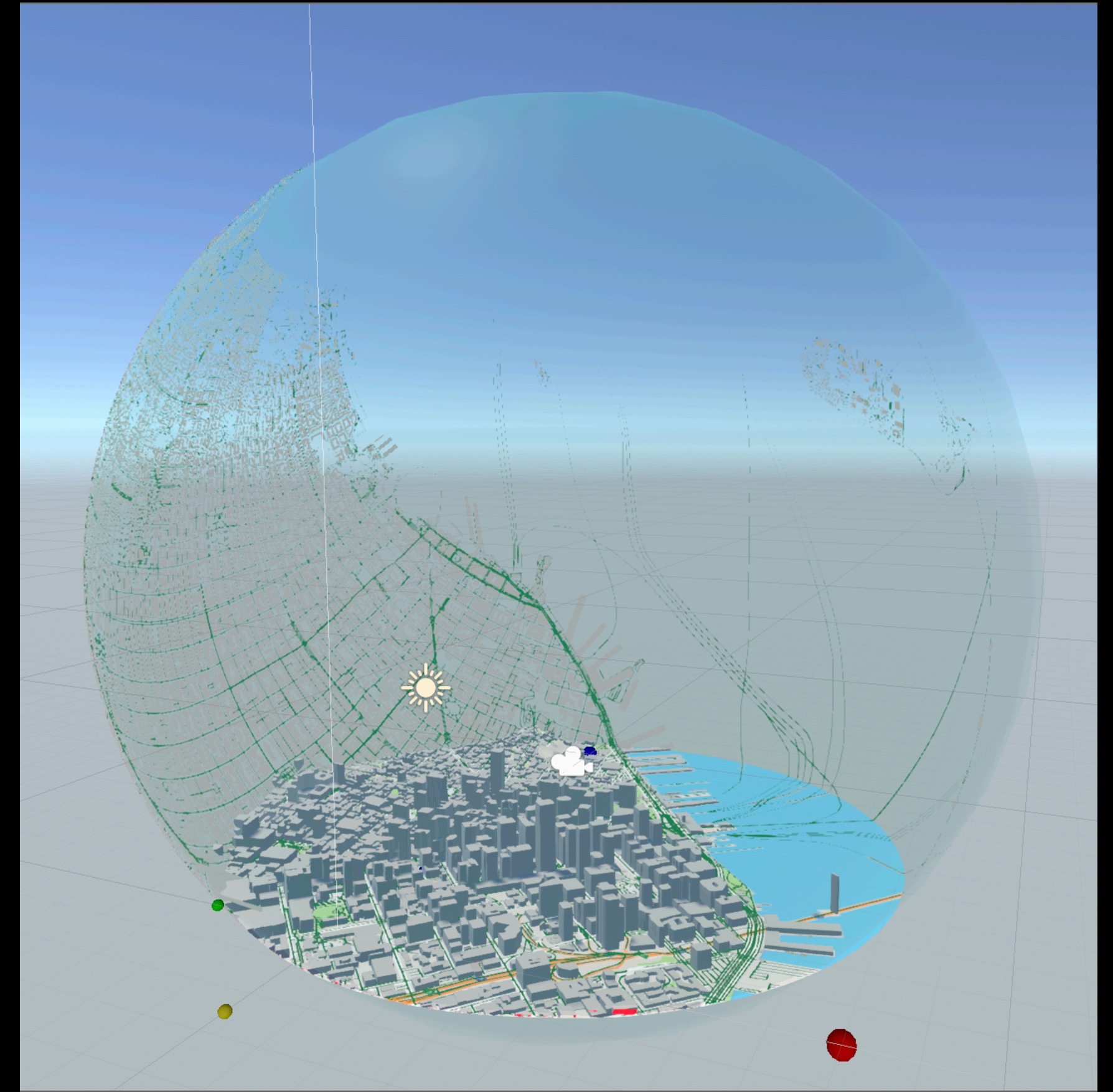