2020 CIVITAS
Cleaner and better transport in cities
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Integrating mobility data sources

An example for the city of Turin

SUITS Conference

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Coventry Transport Museum, Coventry UK

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European Platform on Sustainable Urban Mobility Plans

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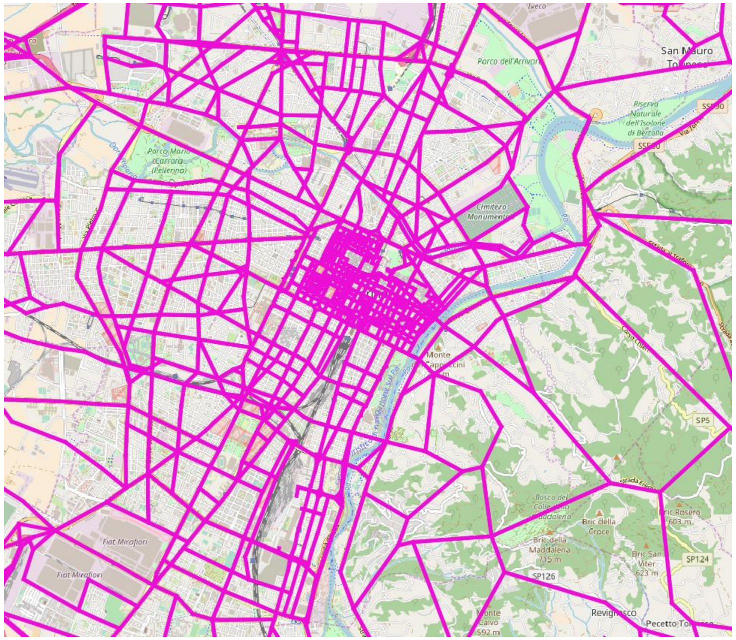
Field of analysis and background motivations

- Identification of a policy-relevant KPI: **average time lost in congestion**
- This is the key to study hot issues (energy efficiency, emissions of pollutants, greenhouse gases and noise, health…)
- **Goal**: measure of the way in which congestion selectively affects different traffic streams / user groups
- **Need** of a highly disaggregated KPI measure to achieve the above goal (each vehicle travelling on each arc)
- **Integration** of different data sources: infrastructure-based (traffic flows) + GPS traces of fleets
- **Feedback from cities**: focus on **light duty vehicles** according to the specific service points that need to be reached in the city and of the time of the day / day of the week

1st Dataset - Torino

data provided by 5T

- 1st dataset: traffic flows on the city network
  - 5,980 arcs (roads) of Turin and its surroundings
  - Average vehicles flow (veh/h)
  - Travel time on the arc (sec)
  - Data collected in May 2017



