Cartography M.Sc.

Visualization of spatial disparities in mobility service frequency with open public transit feed data in Germany
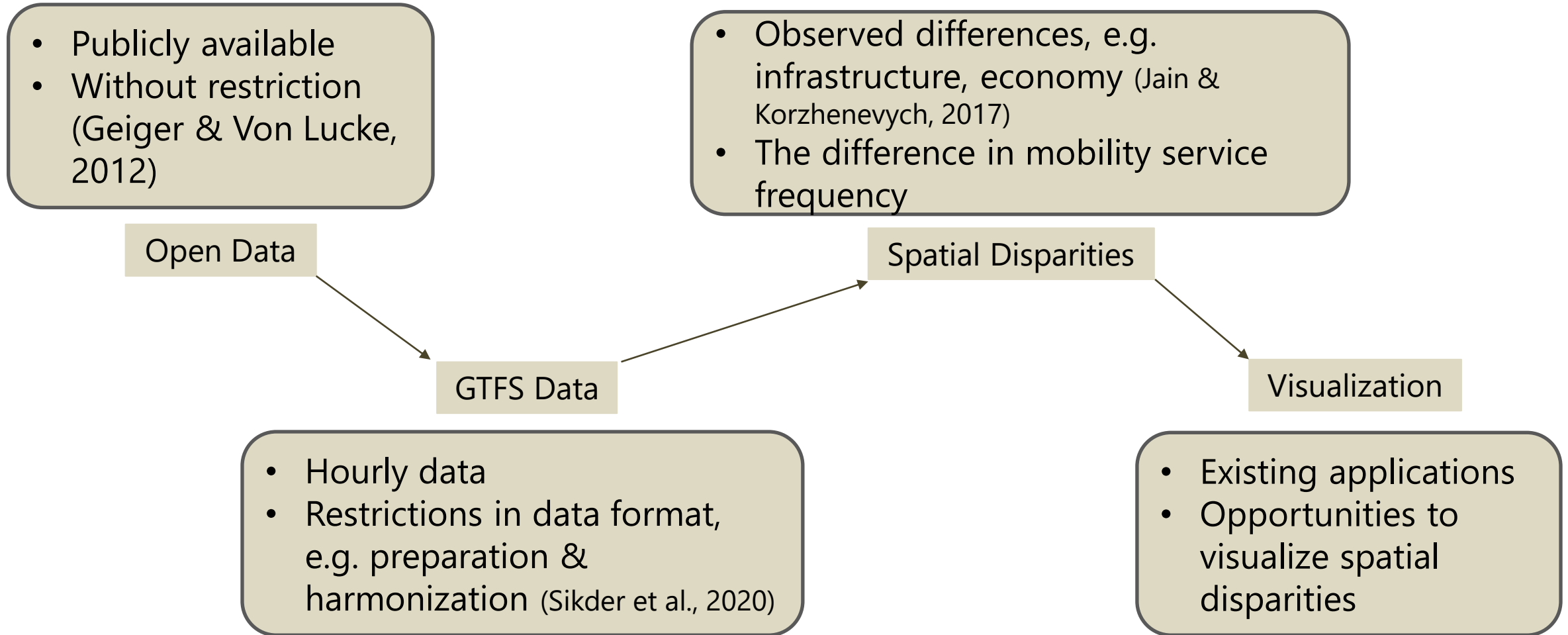
Thesis Presentation

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Outline

- Motivation and Problem Statement

- Terminology

- Research Identification

- Methodology

- Theoretical Approach

- Data Model

- Design & Evaluation

- Discussion

- Conclusion

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Motivation and Problem Statement

- Publicly available
- Without restriction (Geiger & Von Lucke, 2012)

Open Data

- Observed differences, e.g. infrastructure, economy (Jain & Korzhenevych, 2017)
- The difference in mobility service frequency

Spatial Disparities

GTFS Data

Visualization

- Hourly data
- Restrictions in data format, e.g. preparation & harmonization (Sikder et al., 2020)

- Existing applications
- Opportunities to visualize spatial disparities

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Terminology

Public Transit

'transport' ≈ 'transit'
'public transport' in Europe, Japan, and Australia
'public transit' in North America and Southeast Asia
(Redman et al., 2013)

Public Transit Frequency

Number of times for an hour that a transit service
user has access to transit mode (Xin et al., 2005).

