POLIS
CITIES AND REGIONS FOR TRANSPORT INNOVATION

regio arnhem nijmegen

# Smart Public Transport Network Redesign


**Franck JACON & Anthony PATERNA**
**T2C**

**Robin GOIX**
**SYSTRA**



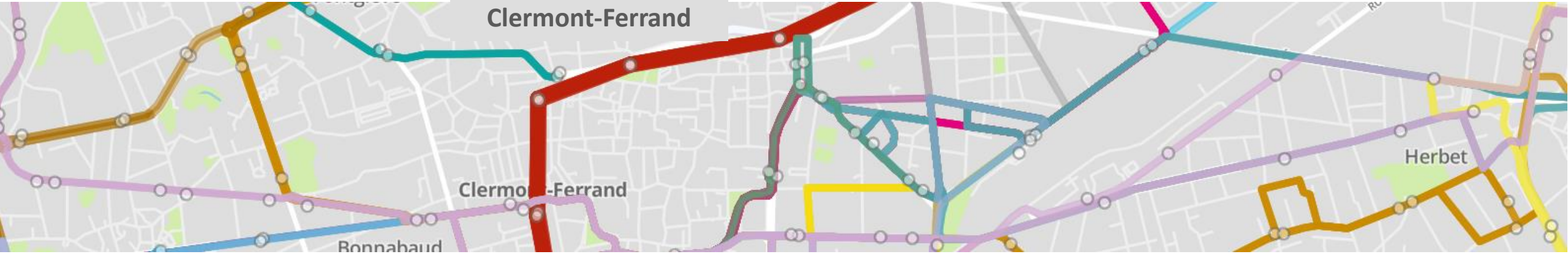
**Annual Conference 2020**

**#POLIS20**

# Speakers – T2C and SYSTRA

**Public Transport Operator** for Clermont-Ferrand Agglomeration – FRANCE

Franck JACON & Anthony PATERNA


**Engineering and Consulting Company**

Robin GOIX

# Introduction and context

***Opportunity*** *Need*

- **Web applications** provide innovative way of collaborating
- **Python** programming language provides flexibility, performance and community-effect to:
  - Build on state-of-the art **open-source computing libraries** for data-oriented applications
  - Quickly build **affordable**, **efficient**, light **tools** such as traffic models, or cost-benefits analysis models
  - Easily **interface** with other applications such as web services
- It is now possible to build **affordable tailor-made collaboration tools** to engage transport operators, agencies, collectivities into the planning of their PT network
- A new opportunity to rethink transport planning


- Example of Clermont-Ferrand (France): delivery of two tools to support bus network restructuring

# Introduction and context

*Opportunity* ***Need***

**T2C : Public Transport Operator** at Clermont-Ferrand – FRANCE

- Network: 1 tramway line – 27 bus lines
- Fleet: 30 tramways – 200 buses
- 33 millions of trips
- 850 employees

**SMTC**

Public Transport Authority at Clermont Ferrand

Project Owner of BRT B & C

**T2C**

Technical Project Owner assistant

BUS NETWORK RESTRUCTURING

EXPERTISE ON BRT LINES B & C AND CONNECTED PROJECTS (RTPI-AVL…)

## Our needs

- T2C must have **easy-to-use** study tools to optimize its bus network in order to be efficient and attractive for passengers
- The bus network must meet performance and efficiency targets

We are currently working on the **restructuring** of the bus network triggered by shift towards e-mobility and we needed a tool to help us make the right choices :

- **Optimize** bus **routes**
- Choose the **level of service** matching travelers' expectations
- Compute different **KPI** (costs, population served by bus, number of buses…) in order to **compare** scenarios and meet project objectives
- Make the most out of our **traffic demand survey data**

# ITSIM: a PT network planning and restructuring solution



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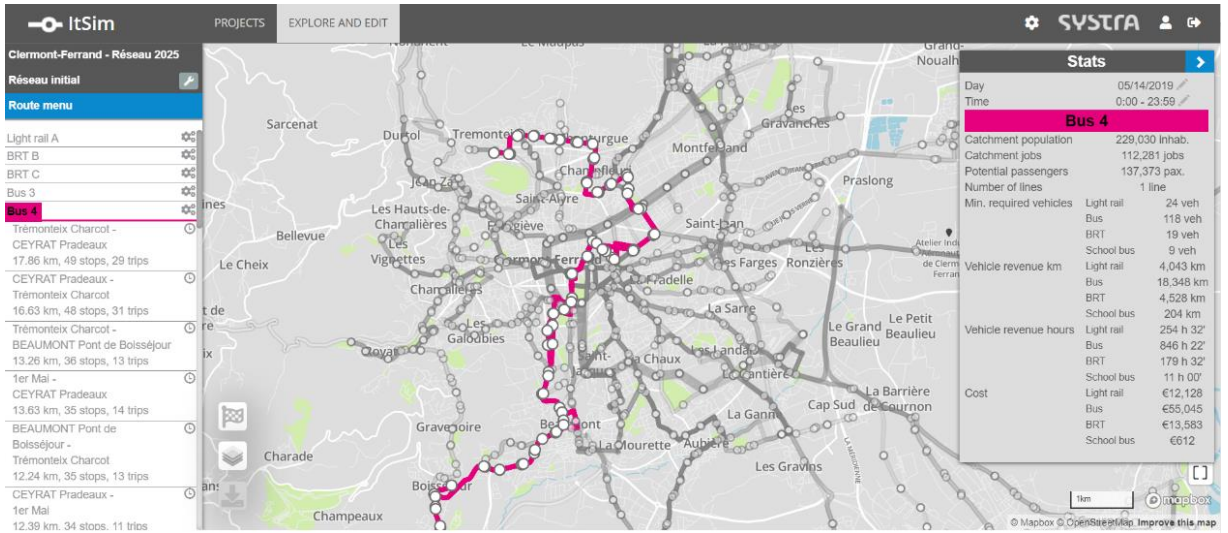
## Features

- A **web-application**
- **Visualise** PT network
- **Create**, edit and assess various scenarios
- Automatically **measure** KPIs
- Assess **accessibility**
- **Collaborate** in real-time
- Open, light and easy to **share** data formats, in particular **GTFS**






SYSTRA

## Why did we choose ITSIM ?

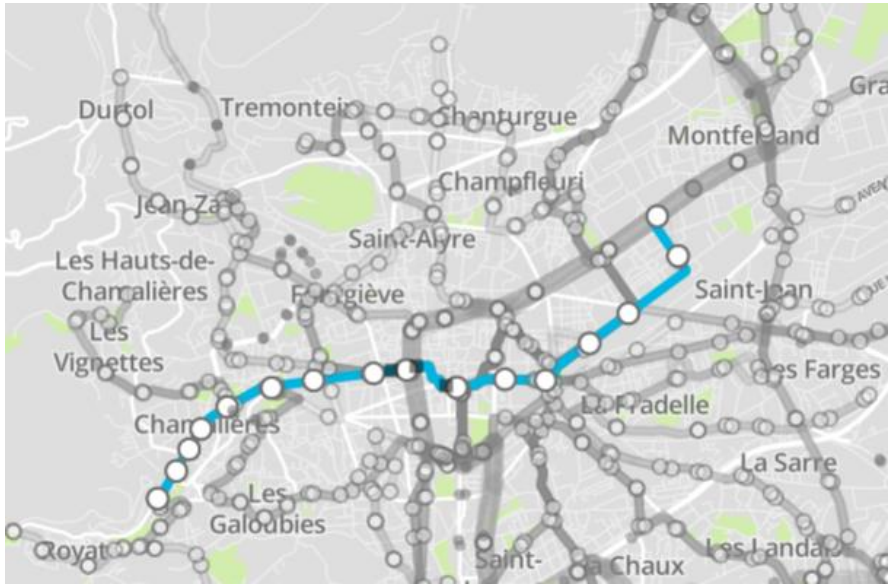
- Simple, easy-to-use, user-friendly interface
- Quick
- Several people can work on a scenario (very useful for our team)
- Accessible from anywhere through a website (very useful during the lock-downs!)
- Easy-to-share data formats (GTFS, xlsx…)
- Additional use with Quetzal
- **Meets our work expectations and help us to make the right decisions**