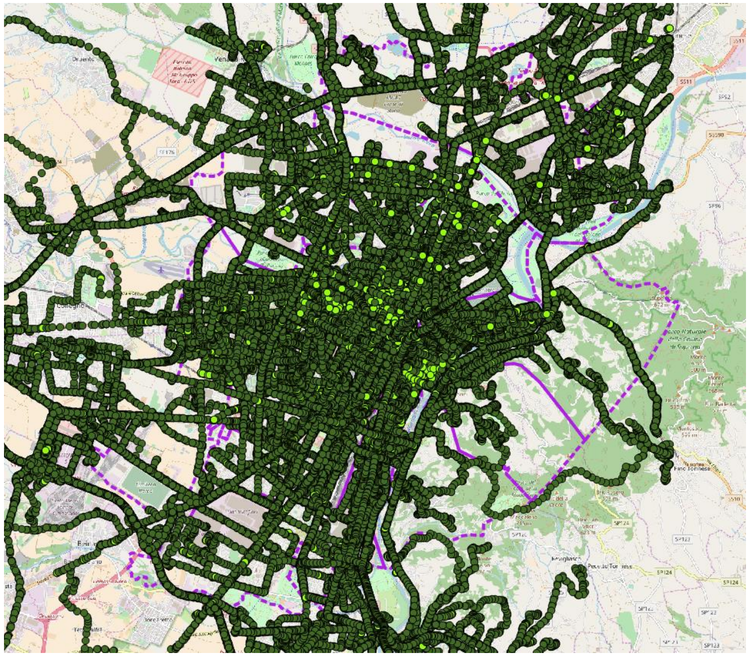
- highly disaggregated information

- partition heavy/light missing
- mix of measured + modeled data

2nd dataset - Torino

data provided by 5T

- 2nd dataset: GPS traces of logistics vehicles fleet
  - Positions recorded in a month period (29/04/2017-29/05/2017)
  - 28 vehicles (vans)
  - Data available: position (lat, lon), time of acquisition, average speed, course



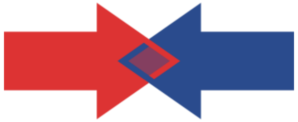
- frequent routes
- vehicle side information (not infrastructure)

- small sample size
- discontinuity of acquisition
- need for heavy data post processing

Methodology

Integration of 1^{st} and 2^{nd} dataset to compute specific KPI defined in Task 3.1:
"Average time lost per vehicle-km"

1. Spatial **join** of GPS positions and network arcs



2. Travel **time** computation from GPS traces

3. Identification and analysis of **service stops**

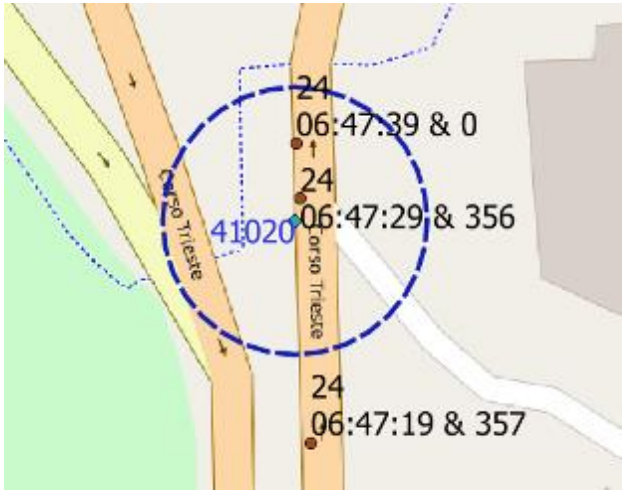
4. Evaluation of the directional **free-flow** travel time

5. Calculation of **KPI**

Spatial join of GPS positions and network arcs

- Flow dataset reported in **hour range** (i.e. 6:00-6:59 AM), so GPS positions are **grouped** according to the hour of their registration
- Analysis restricted to the **working days** in the week (namely from Monday to Friday)
- Focus on **each vehicle** of the fleet and in each day separately
- GPS positions have to be **assigned** to the different arcs of the network!
- Search for GPS positions in the **surrounding** of the **nodes** at the extreme of the arcs

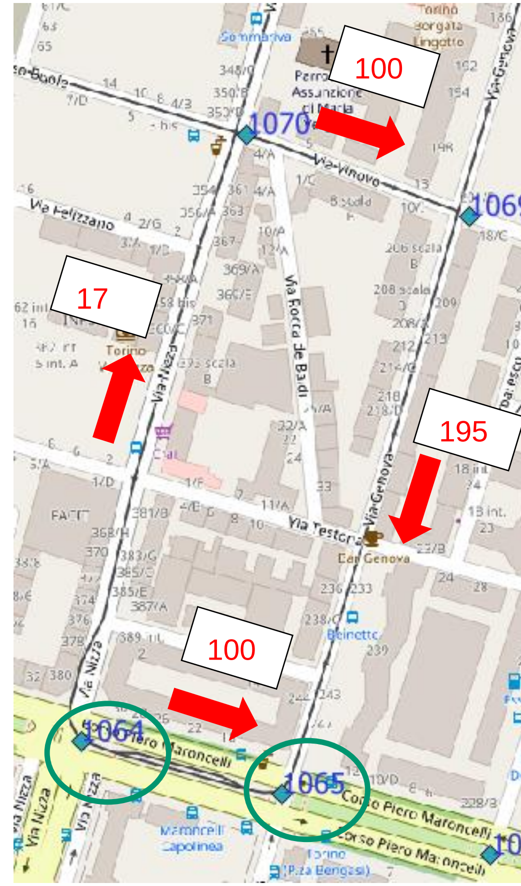
<u>Example</u>:
Arc 393-41020
Vehicle 24
Hour range: 6:00-6:59AM UTC