'Mobility Service' ≈ 'Public Transit'

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Research Identification

Research Objectives

1. To identify and determine methods of exploring spatial disparities in public transit.

2. To adopt open-source data for interactive web-map-based visualization of spatial disparities in mobility service frequency

3. To develop and evaluate a tool for interactive web-map-based visualization of spatial disparities in mobility service frequency

Research Questions

1. What are the methods to explore spatial disparities in public transit?

2. What are the available visualization tools can be found online that used GTFS data?

3. What are the user requirements and design parameters for interactive web-map-based visualization?

1. How can the GTFS data be integrated to calculate mobility service frequency in the best possible spatial resolution?

2. What are the major challenges to harmonize required multi-sourced input dataset in the calculation process of mobility service frequency in Germany?
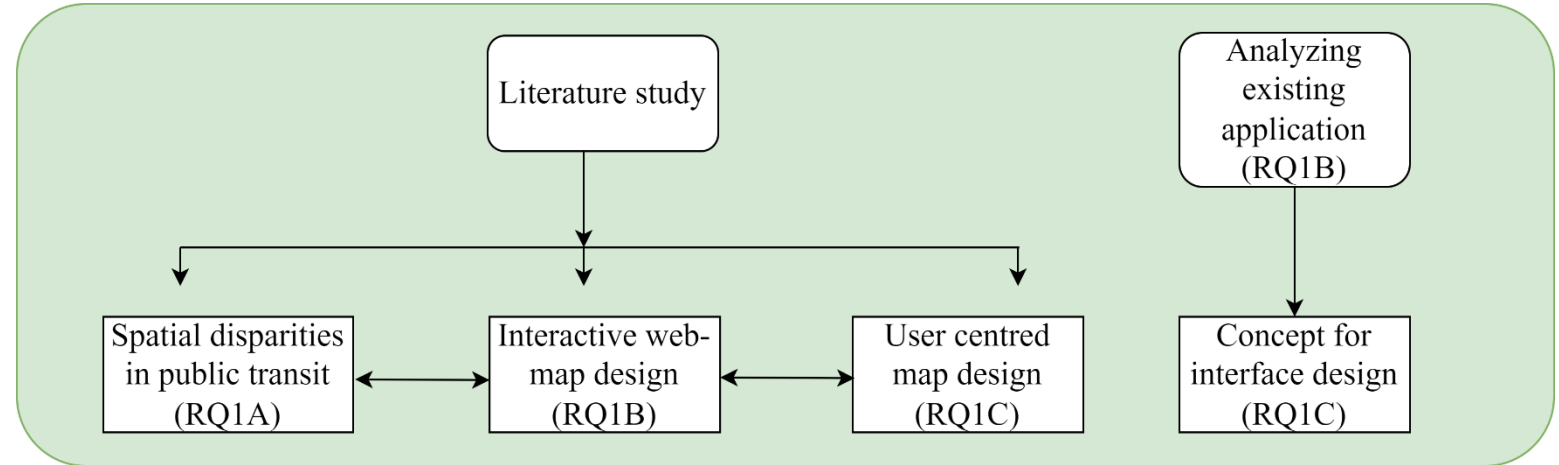
1. How can the mobility service frequency be represented in the interactive web-map-based visualization application?
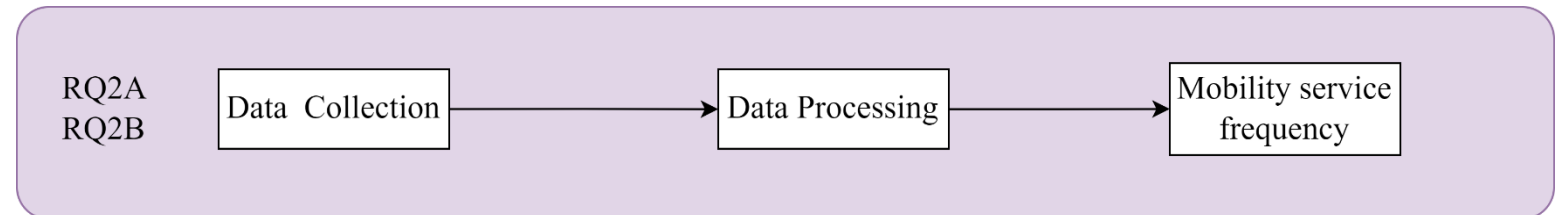
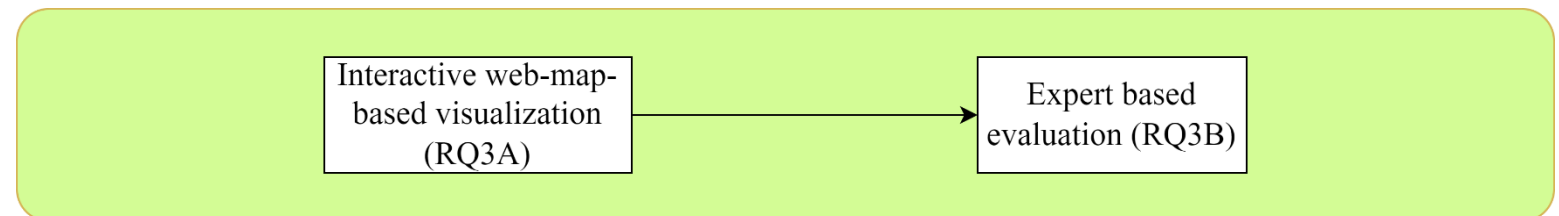2. What are the evaluation outcomes of the designed application based on expert opinions?