# ITSIM: a PT network planning and restructuring solution

*Presentation* *Choice* ***Use cases***

## Edit the digital replica of the PT network

**Quickly** create a bus line and the bus stops on the map





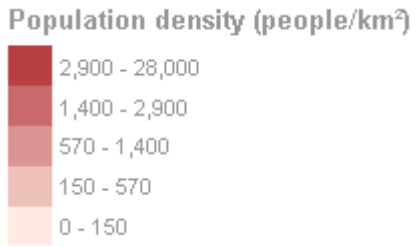
**Easily** define the level of service on each time period

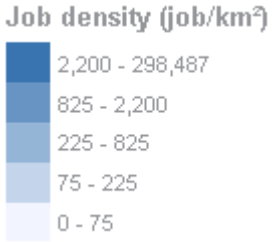
| Time Period | Average headway |
|---|---|
| Select a time range to add | |
| Heures de pointe du matin – 7:00 - 9:00 | 10' |
| Heures creuses du matin – 9:00 - 12:00 | 10' |
| Heures de pointe du midi – 12:00 - 14:00 | 10' |
| Heures creuses après-midi – 14:00 - 16:00 | 10' |
| Heures de pointe du soir – 16:00 - 18:00 | 10' |
| Heures creuses du soir – 18:00 - 20:00 | 11' |

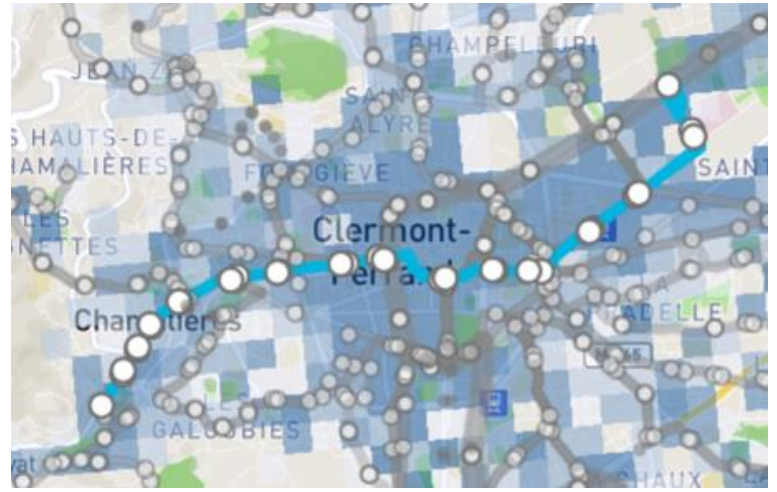
# **ITSIM**: a PT network planning and restructuring tool

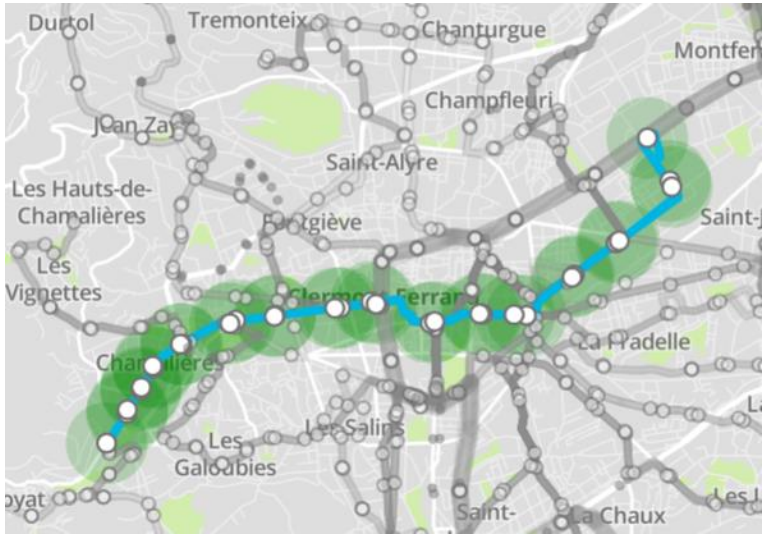
*Presentation* *Choice* ***Use cases***

## Display different layers on the map depending on your needs


Stop catchment areas

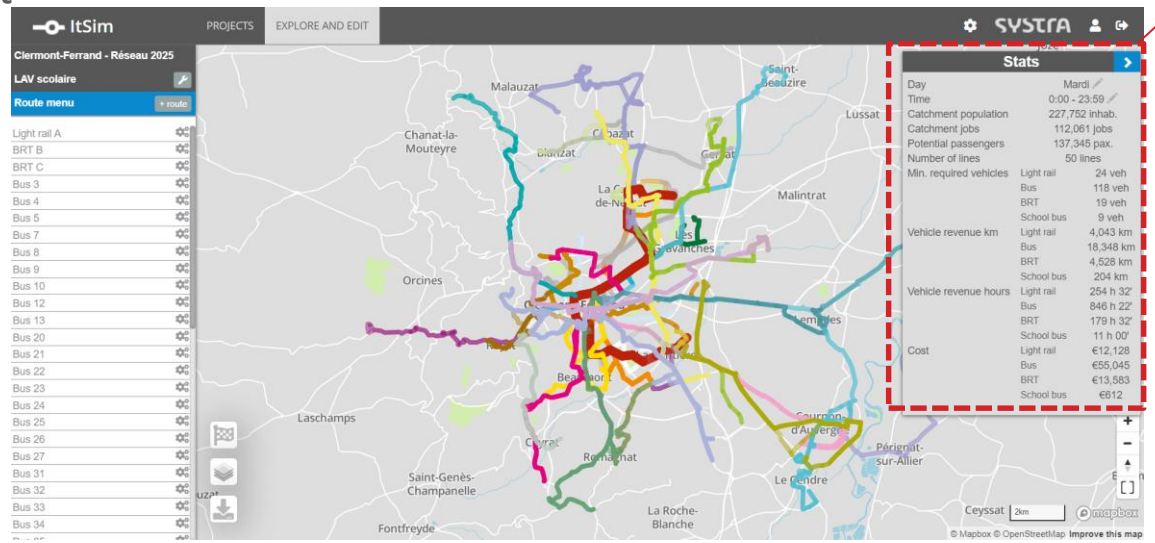
Satellite view

## Automatically compute KPIs at different levels

After defining our levels of service, we can view different **KPIs** for all the bus network or one line, or one stop.

Very useful to **compare** different scenarios

**Units of work** (vehicles, km or hours) are **estimations** (ItSim is not a tool of scheduling and it does not optimize the means), not an exact result




**Stats**

| | | |
|---|---|---|
| Day | | Mardi |
| Time | | 0:00 - 23:59 |
| Catchment population | | 227,752 inhab. |
| Catchment jobs | | 112,061 jobs |
| Potential passengers | | 137,345 pax. |
| Number of lines | | 50 lines |
| Min. required vehicles | Light rail | 24 veh |
| | Bus | 118 veh |
| | BRT | 19 veh |
| | School bus | 9 veh |
| Vehicle revenue km | Light rail | 4,043 km |
| | Bus | 18,348 km |
| | BRT | 4,528 km |
| | School bus | 204 km |
| Vehicle revenue hours | Light rail | 254 h 32' |
| | Bus | 846 h 22' |
| | BRT | 179 h 32' |
| | School bus | 11 h 00' |
| Cost | Light rail | €12,128 |
| | Bus | €55,045 |
| | BRT | €13,583 |
| | School bus | €612 |

# QUETZAL: an open-source library for modeling



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## Features

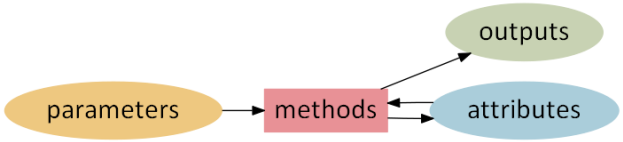
- An **open-source Python** library developed by Systra, hosted on **GitHub**

