

# Decision Support Tool to unlock the potential of large-scale agent-based transport demand simulation for planning practice

Alex Erath, Michael van Eggermond,  
Pieter Fourie, Artem Chakirov

EASTS Conference 2013  
Taipeh, September 2013

(FCL) FUTURE CITIES LABORATORY 未来城市实验室

**ETH**

Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich

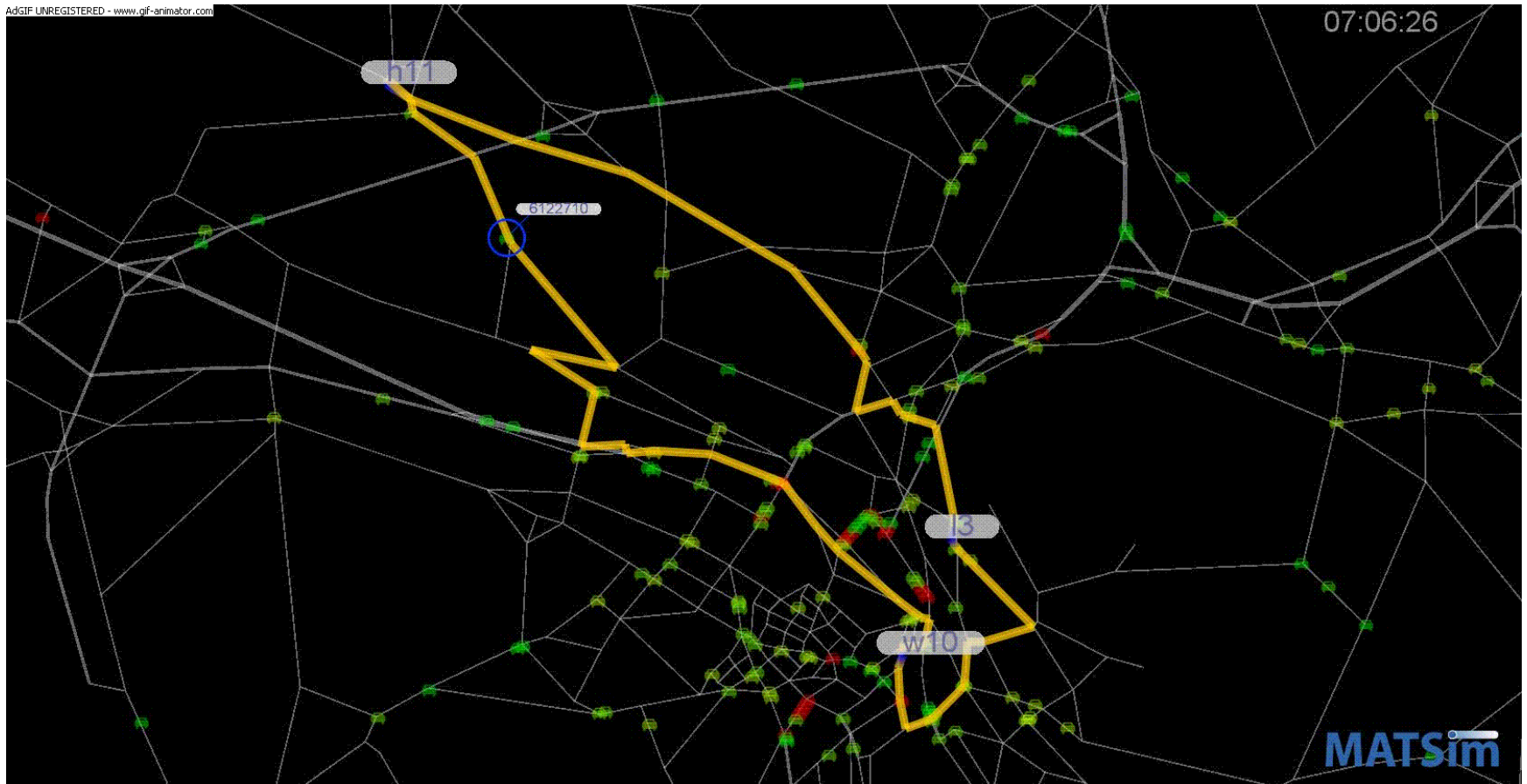
# Principles of agent-based transport modeling

---



# Example of an agent's daily activities and travel

---



# Agent-based transport simulation for planning

---



# Agent-based transport simulation for planning

---

## Advantages

Full temporal dynamics

- Bunching phenomena
- Overcrowding of individual vehicles
- Time-dependent demand management

Agent-based paradigm

- Individuals
- Parcel or building (or unit) as base unit
- Interdependency of trips and activities, e.g. tour based mode choice

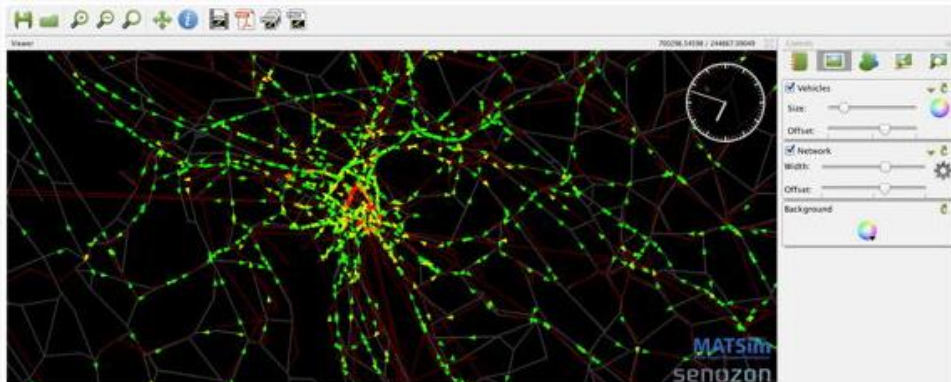
## Challenges

How to deal with the **wealth of data**?