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Methodology

Research Objective 1
Theoretical Approach

- Literature study
- Analyzing existing application (RQ1B)
- Spatial disparities in public transit (RQ1A)
- Interactive web-map design (RQ1B)
- User centred map design (RQ1C)
- Concept for interface design (RQ1C)

Research Objective 2
Data Model

RQ2A
RQ2B
- Data Collection → Data Processing → Mobility service frequency

Research Objective 3
Design & Evaluation

- Interactive web-map-based visualization (RQ3A) → Expert based evaluation (RQ3B)

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Theoretical Approach - Methodology

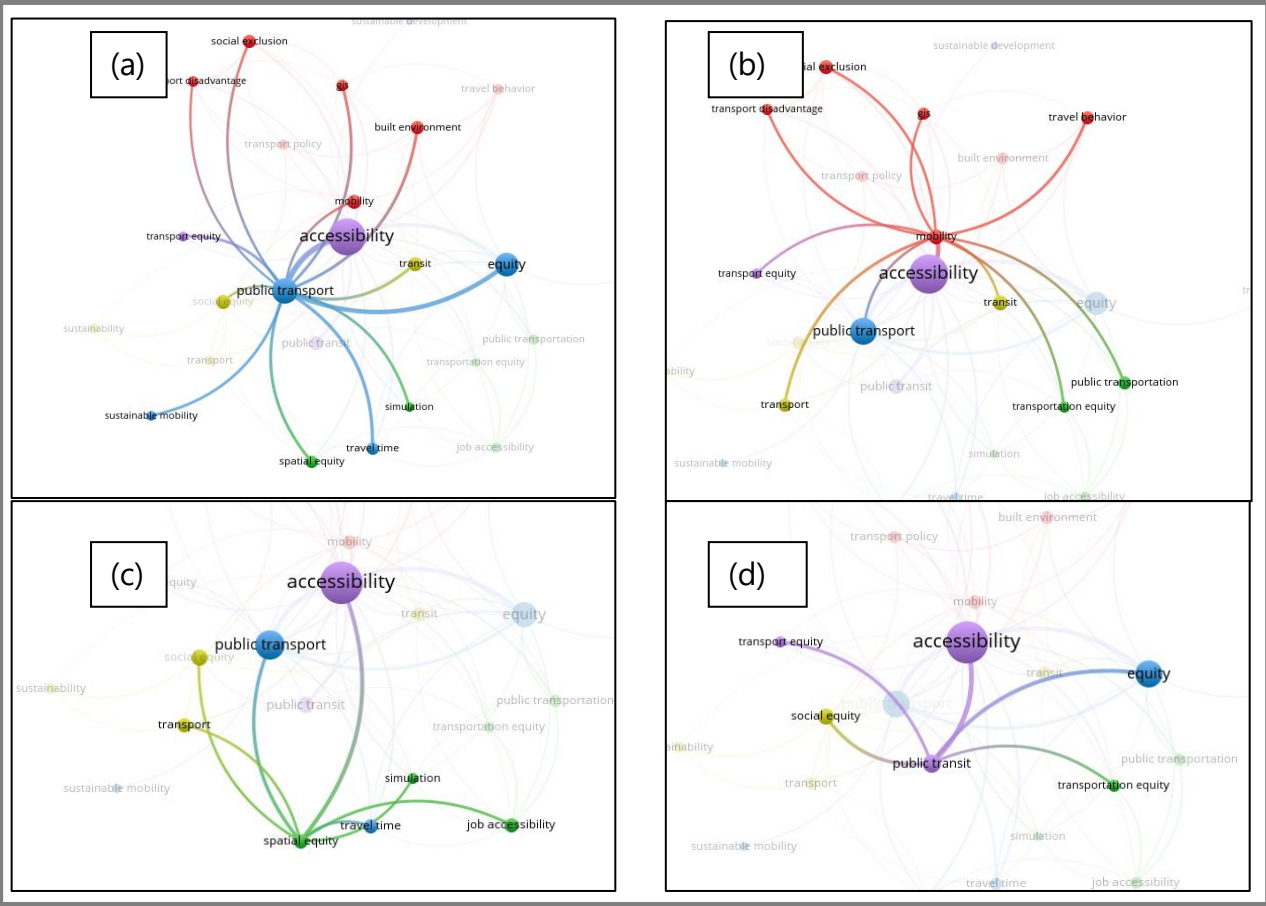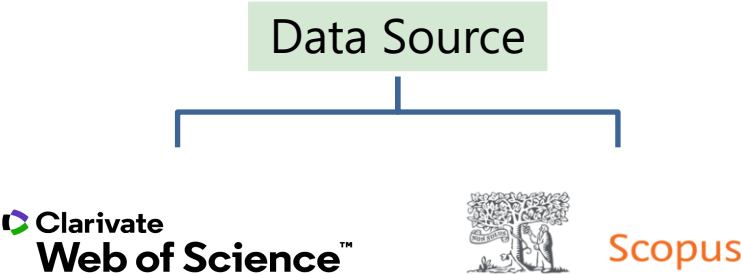## Spatial Disparities in Public Transit