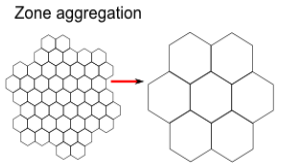
python™ GitHub

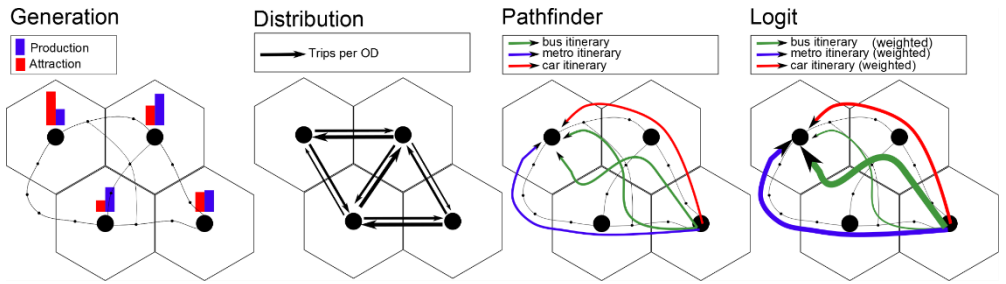
pandas scikit learn

- Relies on other powerful **open-source** computing **libraries**

- **Quetzal** provides:
  - A **data structure** to efficiently handle transport data with a consistent **object model**
  - A **preparation** suite to pre-process transport data
  - A **transport** suite gathering algorithms to build a customized four-step model