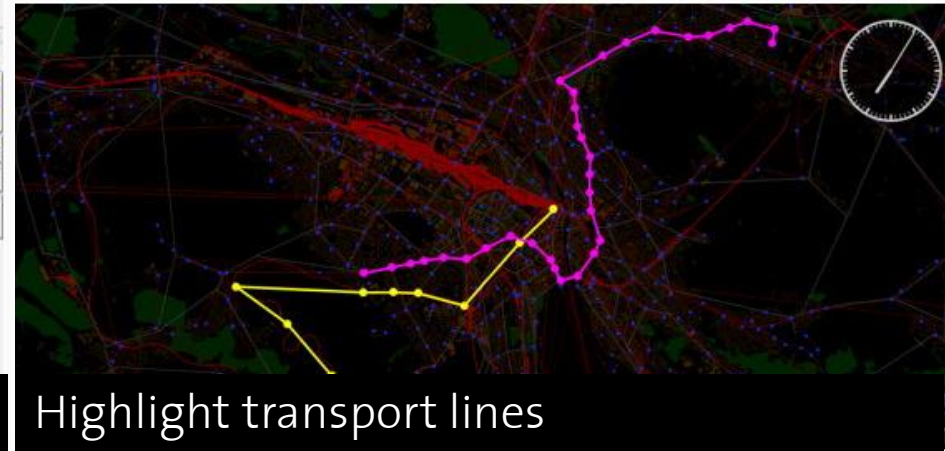
- **Who?**
- With how much **time**?
- What **skills**?
- New questions?



# Current situation I



Network and moving vehicles



Highlight transport lines



Follow individual agents



Public transport demand analysis

# Current situation II

```
330
331     chart.addSeries("Flow", xs, ys);
332     chart.saveAsPng("./data/youssef/densityLinksAverage"+"-"+fromBin+"-"+toBin+"-"+".png", 800, 600);
333 }
334
335 public void showSpeedAvgGraph(int fromBin, int toBin) {
336     XYLineChart chart = new XYLineChart("Speed Average", "Time(h)", "Speed(m/s)");
337     double[] xs = new double[toBin-fromBin];
338     double[] ys = new double[toBin-fromBin];
339     for(int t=fromBin;t<toBin;t++) {
340         xs[t-fromBin]=(t*TIME_INTERVAL+TIME_INTERVAL/2)/(60*60);
341         double value = 0;
342         int numLinks = 0;
343         for(Link link:network.getLinks().values()) {
344             LinkData linkData = linksData.get(link.getId());
345             if(linkData==null && linkData.isUsed()) {
346                 value=linkData.getAvgSpeedsGraphs(t);
347                 numLinks++;
348             }
349         }
350         ys[t-fromBin]=value/numLinks;
351     }
352     chart.addSeries("Speed", xs, ys);
353     chart.saveAsPng("./data/youssef/speedLinksAverage"+"-"+fromBin+"-"+toBin+"-"+".png", 800, 600);
354 }
355
356 public void showTTAvgGraph(int fromBin, int toBin) {
357     XYLineChart chart = new XYLineChart("TT Avg", "Time(h)", "Travel Time(s)");
358     double[] xs = new double[toBin-fromBin];
359     double[] ys = new double[toBin-fromBin];
360     for(int t=fromBin;t<toBin;t++) {
361         xs[t-fromBin]=(t*TIME_INTERVAL+TIME_INTERVAL/2)/(60*60);
362         double value = 0;
363         int numLinks = 0;
364         for(Link link:network.getLinks().values()) {
365             LinkData linkData = linksData.get(link.getId());
366             if(linkData==null && linkData.isUsed()) {
367                 value=linkData.getAvgTravelTimesGraphs(t);
368                 numLinks++;
369             }
370         }
371         ys[t-fromBin]=value/numLinks;
372     }
373     chart.addSeries("Travel Time", xs, ys);
374     chart.saveAsPng("./data/youssef/TLLinksAverage"+"-"+fromBin+"-"+toBin+"-"+".png", 800, 600);
375 }
376
377 public void showKAvgGraph(int fromBin, int toBin) {
378     XYLineChart chart = new XYLineChart("Concentration", "Time(h)", "K(veh/m)");
379     double[] xs = new double[toBin-fromBin];
380     double[] ys = new double[toBin-fromBin];
381     for(int t=fromBin;t<toBin;t++) {
382         xs[t-fromBin]=(t*TIME_INTERVAL+TIME_INTERVAL/2)/(60*60);
383         double value = 0;
384         int numLinks = 0;
385         for(Link link:network.getLinks().values()) {
386             LinkData linkData = linksData.get(link.getId());
387             if(linkData==null && linkData.isUsed()) {
388                 value=linkData.getConcentration(t);
389                 numLinks++;
390             }
391         }
392         ys[t-fromBin]=value/numLinks;
393     }
394 }
```

# Decision support system for transportation

---

## **Transport planners**

- Effects of new bus services/network
- Impact of travel demand management schemes

## **Urban planners:**

- Temporal patterns of buildings and neighbourhood
- Flow between public transport stops to surrounding buildings

## **Policy-makers**

- Costs and benefits of a infrastructure measures?
- Who and where are the winners and losers?