Systematic Literature Review

Data Source

Figure 1: Cluster wise co-occurrences of authors' keywords a) public transit, b) mobility, c) public transport, and d) spatial equity

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Theoretical Approach – Result (RQ1A)

Spatial Disparities in Public Transit

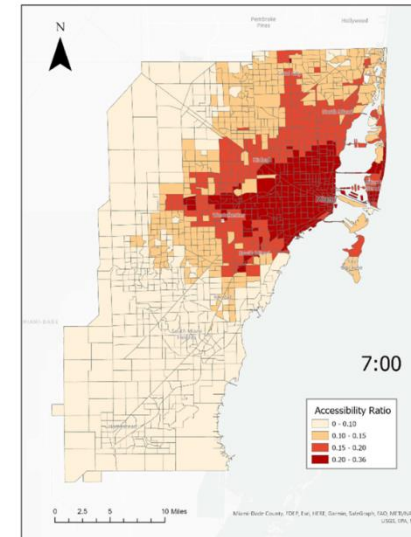| Tools	Statistical Analysis	Visualization
• OpenTripPlanner • Esri ArcGIS Network Analyst • Graph-based Network Analysis	• Central Tendency • Dispersion/ Variability • Local Moran's Index	• Graph • Map

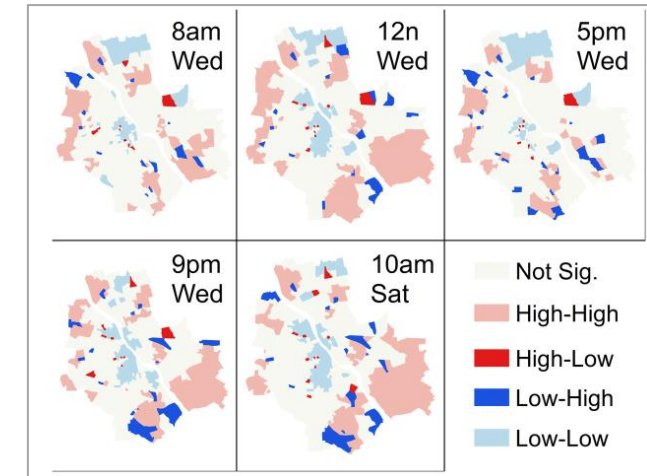Figure 2: Transit & Auto Accessibility Ratio (Yan et al., 2022)

Figure 3: Local Moran's I Result by the Time of Day across All Metrics (Niedzielski, 2021)

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Theoretical Approach – Result (RQ1B)

Existing Applications

1. PubtraVis	• Mobility, speed, flow, density, headway, and analysis • Side-by-side evaluation
2. Swiss Railways Network	• 3 basemaps • Overview map • Color difference
3. TRAVIC (Transit Visualization Client)	• 6 basemaps • Overlay • Transport mode differentiation