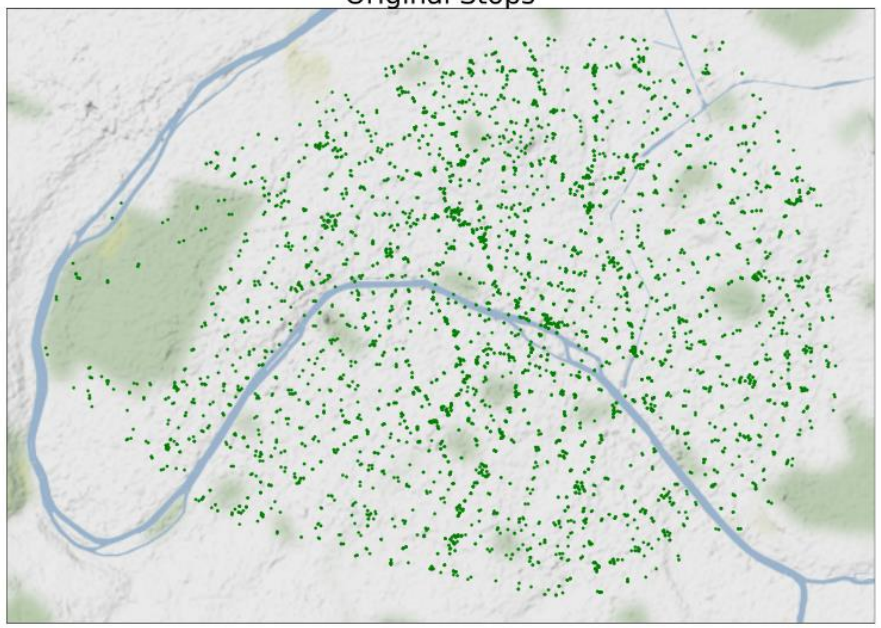





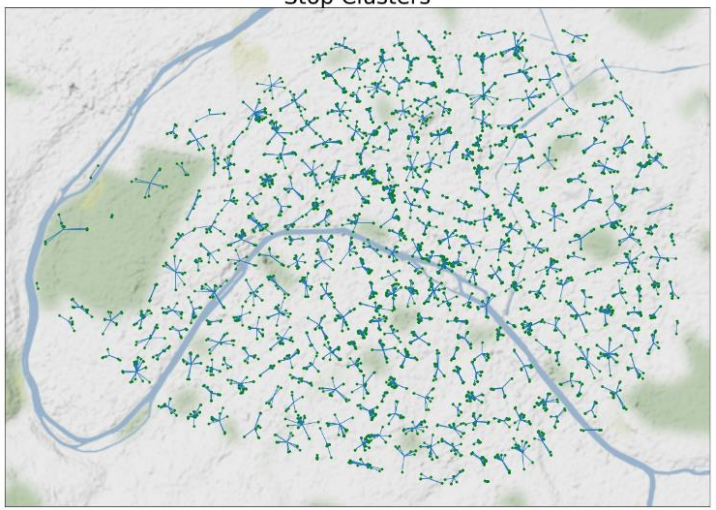

SYSTRA

## Example – node clustering

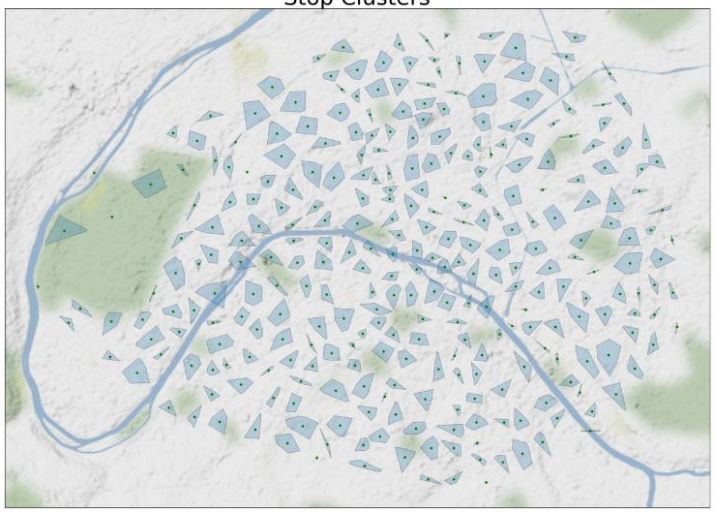
Original Stops



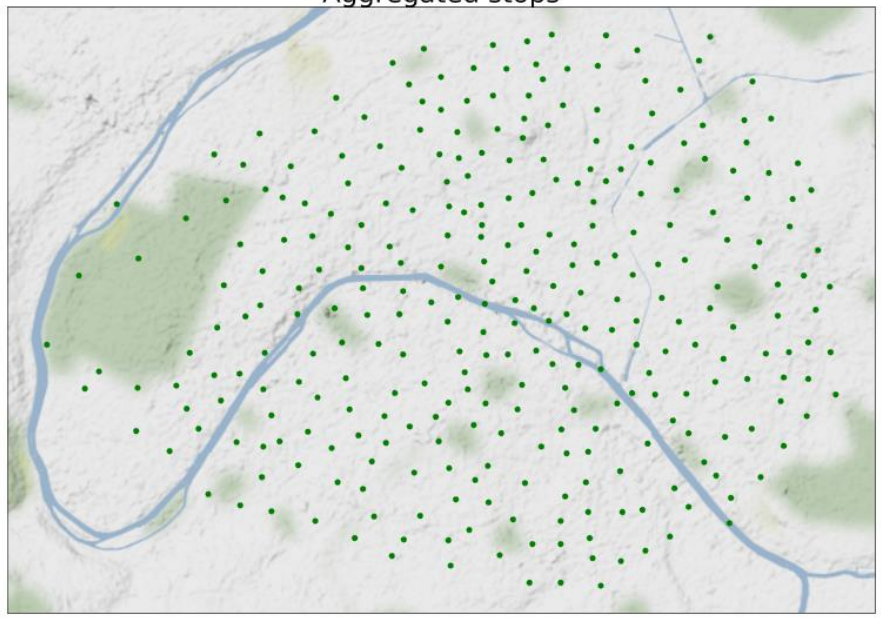
Stop Clusters



Stop Clusters



Aggregated stops



# QUETZAL: an open-source library for modeling



## Example – network matching (OpenStreetMap / GTFS)

Road network

GTFS

# **QUETZAL**: an open-source library for modeling

***Presentation*** *Tailor-made solution* *Use cases*

## Example – network matching (OpenStreetMap / GTFS)

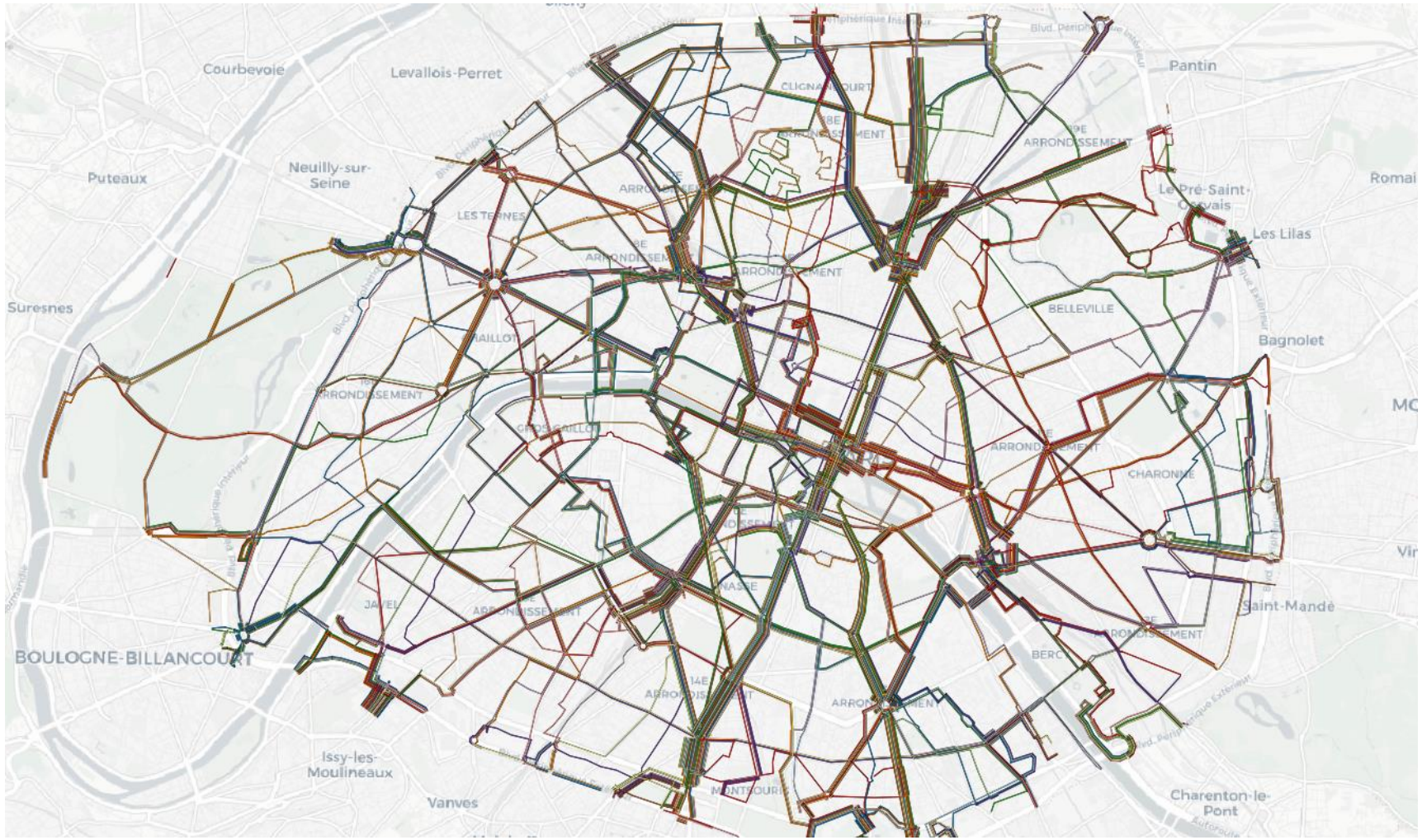
raw GTFS & road network

Processed GTFS & Road Network

# **QUETZAL**: an open-source library for modeling

***Presentation*** *Tailor-made solution* *Use cases*

## Example – network matching (OpenStreetMap / GTFS)

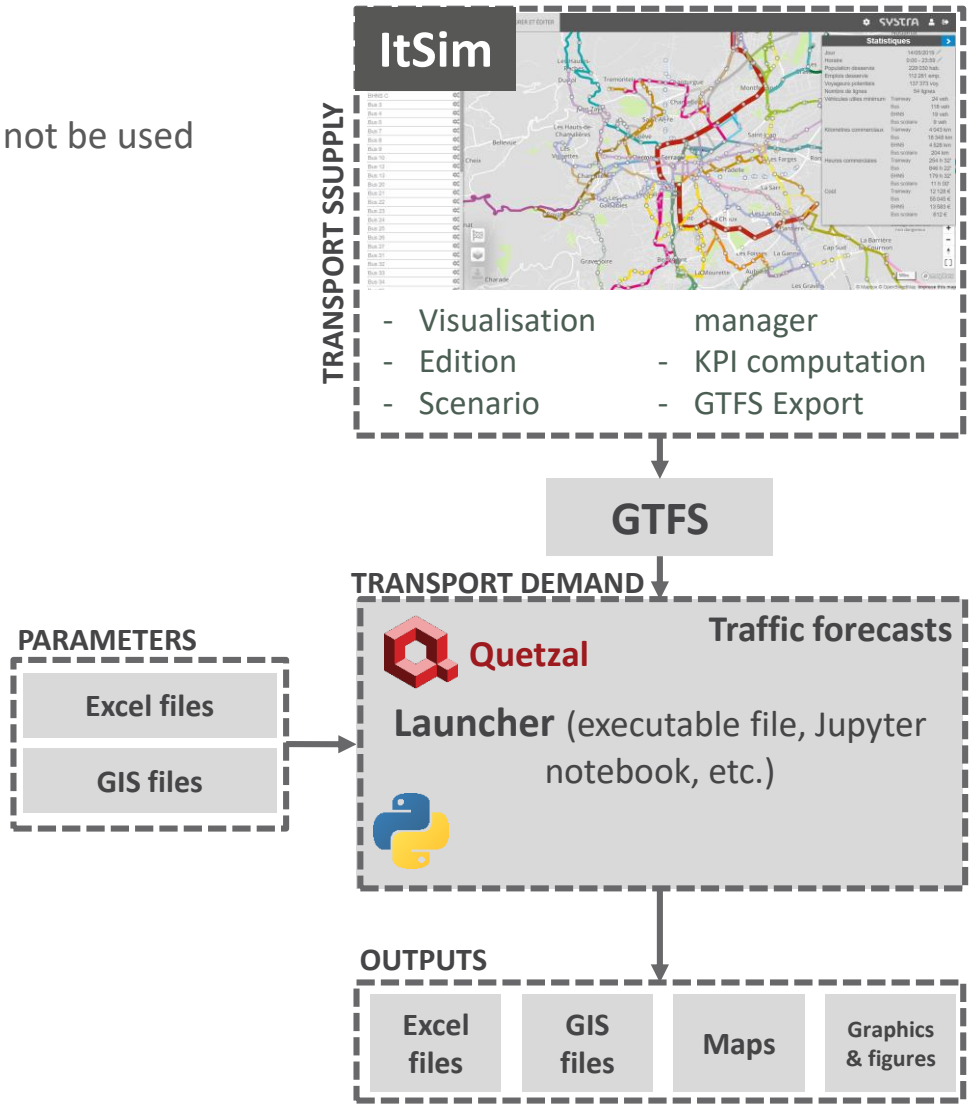


# QUETZAL: an open-source library for modeling

*Presentation* ***Tailor-made solution*** *Use cases*

Major **drawback**: Quetzal does not have a graphic interface and cannot be used easily by non-experts

1. **Design workshop** to specify:
   - Available data
   - Input parameters
   - Model objectives
   - Model methodology
   - Outputs and format
2. Tool **implementation** phase
3. Tool **delivery**: set-up and training
4. Use



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## Define scenarios and obtain traffic forecasts