## **Public transport operators**

- Who profitable will a new line be?

## **Service industry**

- Which customers are in catchment areas, separated by mode?



# Requirements for DSS in transport planning

---

## Functional:

### Appraisal

- Cost-benefit
- Winners and losers

### Scope

- Journeys
- Stages
- Activities

### Temporal analysis

- Full temporal resolution for filtering and aggregation

## Technical:

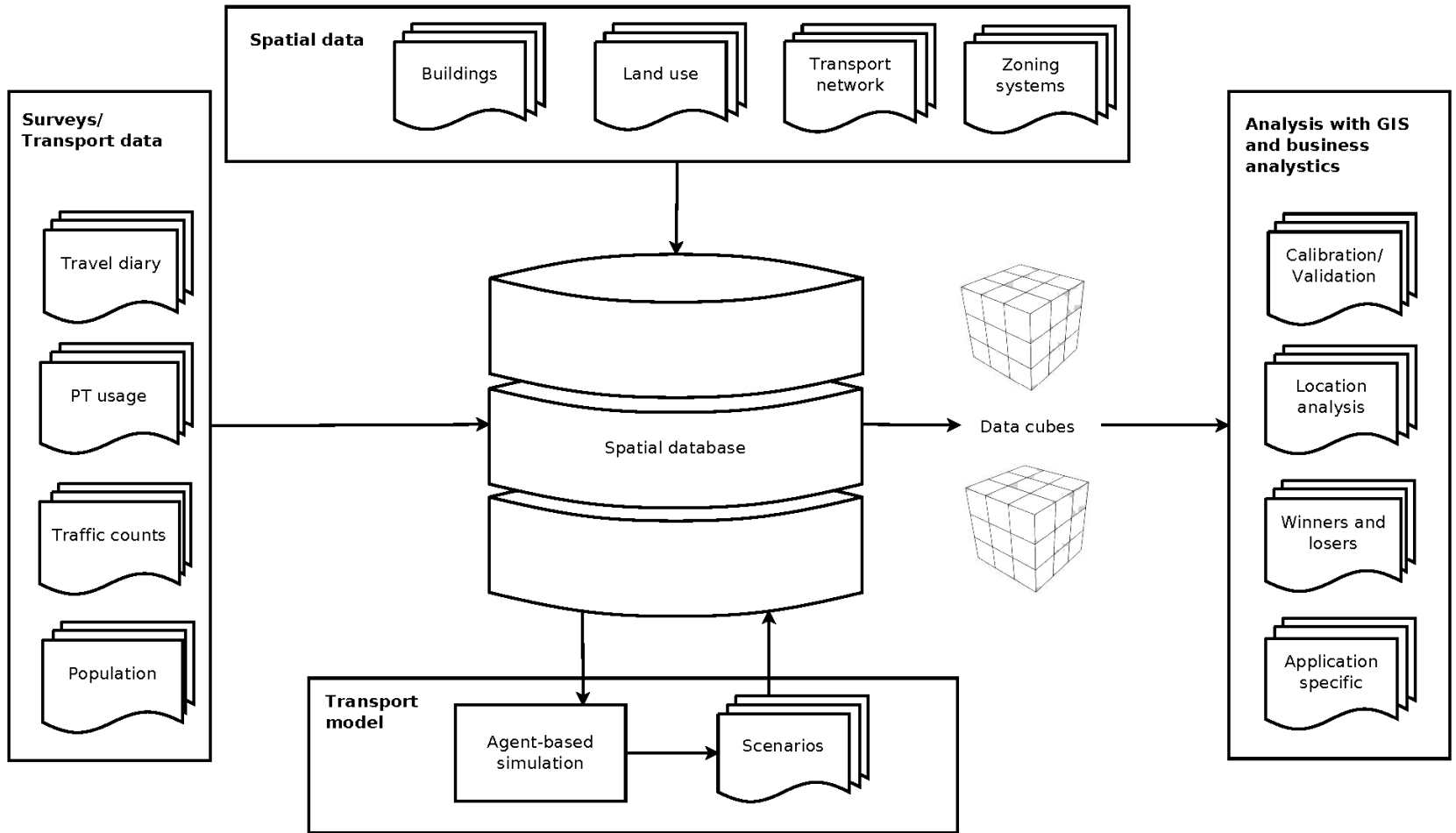
### Database

- Open source with open interface
- Spatial queries
- Flexible permission setting