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Design Principles

Map Elements

Map title & scale

Mapped area

Supplemental information & Graphs

Map Metadata

Labels & Legend

Menus & Help

(Tolochko, 2016)

Cartographic Interaction Operator Primitives

Work operators		Enabling Operators
Reexpress Arrange Sequence Resymolize Calculate Reproject	Pan Zoom Filter Search Overlay Retrieve	Import Export Save Edit Annotate

(Roth, 2013)

User-centered Map Design

Work Domain Analysis

Conceptual Development

Prototyping

Interaction and Usability Studies

Implementation

Debugging

(Robinson et al., 2005)

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Data Model

Data

1. General Transit Feed Specification (GTFS)

Feed Name	File size	Unique trips	Stops	Date
Local transit Germany	181	1.3 M	460 K	July, 10 2022
Regional trains Germany	6.7 MB	64 K	15 K	July, 10 2022

Table 1: GTFS data properties
Source: https://gtfs.de/de/feeds

2. Street Network Data

OpenStreetMap data from Geofabrik

3. Administrative Data

Federal Agency for Cartography and Geodesy

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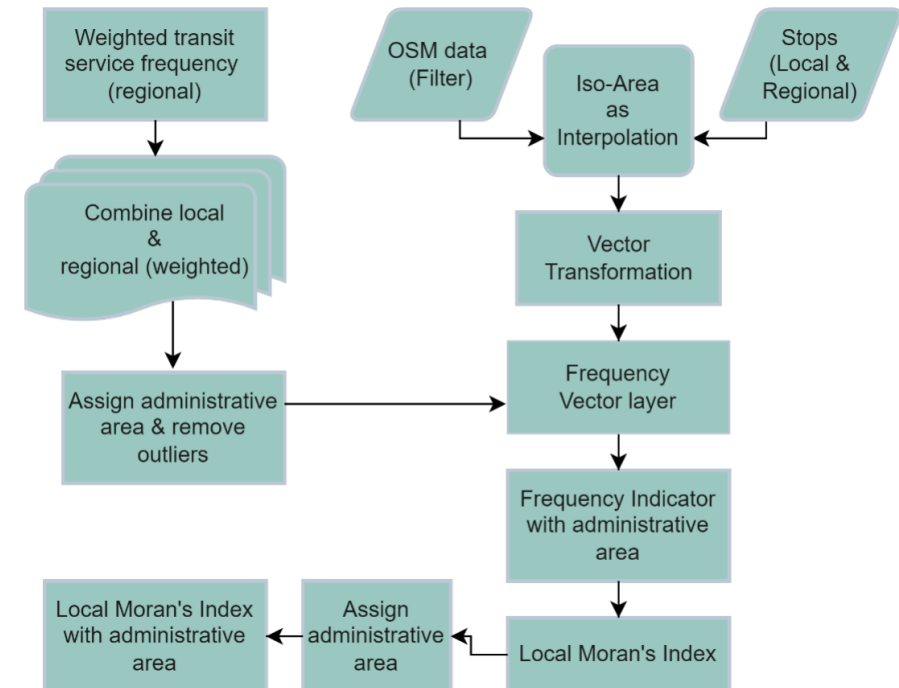
GTFS Data Integration

Figure 4: Workflow to calculate station level frequency

Figure 5: Workflow to calculate Frequency Indicator & Disparity Index

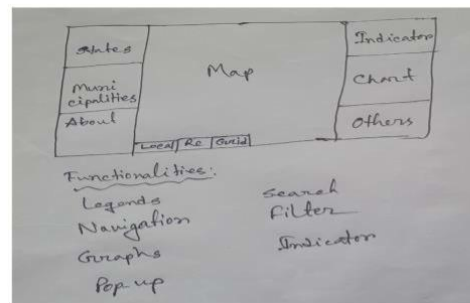## UCD Process in *PubTraDis Visualization*