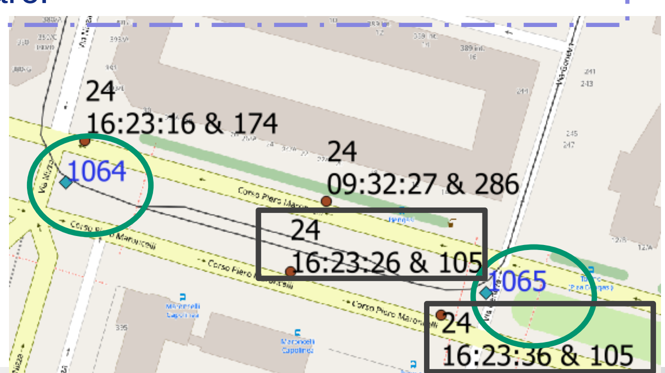
Spatial join of GPS positions and network arcs

Important **check**: the vehicle has **effectively** travelled along the arc in its travel between two nodes?

- Compare the value of the **course** for all the positions registered in the path connecting the two nodes and the **bearing** (direction) of the arc



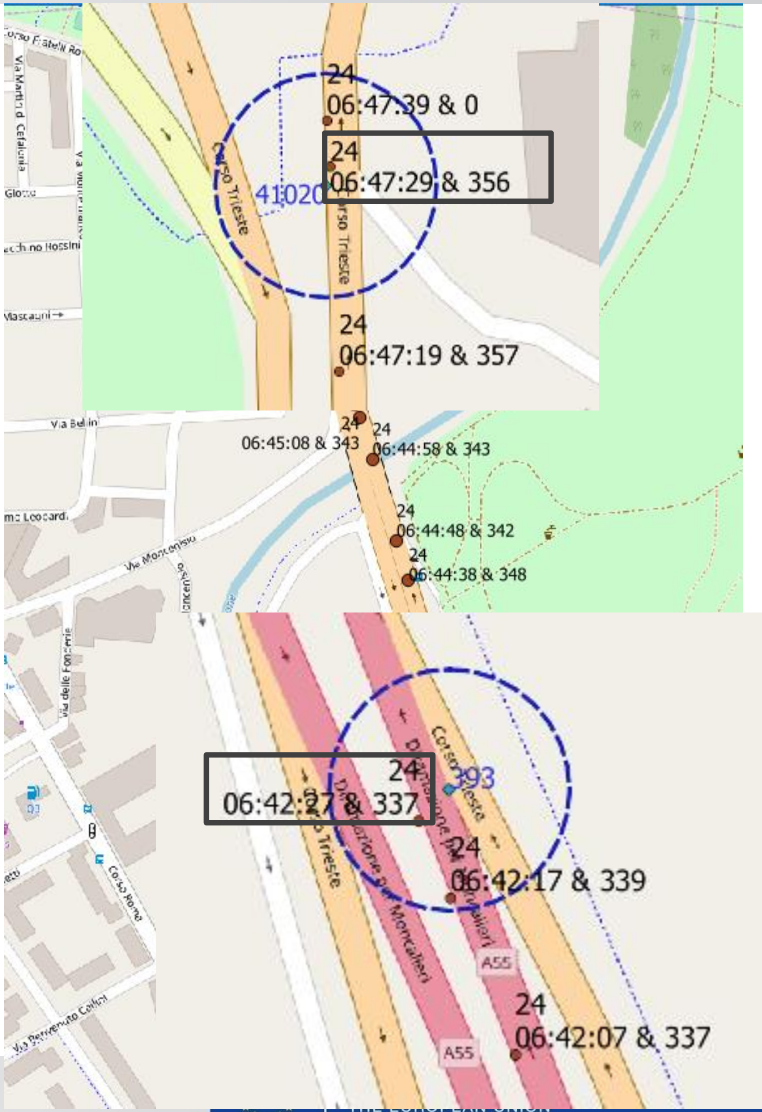
Example:
Arc 1064-1065 [bearing ~ 100]
The vehicle could have travelled through nodes 1070 & 1069, so arcs travelled would be 1064-1070 [bearing ~ 17] + 1070-1069 [bearing ~ 100] + 1069-1065 [bearing ~ 195]
Check the course of all the positions for vehicle 24 between nodes 1064 & 1065: 105
Vehicle 24 has travelled along the arc!