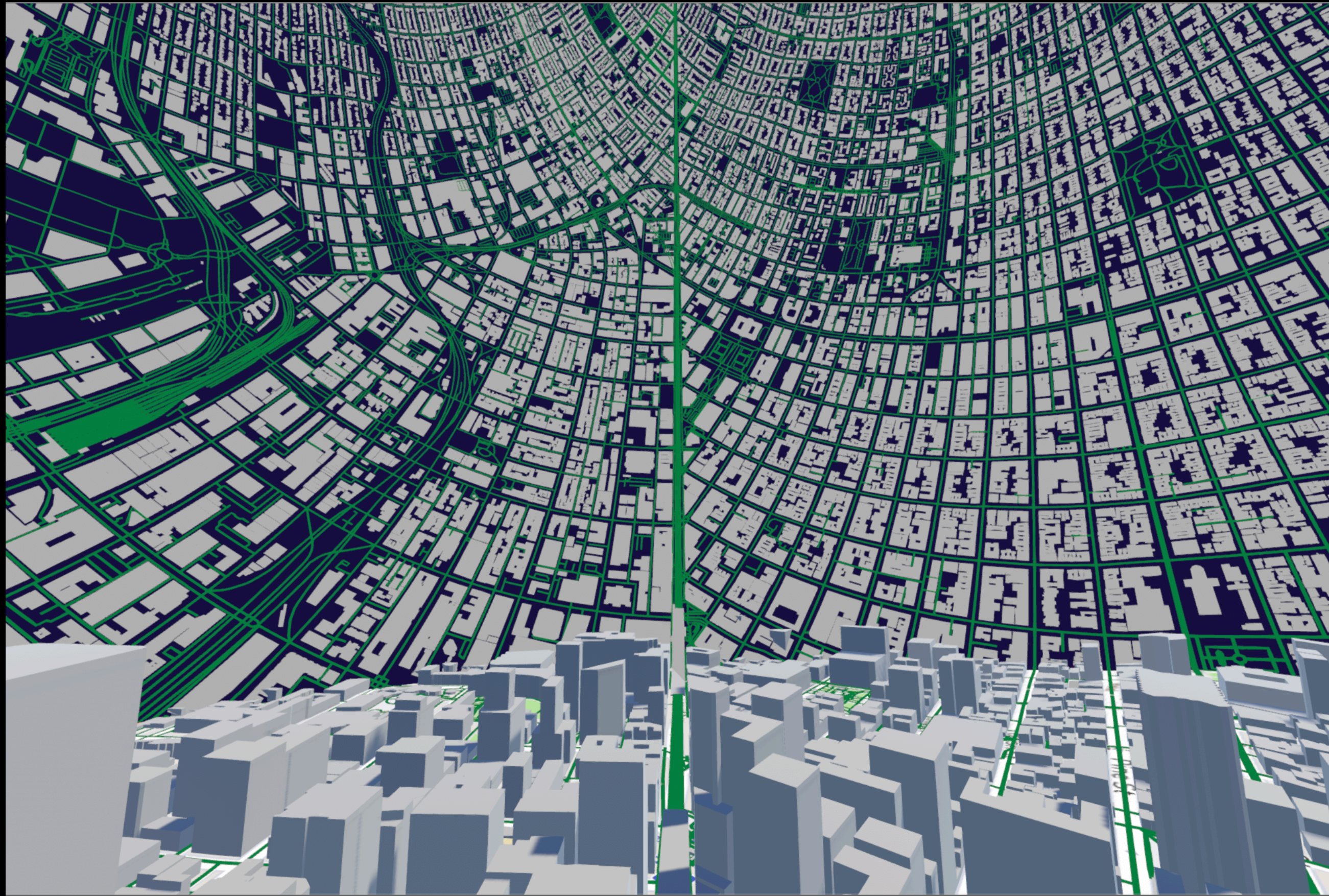
Urban DataSphere Prototype