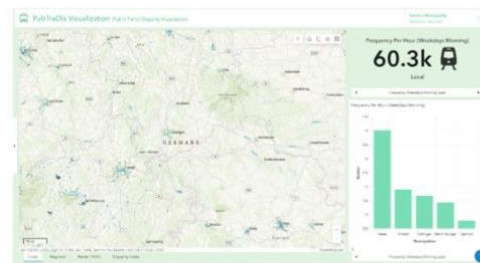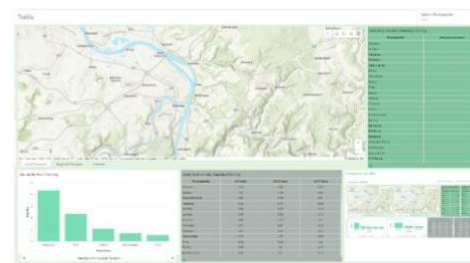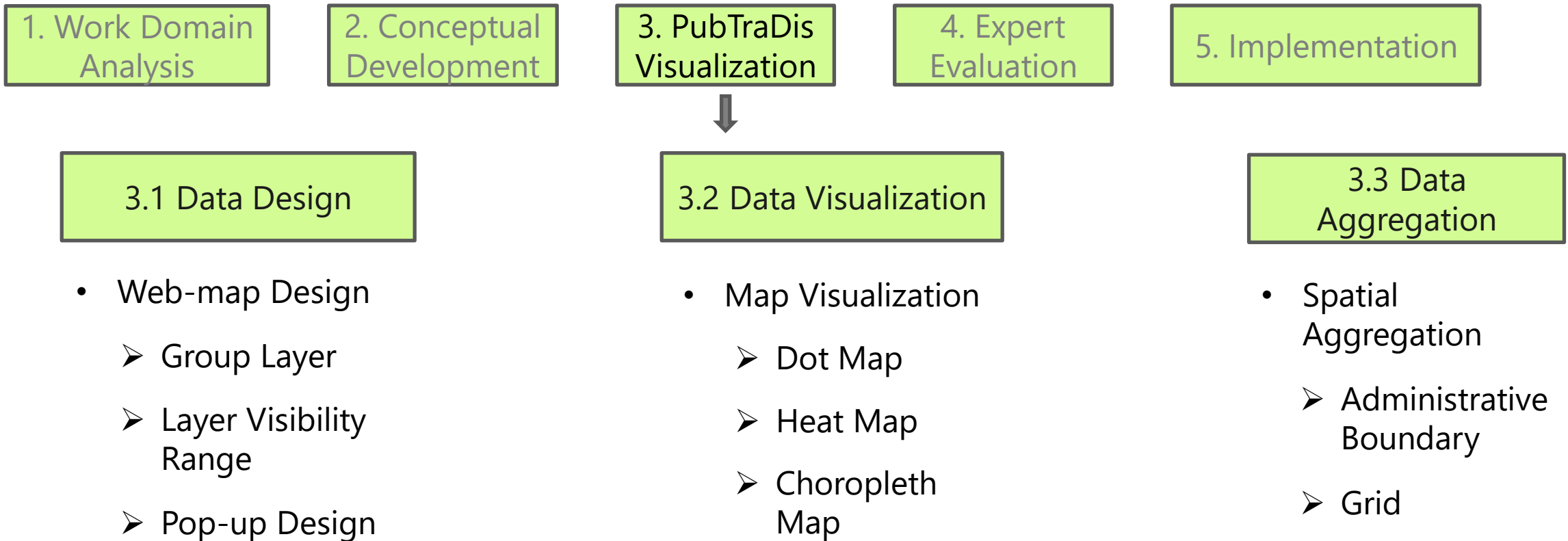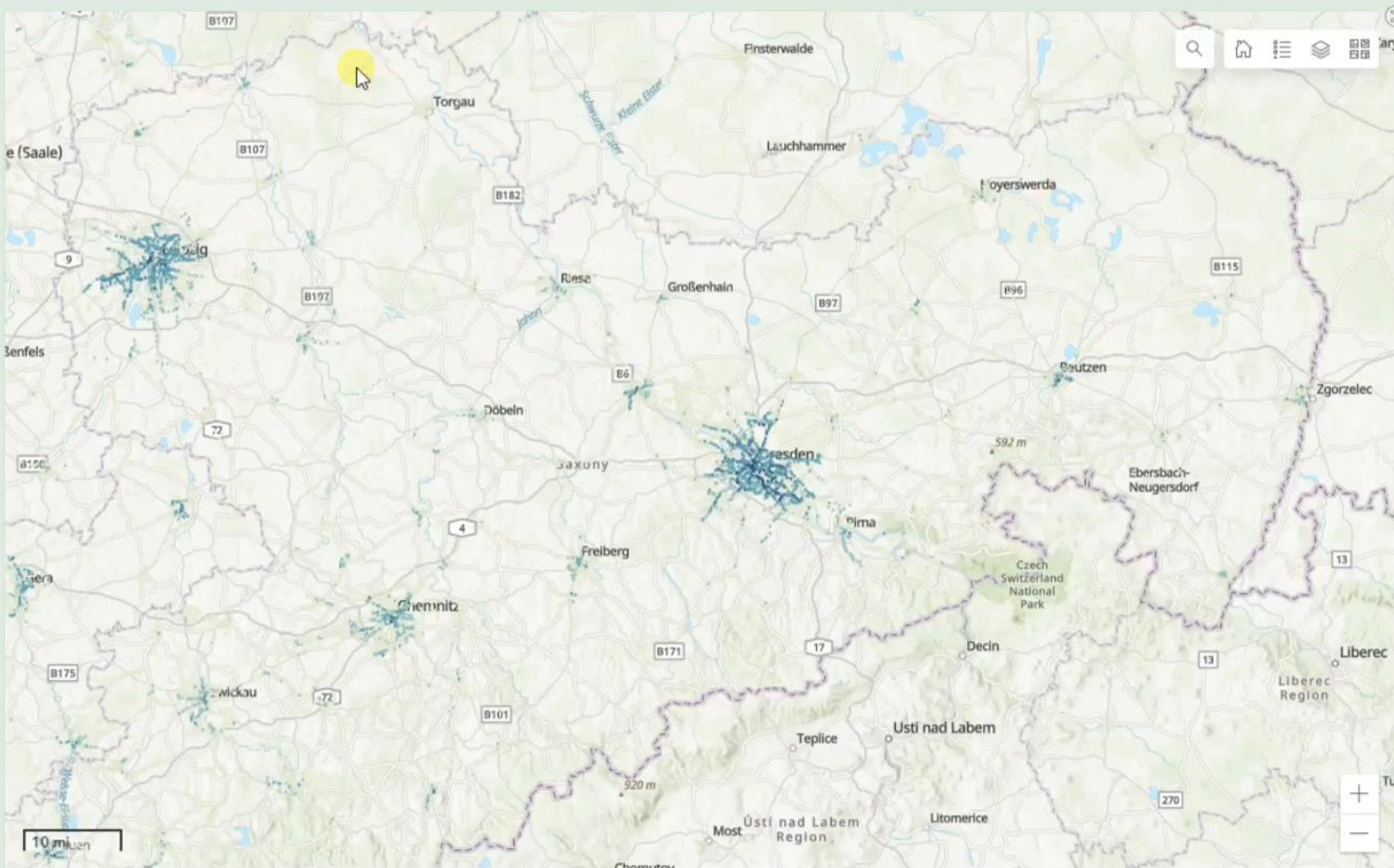| 1. Work Domain Analysis	2. Conceptual Development	3. PubTraDis Visualization	4. Expert Evaluation	5. Implementation