Travel time computation from GPS traces

Computation of the **time** $T\_GPS_{j,k}$ the vehicle *k* took to travel along the arc *j* in a certain hour range

- select the **last measurement** registered in the boundary around the origin node and the **first measure** registered in the boundary around the end node



<u>Example</u>:
Arc 393-41020
Vehicle 24
Hour range: 6:00-6:59AM UTC
Last measurement in node 393: 06:42:27 AM UTC
First measurement in node 41020: 06:47:27 AM UTC
T_GPS: 302 seconds (5 minutes and 2 seconds)

Identification and analysis of service stops

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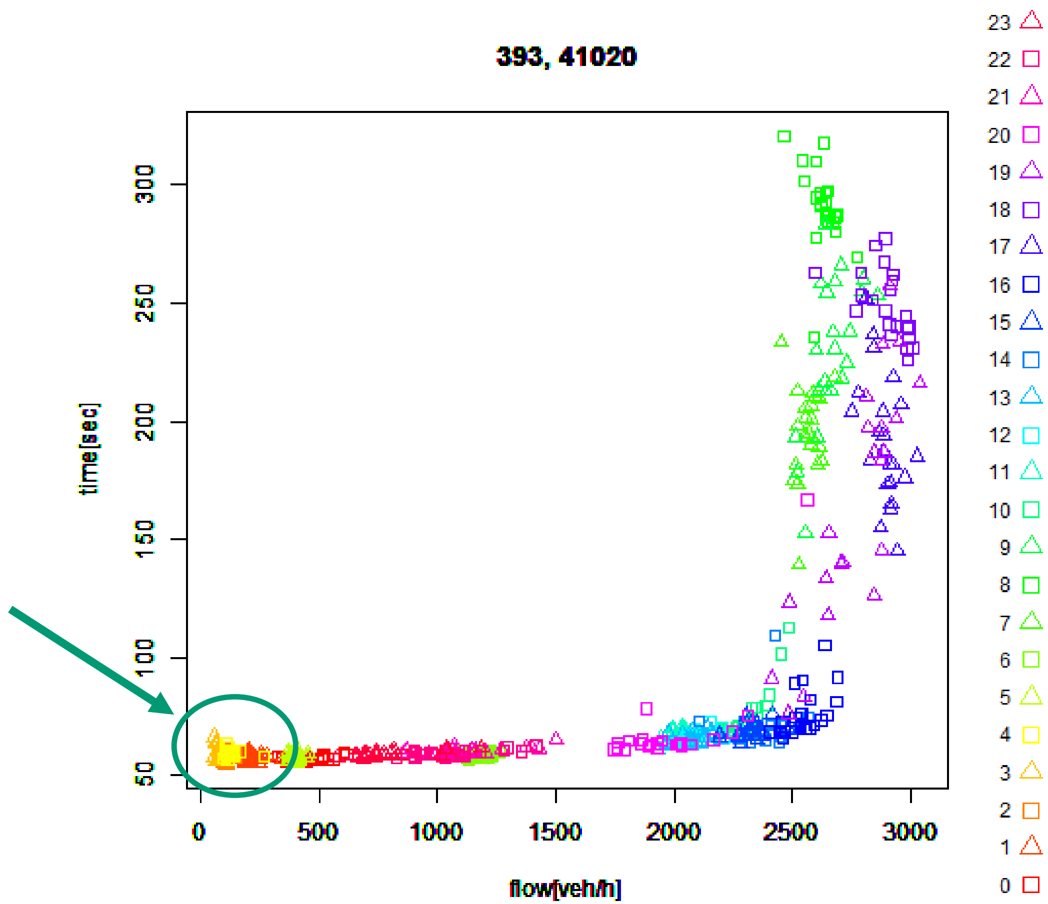
- It is important to analyse when the vehicle is **not moving** (due to reasons as deliveries, stops at crossings or traffic…) and the **duration** of these stops
- Calculation of "**net GPS travel time value**" = *T_GPS* (GPS travel time computed previously) - *T_GPS_s* (time associated to such stops)
- Different reasons and duration of **stops**:
  - ≤ 120 seconds (2 minutes) → due to normal traffic condition, yielding, red phase of traffic light → **NO contribution** to *T_GPS_s*
  - > 120 seconds (2 minutes) → due to deliveries and proper stops → **contribution** to *T_GPS_s*