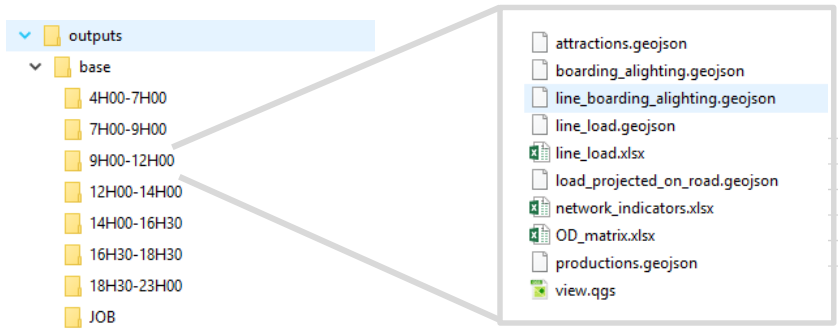
### Inputs and scenario definition

- Entirely done in one Excel sheet

| CATEGORIE | PARAMETRE | PERIODE | base | scenario_BHNS | base_2030 | scenario_L3 |
|---|---|---|---|---|---|---|
| general | parent | | base | base | base | base |
| | | | | | | |
| PARAMÈTRES D'OFFRE | | | | | | |
| general | itsim_scenario | | reference_2016 | reference_2016 | | reference |
| facteur_vitesse | B | 4H00-7H00 | | 1 | | |
| facteur_vitesse | B | 7H00-9H00 | 1 | 2 | | |
| facteur_vitesse | B | 9H00-12H00 | 1 | 1 | | |
| facteur_vitesse | 3 | 4H00-7H00 | 1 | 1 | | |
| facteur_vitesse | B | 12H00-14H00 | 1 | 1 | | |
| facteur_vitesse | C | 4H00-7H00 | 1 | 1 | | |
| facteur_vitesse | C | 7H00-9H00 | 1 | 1 | | |
| facteur_vitesse | C | 16H30-18H30 | 1 | 1 | | |
| facteur_frequence | B | 16H30-18H30 | 1 | 1 | | |
| facteur_frequence | B | 7H00-9H00 | 1 | 2 | | |
| facteur_frequence | C | 7H00-9H00 | 1 | 1 | | |
| facteur_frequence | C | 12H00-14H00 | 1 | 1 | | |
| facteur_frequence | C | 16H30-18H30 | 1 | 1 | | |
| | | | | | | |
| PARAMÈTRES DE PROJECTION | | | | | | |
| projection_niveau_de_service | elasticite_temps | | 0,8 | 0,8 | 0,8 | |
| projection_croissance_homogene | facteur_croissance_population_% | | 0 | 0 | | |
| projection_croissance_homogene | annee | | 2016 | 2016 | | |
| projection_projet_population | dossier_population | | reference_2016 | reference_2016 | reference_2030 | |
| projection_projet | emission | 4H00-7H00 | True | True | | |

### Outputs

- Boarding and alighting per stop
- Bus load
- Passengers per km
- Travel time between 2 locations
- Transfer rate



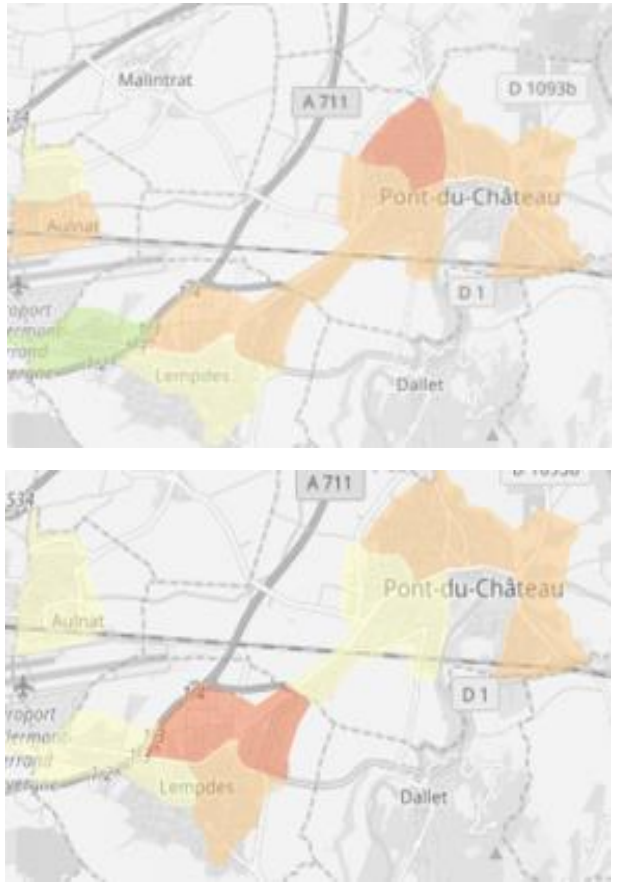

| Departure | Arrival | Boarding | Alighting | Load | Lenght | Passengers / KM |
|---|---|---|---|---|---|---|
| Champratel | Neyrat | 5 | 28 | 47 | 372,7894319 | 0,126076535 |
| Neyrat | Narvik | 0 | 0 | 20 | 126,0294745 | 0,158693037 |
| Narvik | Daudet | 0 | 0 | 20 | 195,1222623 | 0,102499837 |
| Daudet | Gomel | 0 | 18 | 20 | 373,5676185 | 0,053537831 |
| Gomel | Arbos | 1 | 0 | 3 | 274,8213338 | 0,010916183 |
| Arbos | Hauts de Chanturgue | 0 | 0 | 3 | 252,0996562 | 0,011900056 |

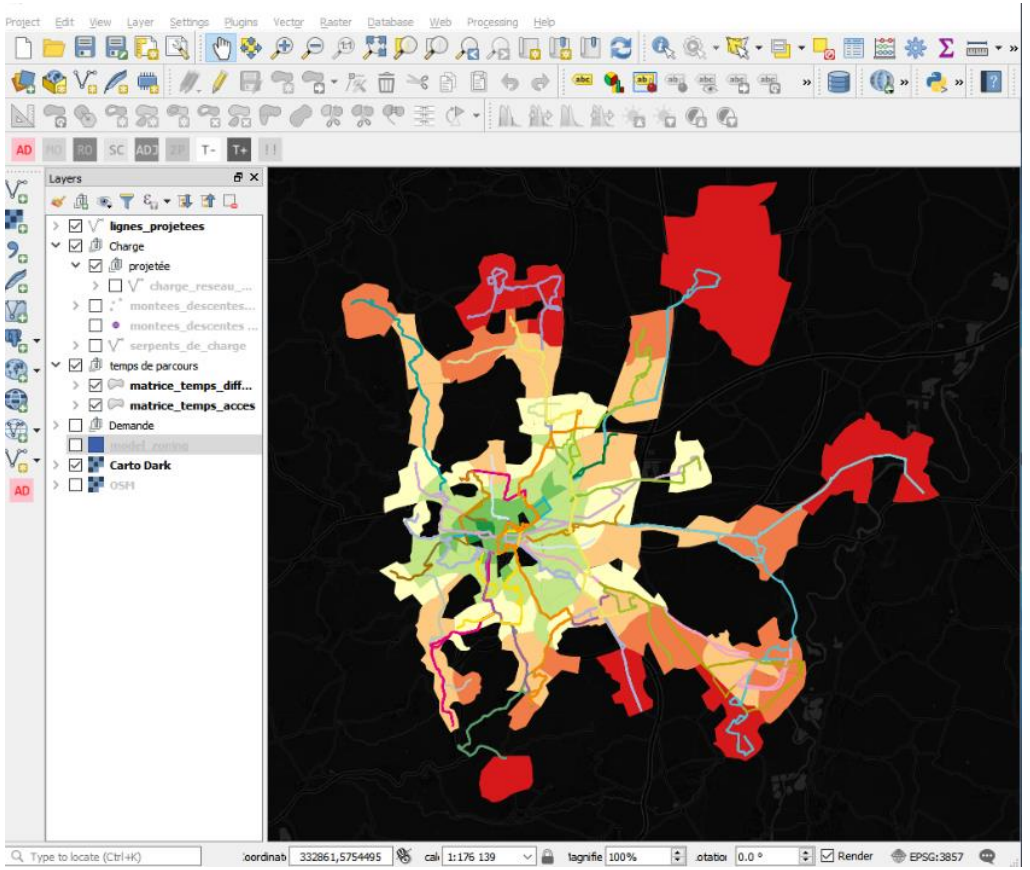


SYSTRA

## Compare accessibility

Create a map with the travel time from a specific location and compare different scenarios