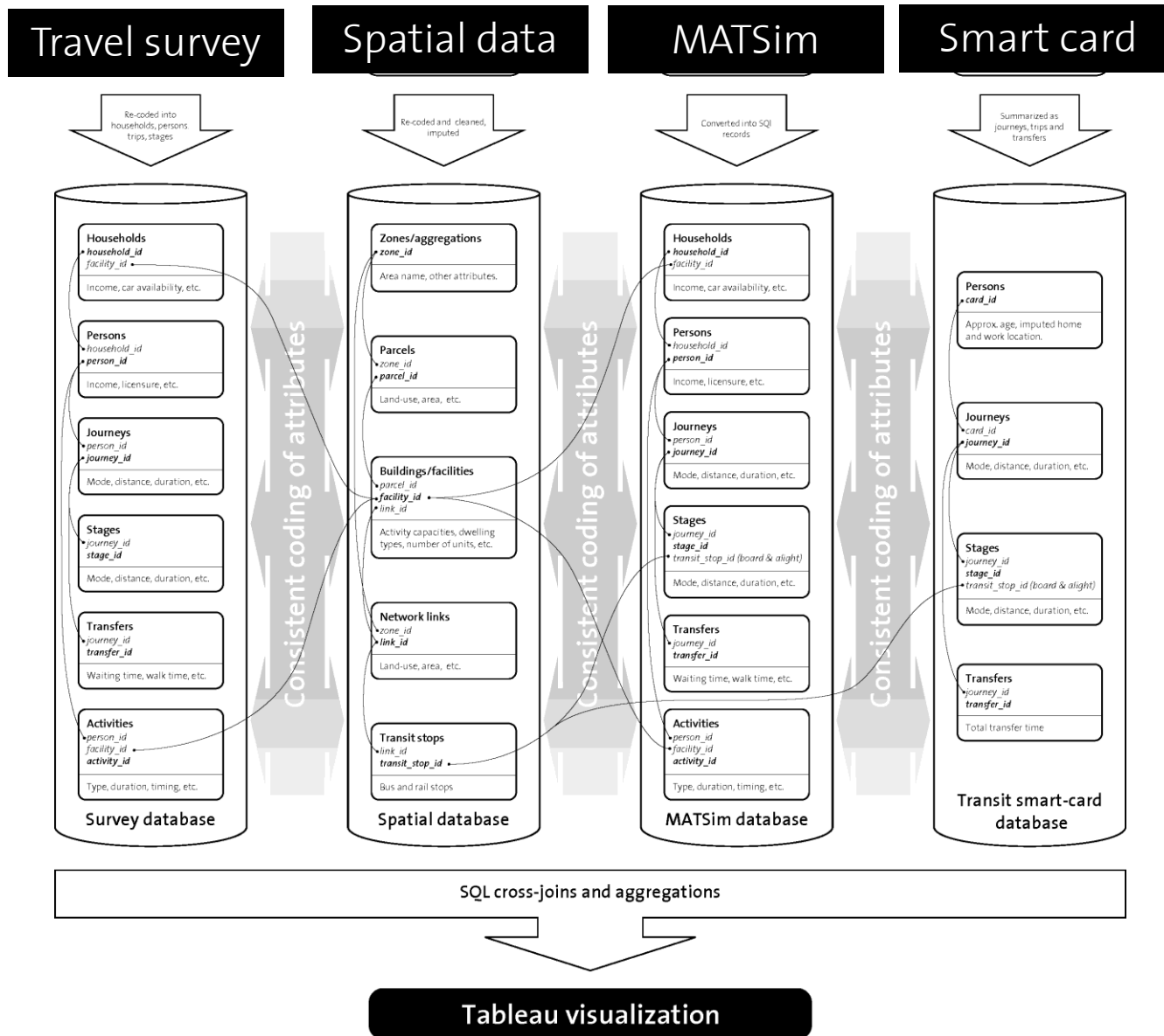
### Front-end

- Business analytics software for customisable and interactive analysis
- GIS

# General Framework



# Case study: decision support tool for Singapore



# Two case study applications

---

## Comparison between modeled and actual travel demand patterns

- Data available from same data platform
- Public transport smart card transactions replicate level of disaggregation provided by agent-based transport simulation

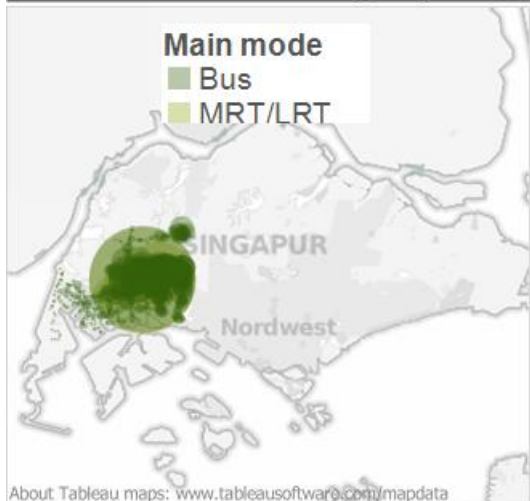
## Travel demand explorer

- Spatial selection
- Special focus
  - Mode share
  - Commuting trips
- Socio-demographics