deviceid	data	fixtime	speed
20	03/05/2017	08:06:32	3.556911
20	03/05/2017	08:06:42	0.000000
20	03/05/2017	08:06:52	0.000000
20	03/05/2017	08:07:02	0.000000
20	03/05/2017	08:07:12	0.000000
20	03/05/2017	08:07:23	0.000000
20	03/05/2017	08:07:33	0.000000
20	03/05/2017	08:07:43	1.016260
20	03/05/2017	08:07:53	7.621951
20	03/05/2017	08:08:03	23.373984
20	03/05/2017	08:08:12	0.000000
20	03/05/2017	08:08:32	0.000000
20	03/05/2017	08:10:00	0.000000
20	03/05/2017	08:10:09	0.000000
20	03/05/2017	08:10:19	0.000000
20	03/05/2017	08:10:29	3.048780

Example:
Vehicle 20
Hour range: 8:00-8:59AM UTC
Stop 1: 51 seconds → NO
Stop 2: 127 seconds → YES!

Evaluation of the directional free-flow travel time

- Information from Dataset1: relation between the **travel times** on arc (average time to travel along the corresponding road in a certain hour range) & **number of vehicles** that have travelled along the same arc in the same hour range
- Identification of "**free flow travel time**": measures referring to uncongested road conditions → *T_0*



Calculation of KPI

Indicator expressing the **level of congestion** experienced by the fleet of the logistic vehicles in their travelling around the city through every single arc of their path