# Conclusion

- **ItSim** is a PT network planning **SaaS solution** with a user-friendly graphic interface that eases scenario creation and facilitate collaboration
- **Quetzal** is an open-source Python library allowing design of light and flexible models / data processing tools
- Combining ItSim and Quetzal results in an **easy-to-use and complete application**, encompassing supply, KPIs, demand, accessibility
- Open-source environments allow creation and delivery of tailored though affordable tools matching specific needs

**Thank you!**

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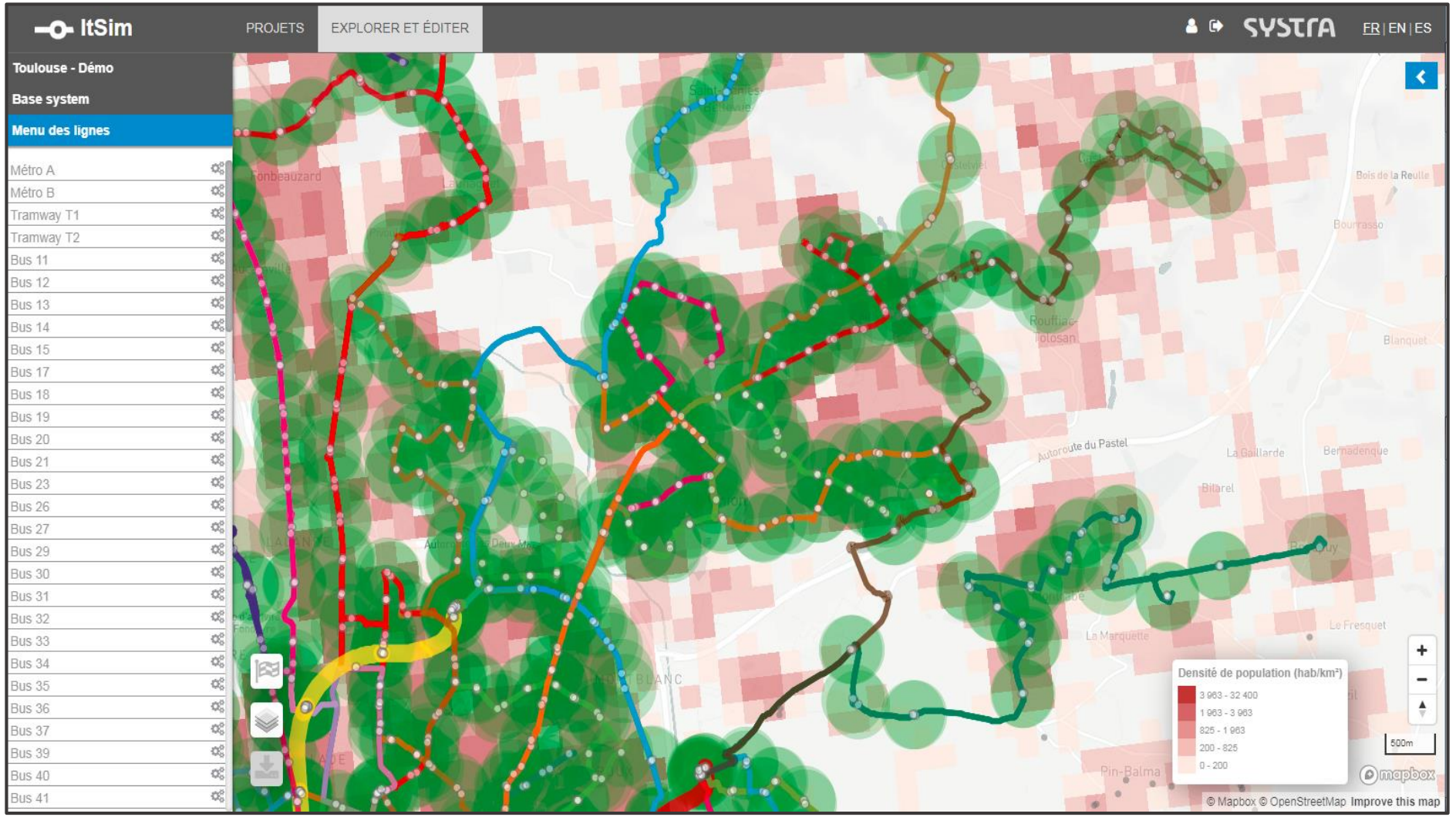
# Appendix