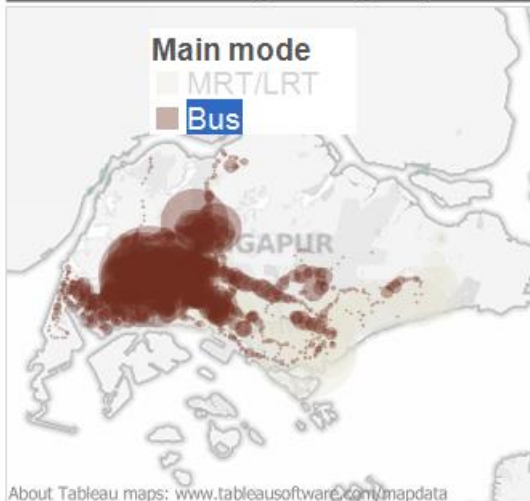


# Public transport trips data explorer

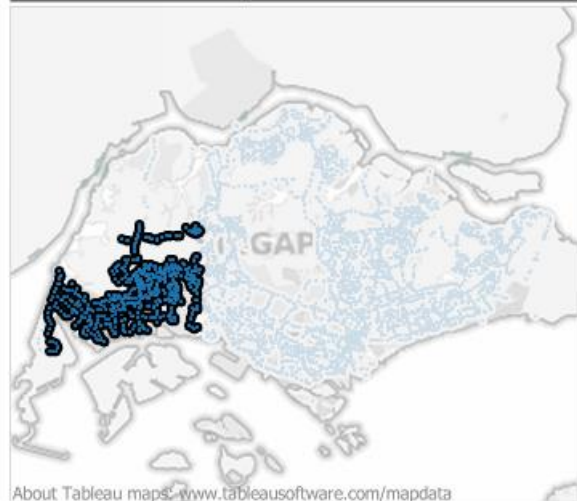
MATSim boardings [pax]



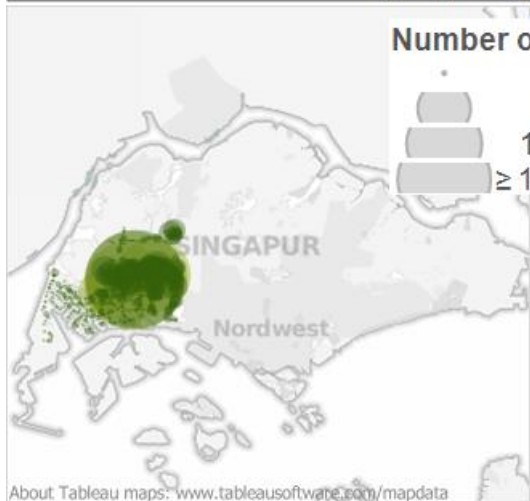
MATSim alightings [pax]



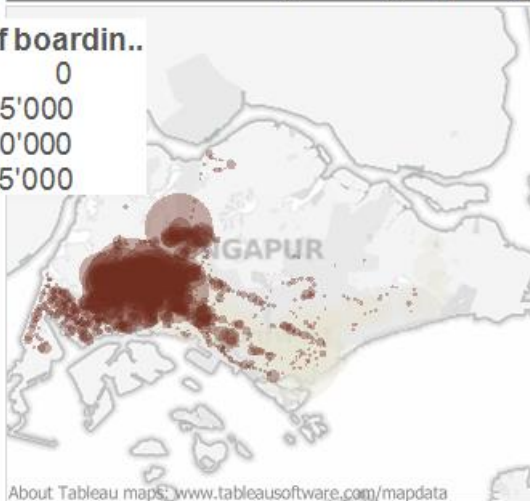
Stop selector



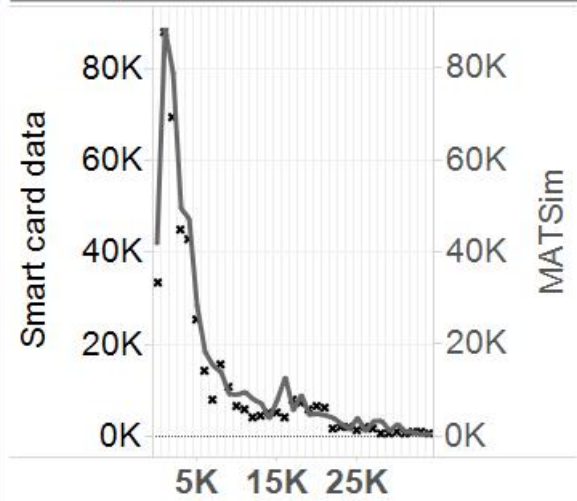
Smart card boardings [pax]