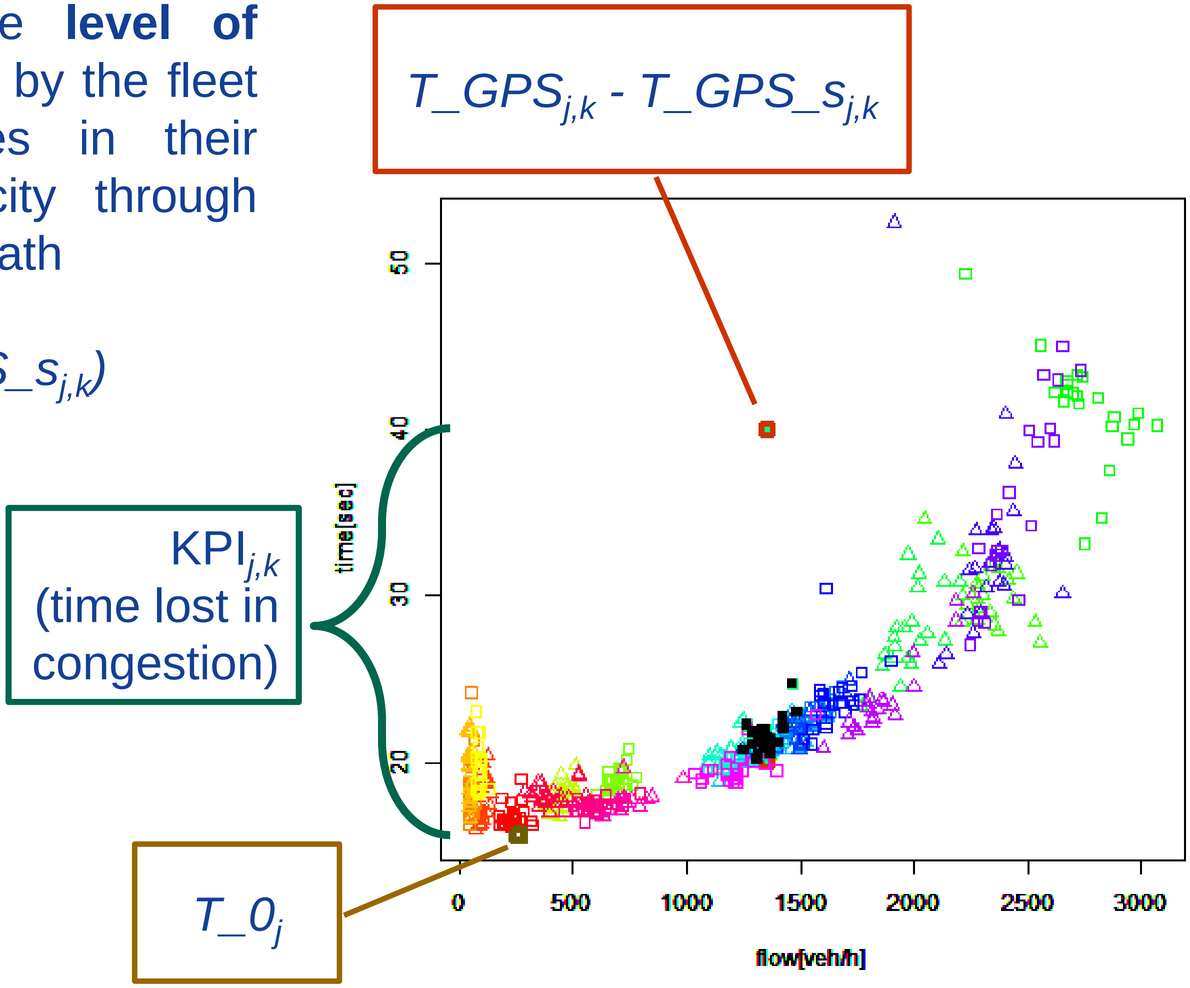
$KPI_{j,k}$ =

$T\_0_j - (T\_GPS_{j,k} - T\_GPS\_s_{j,k})$

T_0_j: free flow travel time

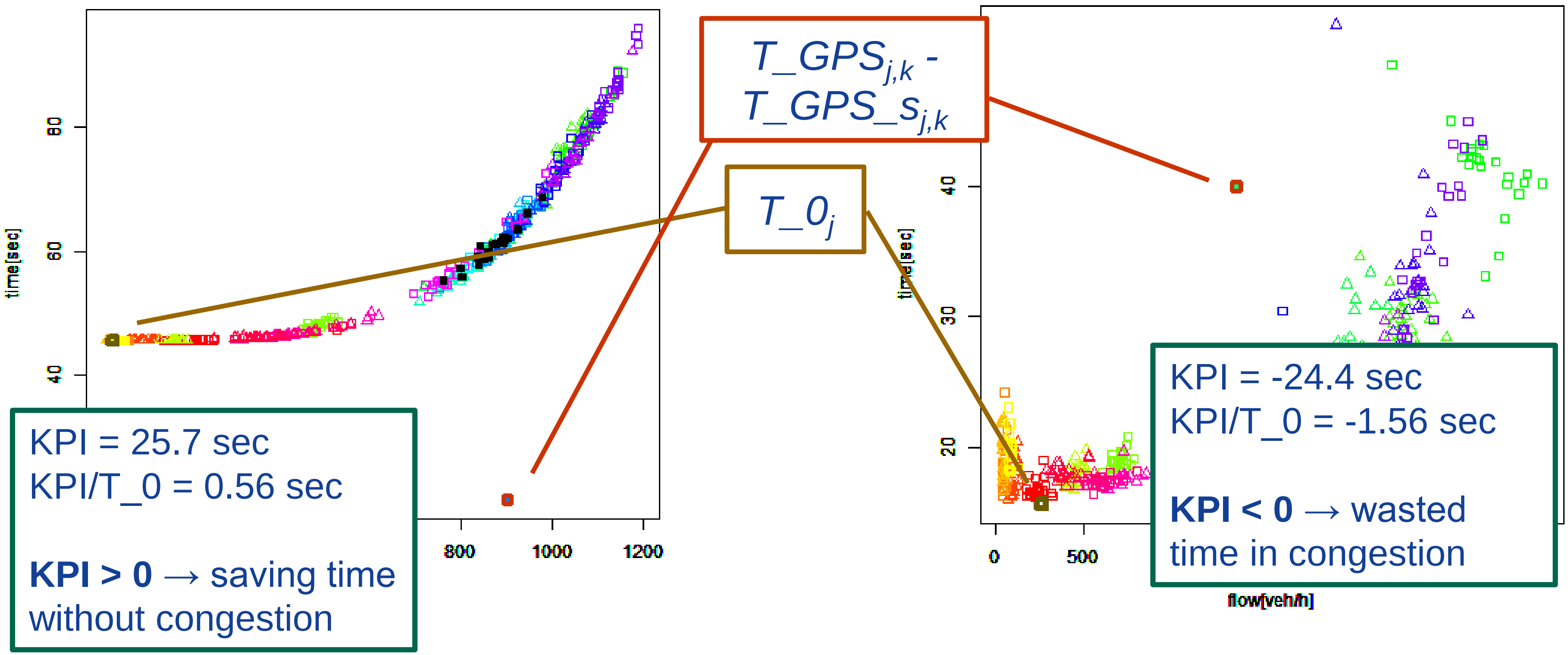