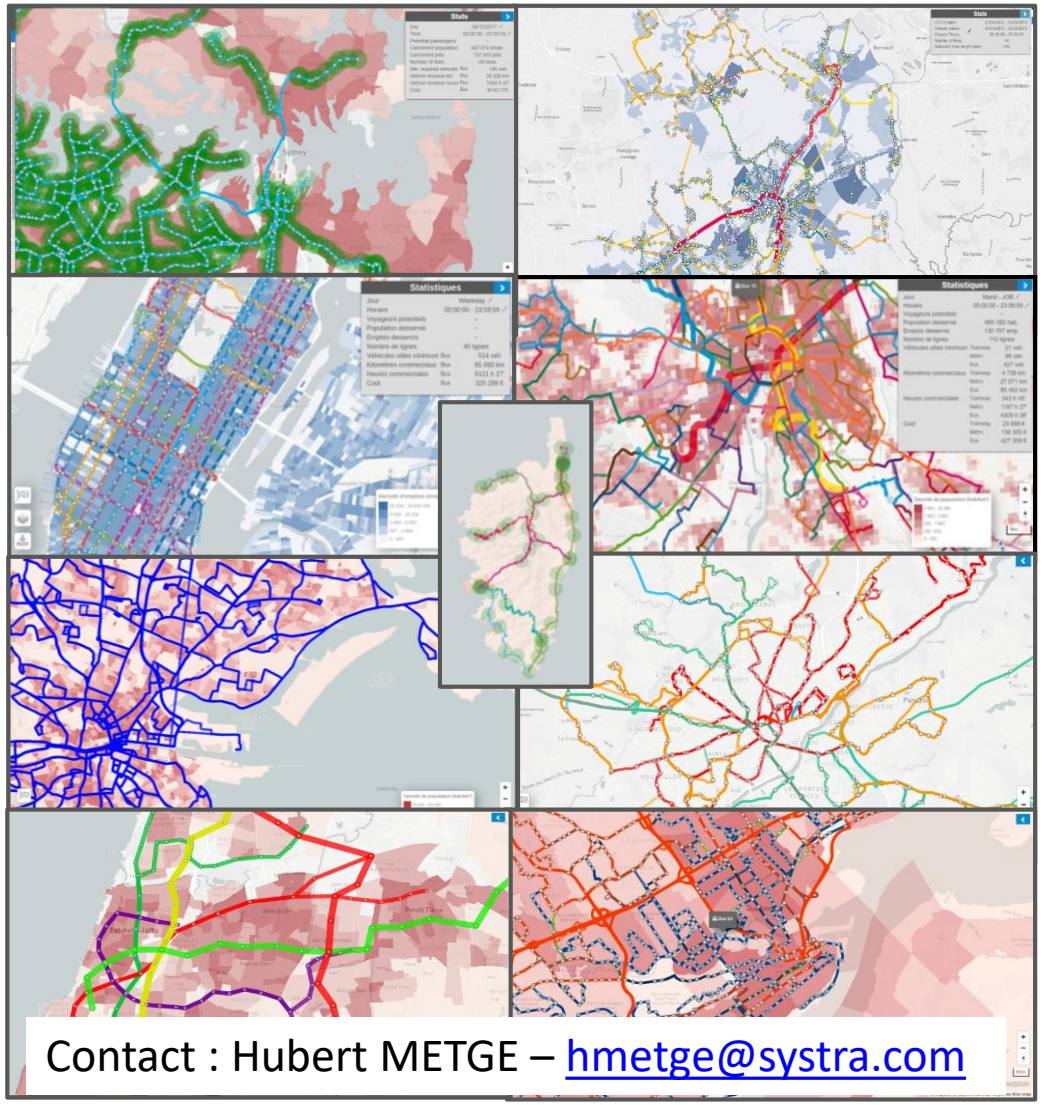

ItSim
PROJETS
EXPLORER ET ÉDITER
SYSTRA
FR | EN | ES
Toulouse - Démo
Base system
Menu des lignes
Métro A
Métro B
Tramway T1
Tramway T2
Bus 11
Bus 12
Bus 13
Bus 14
Bus 15
Bus 17
Bus 18
Bus 19
Bus 20
Bus 21
Bus 23
Bus 26
Bus 27
Bus 29
Bus 30
Bus 31
Bus 32
Bus 33
Bus 34
Bus 35
Bus 36
Bus 37
Bus 39
Bus 40
Bus 41
Densité de population (hab/km²)
3 963 - 32 400
1 963 - 3 963
825 - 1 963
200 - 825
0 - 200
500m
mapbox
© Mapbox © OpenStreetMap Improve this map

# ITSIM: a PT network planning and restructuring tool

***Presentation*** *Choice* *Use cases*

## Key Functionalities

1. **Operating characteristics per line or sub mode of transport**
   - Veh-km, driving time and speed
   - Operating costs
   - Required Fleet
2. **Service level and accessibility quality**
   - Of selected trips generators (population, jobs, ..)
   - Travel time per origin-destination
3. **Creation and evaluation of transit scenarios**
   - Creation or deletion of lines and stop and selection of transport mode
   - Modification of itineraries, headway, section speed, stop duration, radius of influence around station, ..
   - Itineraries stick automatically to the existing road network or option to create new road
4. **Import and Export**
   - Import of GTFS files and export scenario in GTFS files
   - Import GIS Layers (zone or point format)
   - Use of GSM, google map and other map backgrounfs