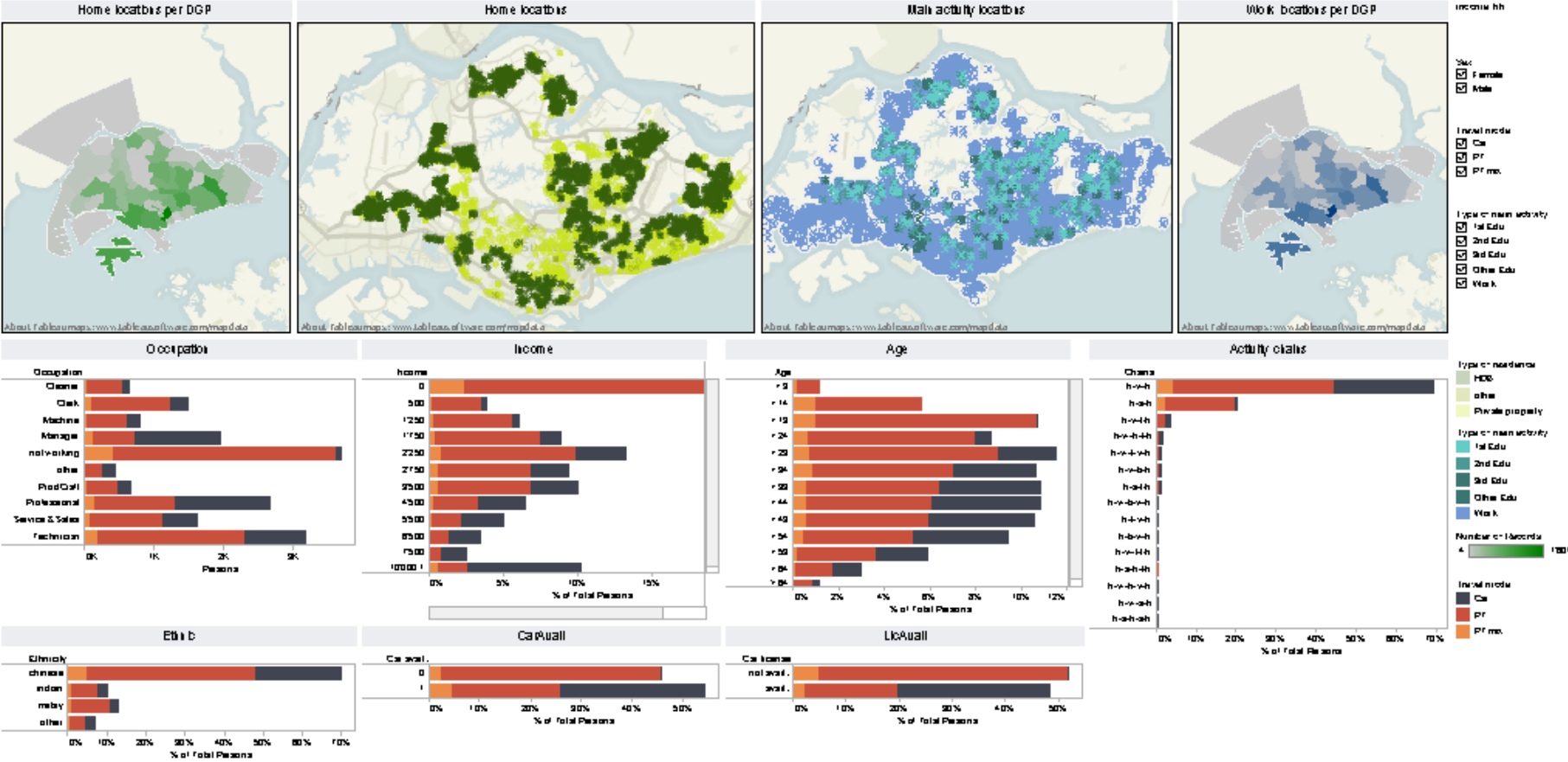
Smart card alightings [pax]



Trip distance comparison



# Travel demand explorer



# Vision, Mission and Strategy

---

## Vision

- Continuously updated data input
- Living (3d) city model to be maintain and shared data across stakeholders
- Automatic generation of MATSim 'live' scenarios

## Mission:

- Developing the necessary tools to make MATSim more accessible for practitioners
- Engaging with practitioners in workshops to overlap of pressing needs with abilities new modelling technology offers

## Strategy / Next steps

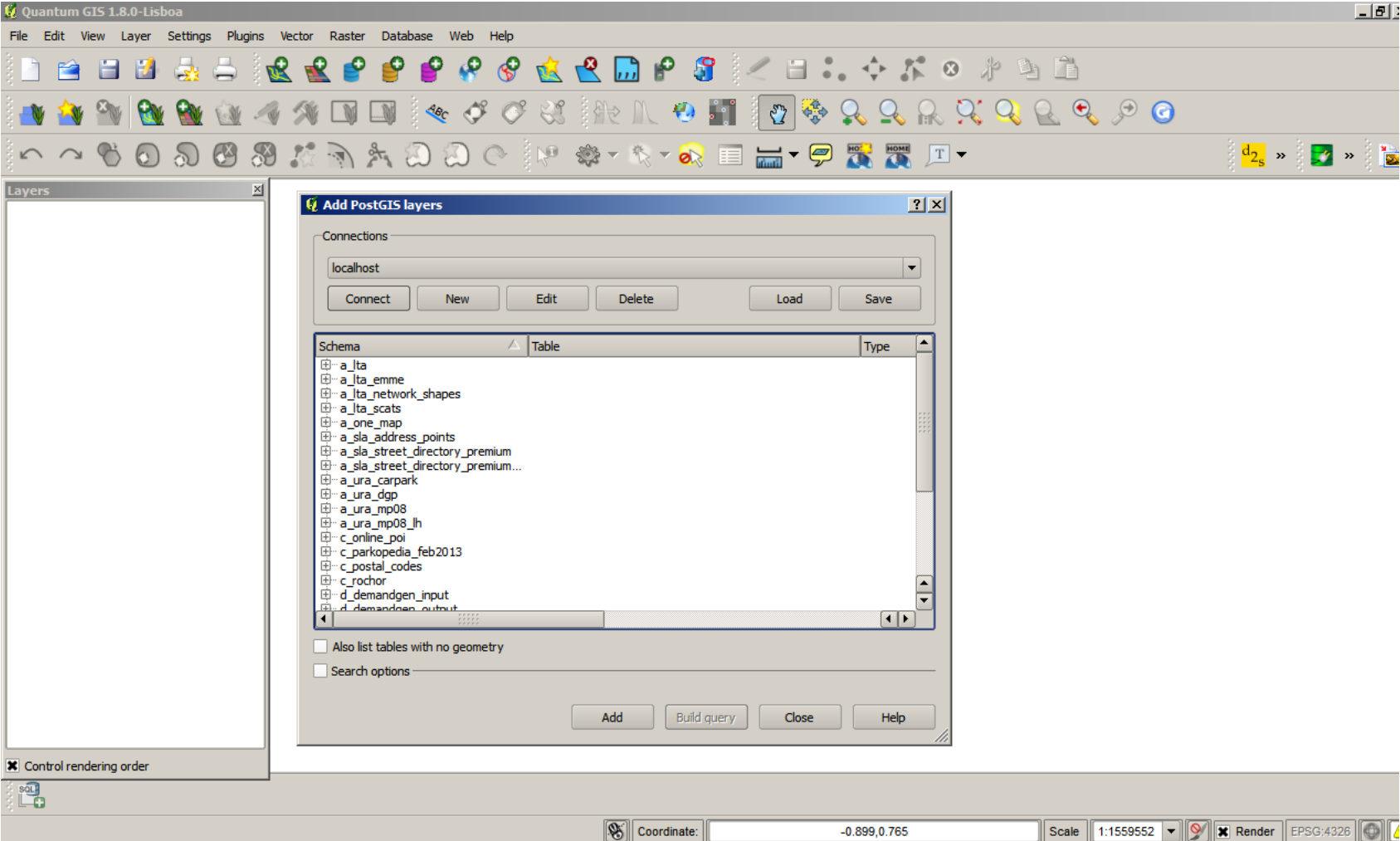
- Calibration and validation of MATSim Singapore with DSS