First Idea

Layout Mockup

Final Interface

First Prototype

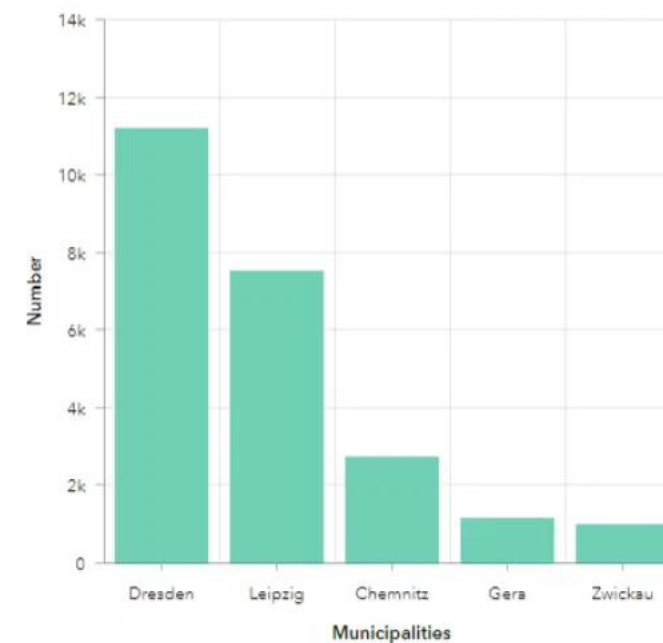Figure 6: Conceptual Development to Final Interface of PubTraDis Visualization

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Design & Evaluation – Methodology

UCD Process in *PubTraDis Visualization*

1. Work Domain Analysis	2. Conceptual Development	3. PubTraDis Visualization	4. Expert Evaluation	5. Implementation

3.1 Data Design

- Web-map Design
  - ➢ Group Layer
  - ➢ Layer Visibility Range
  - ➢ Pop-up Design