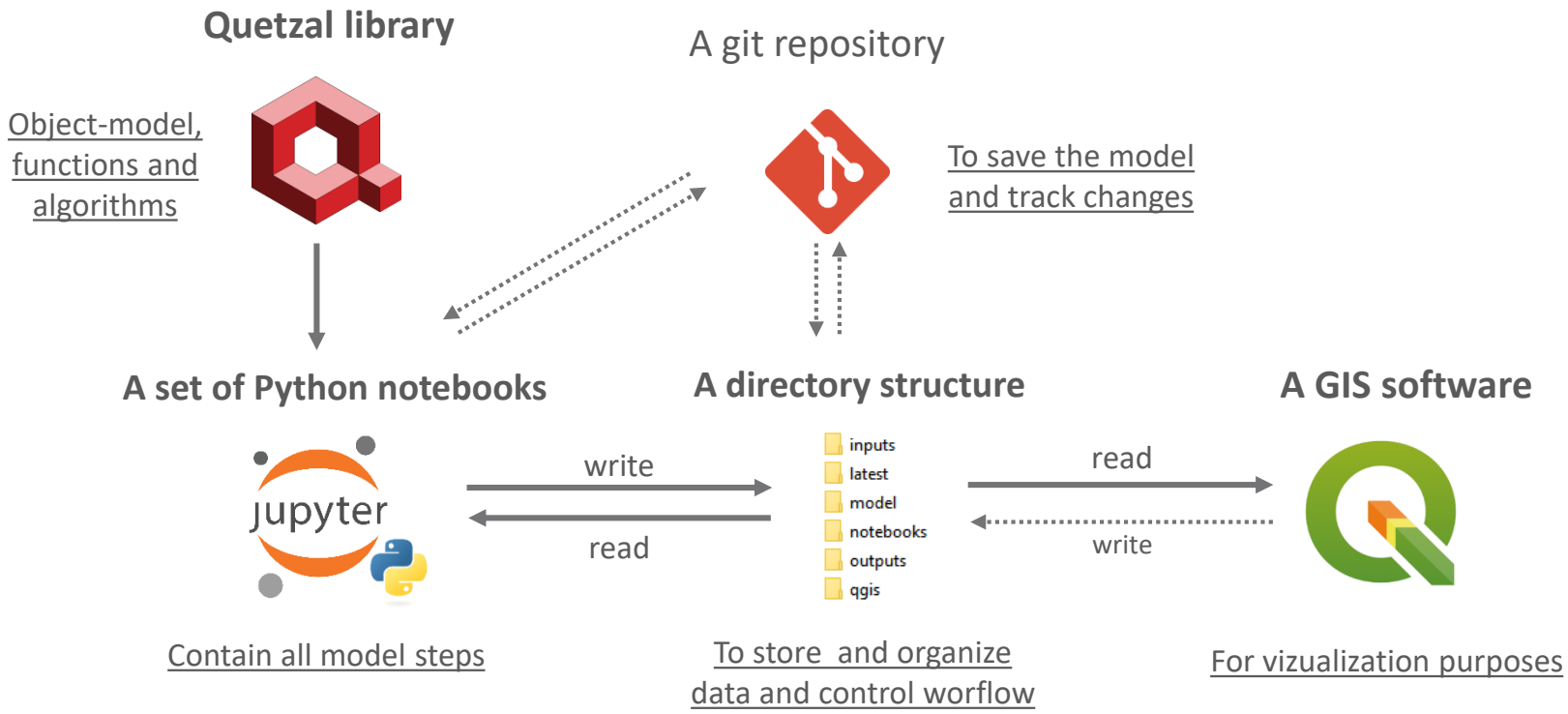


Contact : Hubert METGE – hmetge@systra.com

# QUETZAL: an open-source library for modeling



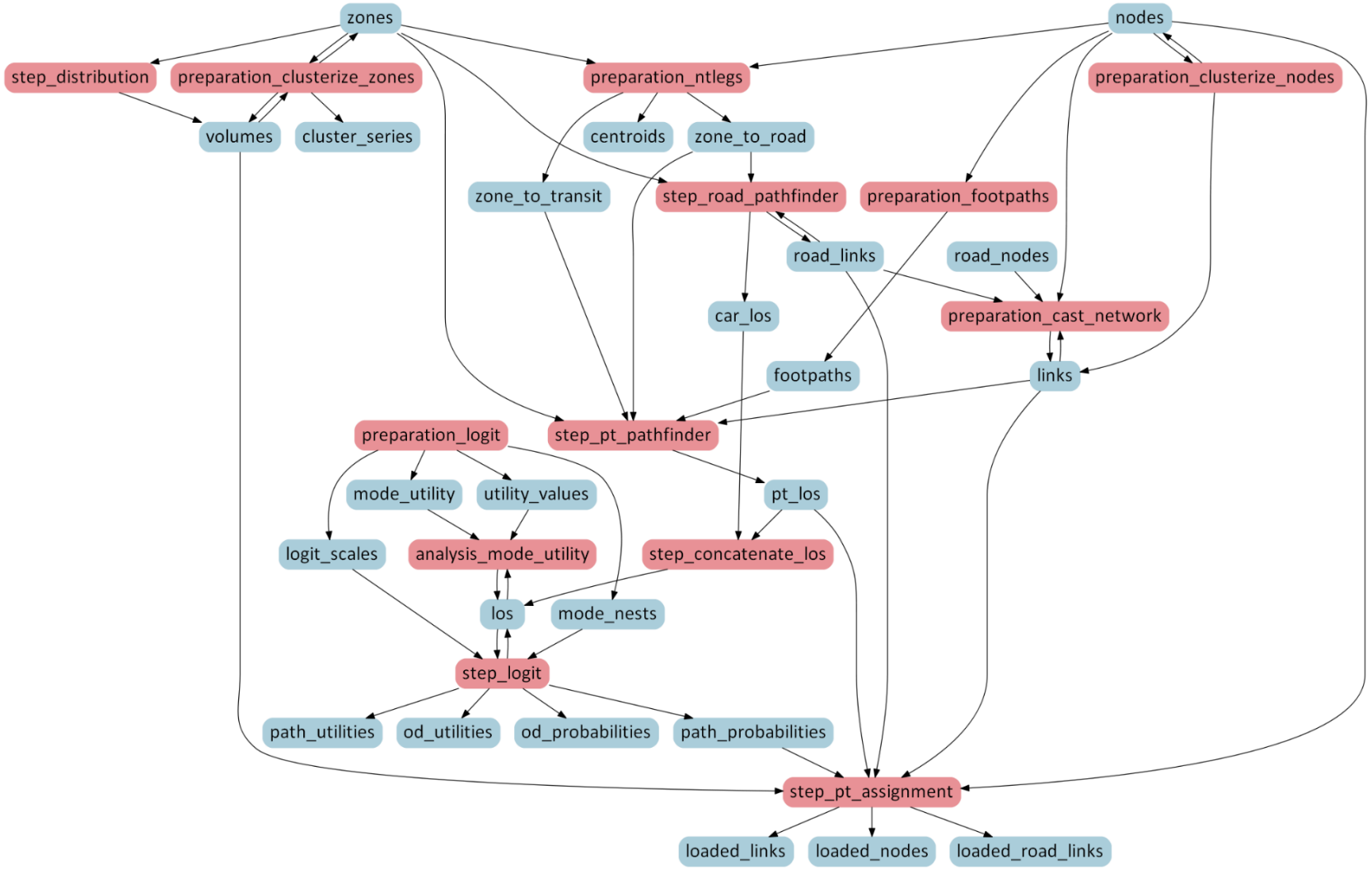
## An open ecosystem along with Python, Jupyter, Git and Qgis




- Documentation : https://systragroup.github.io/quetzal
- Sources : https://github.com/systragroup/quetzal

# QUETZAL: an open-source library for modeling

***Presentation*** *Tailor-made solution* *Use cases*



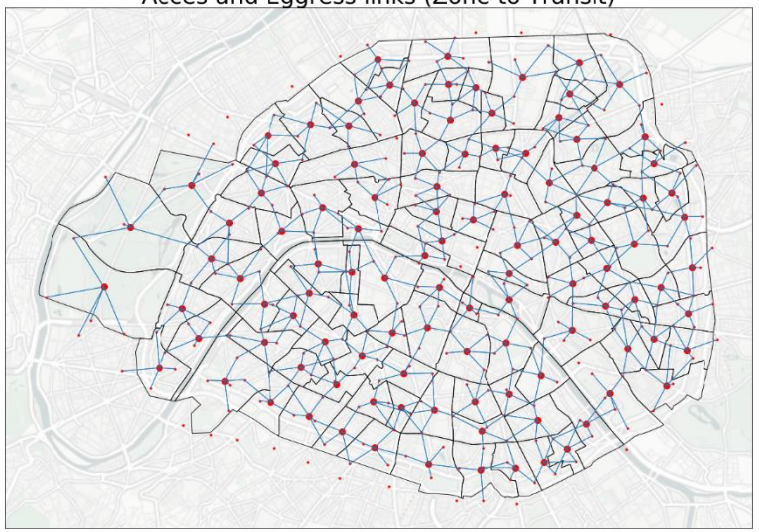
# **QUETZAL**: an open-source library for modeling

***Presentation*** *Tailor-made solution* *Use cases*

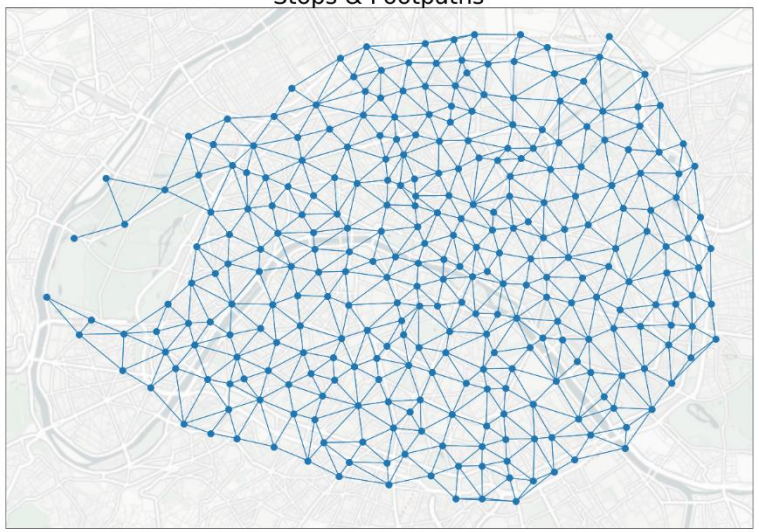
# QUETZAL: an open-source library for modeling

***Presentation*** *Tailor-made solution* *Use cases*

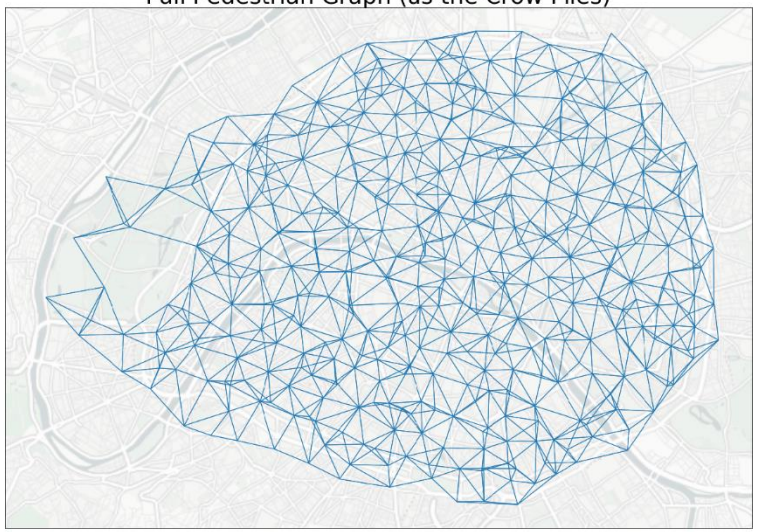
Acces and Eggress links (Zone to Transit)



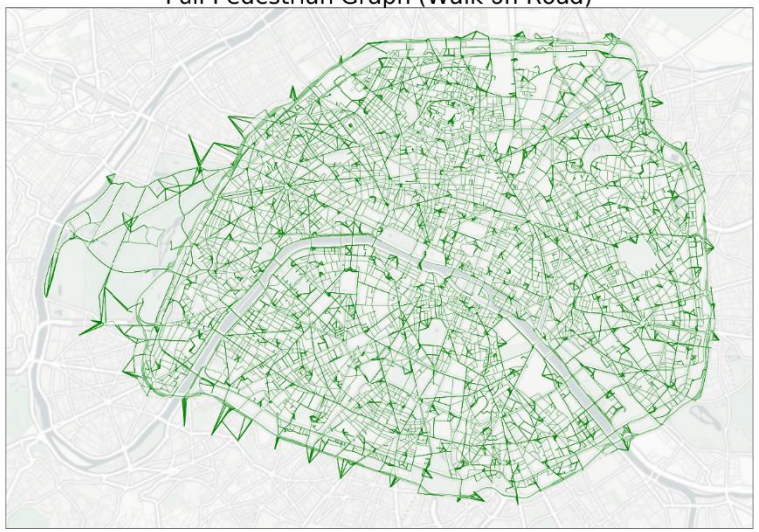
Stops & Footpaths



Full Pedestrian Graph (as the Crow Flies)



Full Pedestrian Graph (Walk on Road)



# QUETZAL: an open-source library for modeling

***Presentation*** *Tailor-made solution* *Use cases*