# Appendix

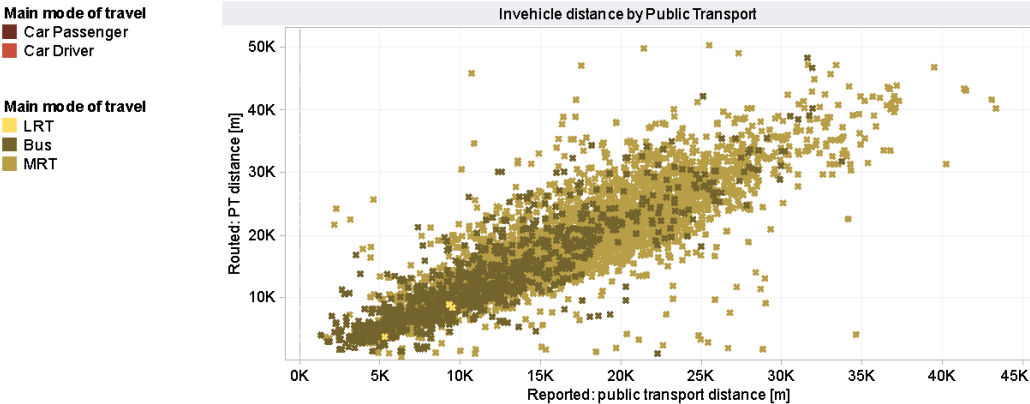
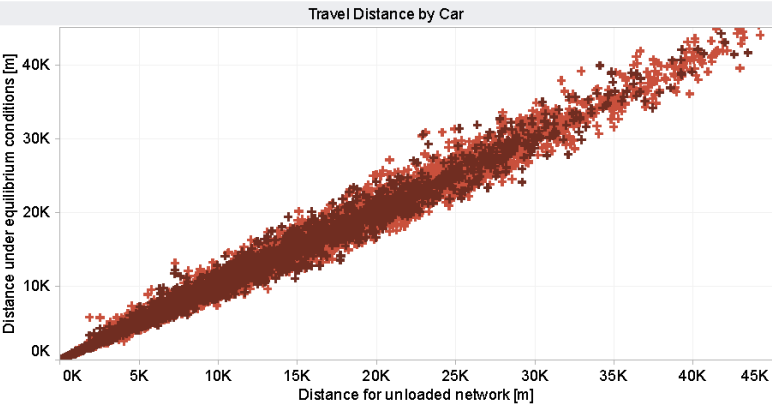
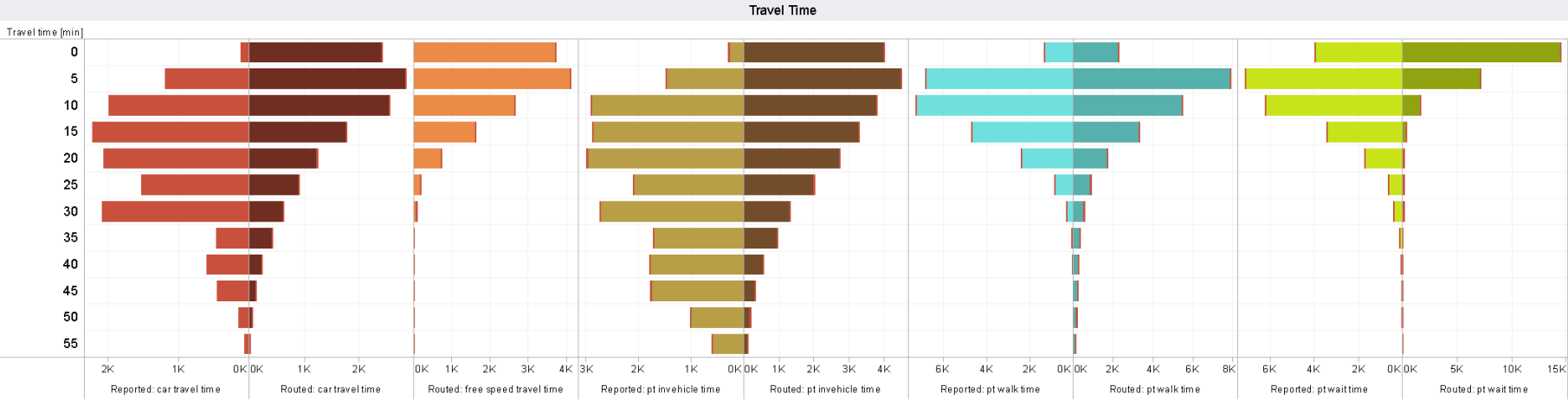
---