3.2 Data Visualization

- Map Visualization
  - ➢ Dot Map
  - ➢ Heat Map
  - ➢ Choropleth Map

3.3 Data Aggregation

- Spatial Aggregation
  - ➢ Administrative Boundary
  - ➢ Grid

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Design & Evaluation – Methodology

UCD Process in *PubTraDis Visualization*

| 1. Work Domain Analysis | 2. Conceptual Development | 3. PubTraDis Visualization | 4. Expert Evaluation | 5. Implementation |

4.1 Participants

4.2 Assessment Method

- Effective for interactive map (Kostelnick et al., 2008)
- Small set of experts available (Roth et al., 2015)

- Visualization and Cartography

- No prior knowledge about the visualization tool

- Presentation with demo (Kostelnick et al. 2008)

- Open discussions

- Interface exploration

- Questionnaire
  - ➢ General information
  - ➢ Interface interaction
  - ➢ Utility & usability rating- 10 positive and 7 negative questions

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Design & Evaluation - Result

Expert-based Evaluation (RQ3B)

General Outlook

Interface ☺ ☺

Visualization Style

- Dot Map ☺ ☺

- Heat Map ☹ ☺

- Disparity Index ☺ ☹

Utility Rating

- Contribute to spatial disparity analysis in public transit research

- Novel approach

- 3.4 (highest 5) is average Utility Rate

Usability Rating

- Pop-up add extra value

- Comparison window is easy to use

- Cartographic principles

- 3.2 (highest 5) is average Usability Rate

Visualization of spatial disparities in mobility service frequency with open public transit feed data in Germany

Design & Evaluation - Result

Expert-based Evaluation (RQ3B)

Suggestions	Implementation
• Same scale/link both windows	✗
• Bookmark location	✓
• Sub layer for tab name	✗
• Functionality for linked selection	✗
• Performance	📋

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Discussion

Challenges in Multi-source Data Harmonization (RQ2B)
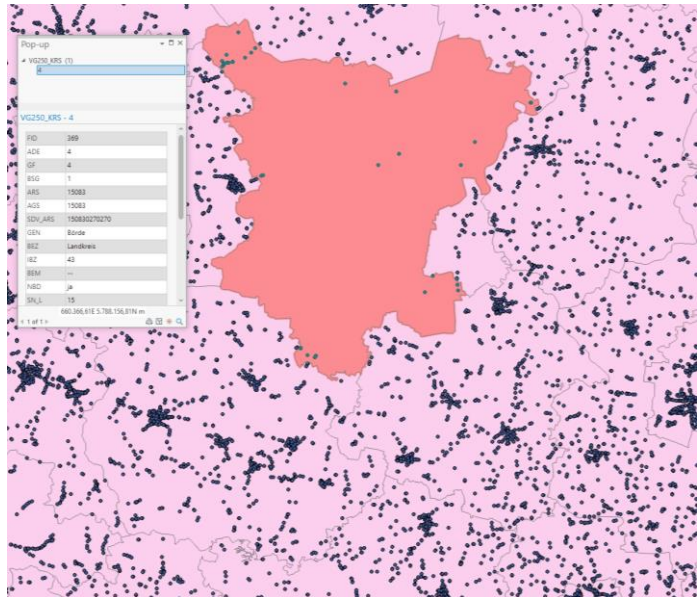
Missing Data

Geographical Reference

Figure 7: Missing data in GTFS

- OpenStreetMap Data – WGS 1984 projection

- Administrative Data – UTM zone 32, Ellipsoid GRS80, Datum ETRS89

Visualization of spatial disparities in mobility service frequency with open public transit feed data in Germany

Discussion

Overall

Research objectives were fulfilled by-

- Literature Study

- Data Processing- Reproducible Workflow Development

- *PubTraDis Visualization* Development & Evaluation

Limitations

- Grid Level Frequency – VVO Area

Challenges

- New Processing Workflow

- GTFS Data Repository

Future Work

- Population Impact

- Building Level Analysis

- Automation of New GTFS Data Integration

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Conclusion

- Systematic literature review to explore spatial disparities.

- Design principles reviewed from literature and existing application.

- GTFS data processing workflow automation.

- *PubTraDis Visualization* to visualize spatial disparities in mobility service frequency.

- Evaluation outcomes suggest that *PubTraDis Visualization* will contribute to the relevant field

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