Merging Focus & Context
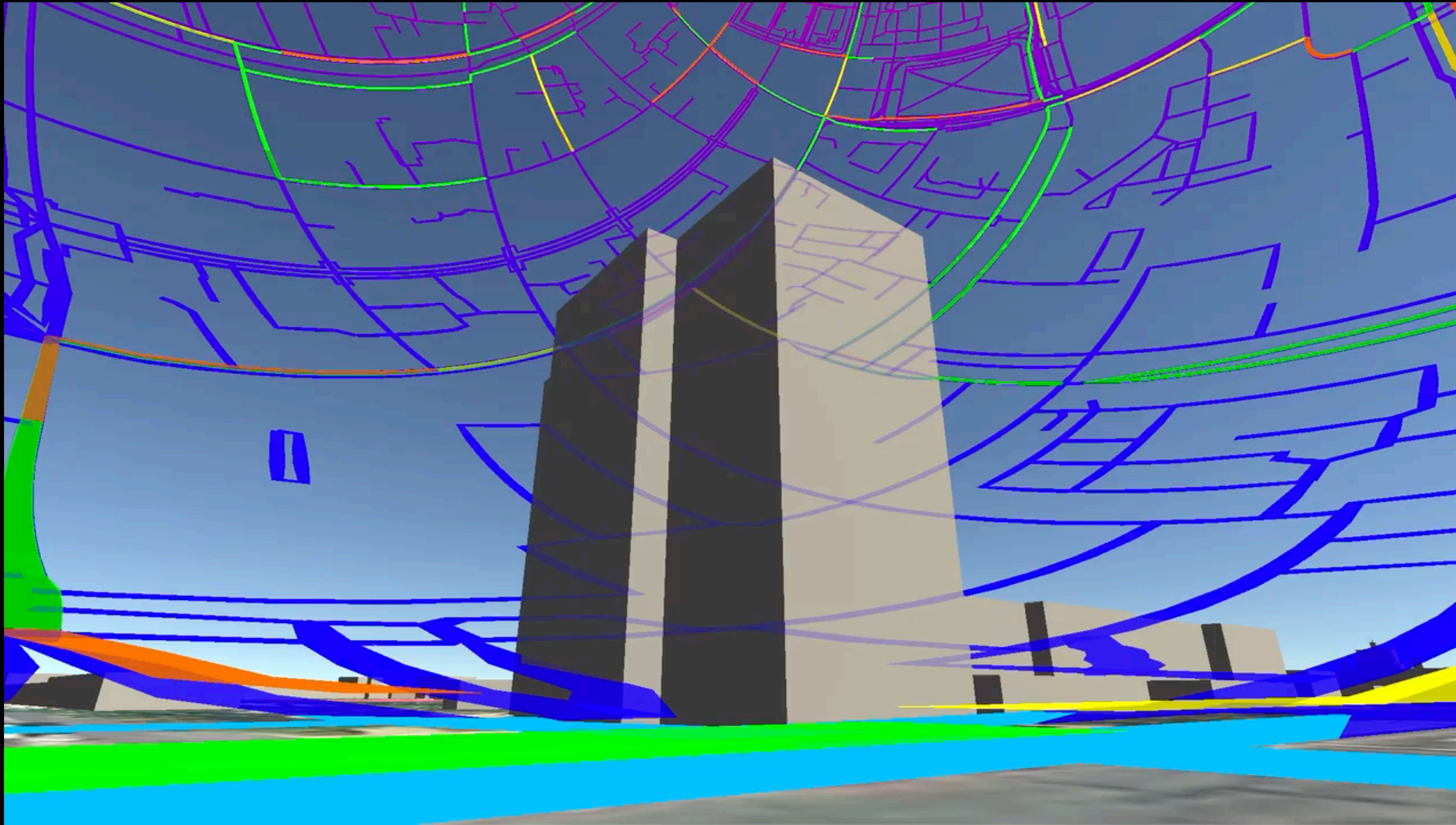
Urban DataSphere Prototype

Transitions between planar and immersive views

Urban DataSphere Prototype

Engaging, interesting… what's next?
Looking for applications!

Thanks for your attention!

Any questions?

Urban DataSphere

Exploring Immersive Multiview Visualizations in Cities