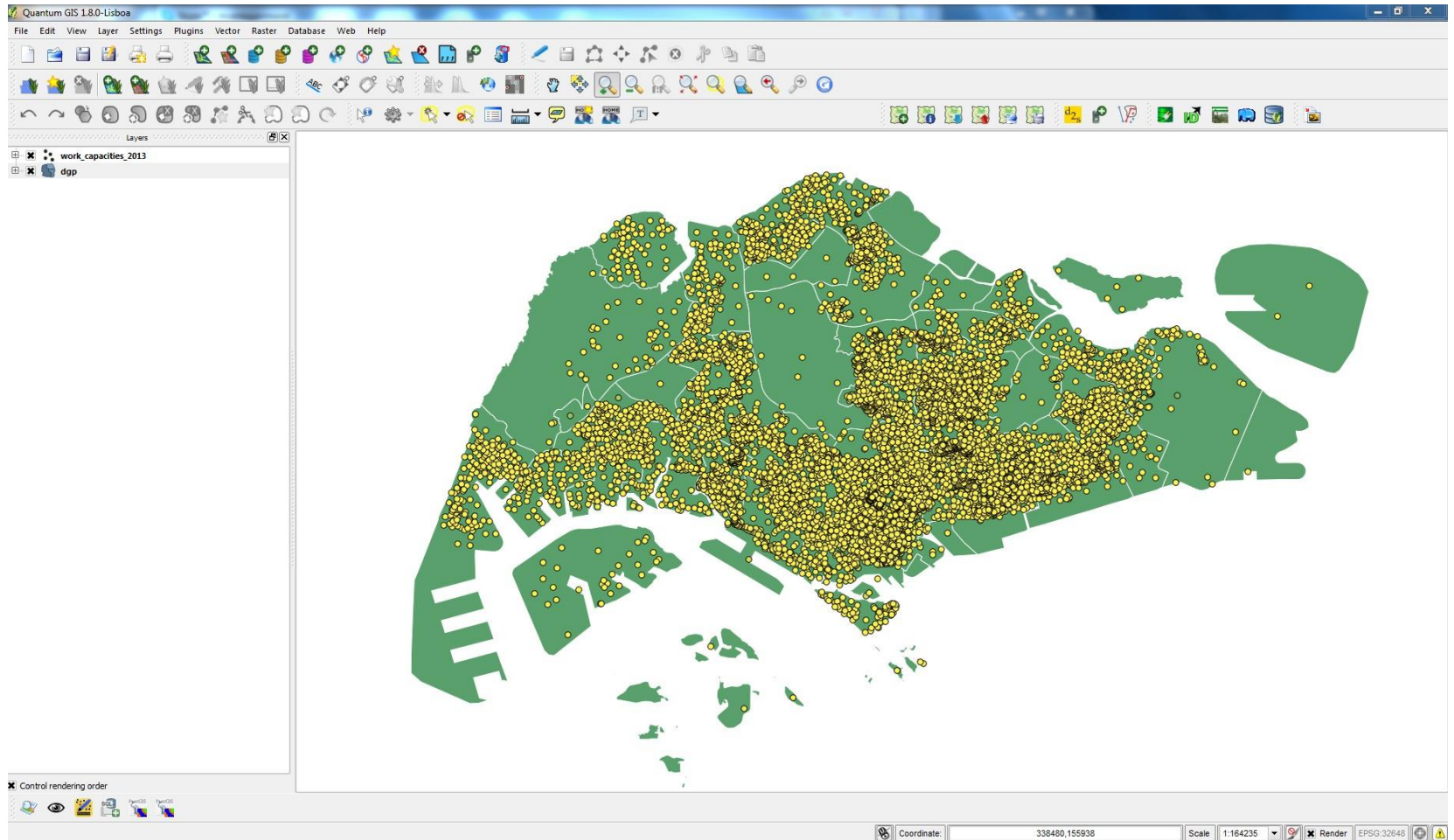
# Connect and edit spatial database with Quantum GIS



# Travel survey: reported vs MATSim routed



# Connect and edit spatial database with Quantum GIS



# How do other disciplines deal with the problem?

---

1960: First Management Information Systems

- Interactive analysis
- Single decision maker

1970: Computer Based Systems to aid decision making

- Databases and models
- Financial planning

1980: Decision Support Systems (DSS)

- Data -> Model -> management software for end user
- Cognitive psychology and operations research join the club



# How do other disciplines deal with the problem?

---

1990: Group decision support system

- Various stakeholders with different agendas

2000: Business intelligence

- Procter&Gamble links retailers scanner data to DSS
- On-Line Analytical Processing (OLAP) for interactive analysis
- Linkage of various data sources, e.g. from different departments

2010: Visualisation

- Analyst circumvents data warehouse specialists
- External, interactive visualisation tools
- State-of-the-Arte visualisation principles