$T\_GPS_{j,k}$: time necessary for vehicle k to travel along arc j

$T\_GPS\_s_{j,k}$: stopping time (when more than 120 seconds) of vehicle k along arc j



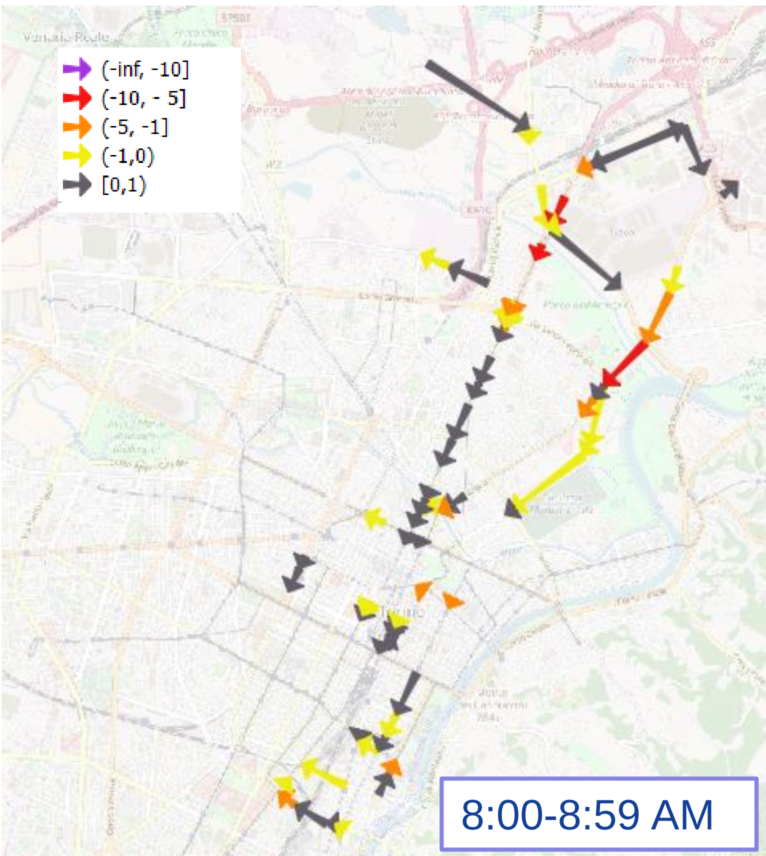
Calculation of KPI

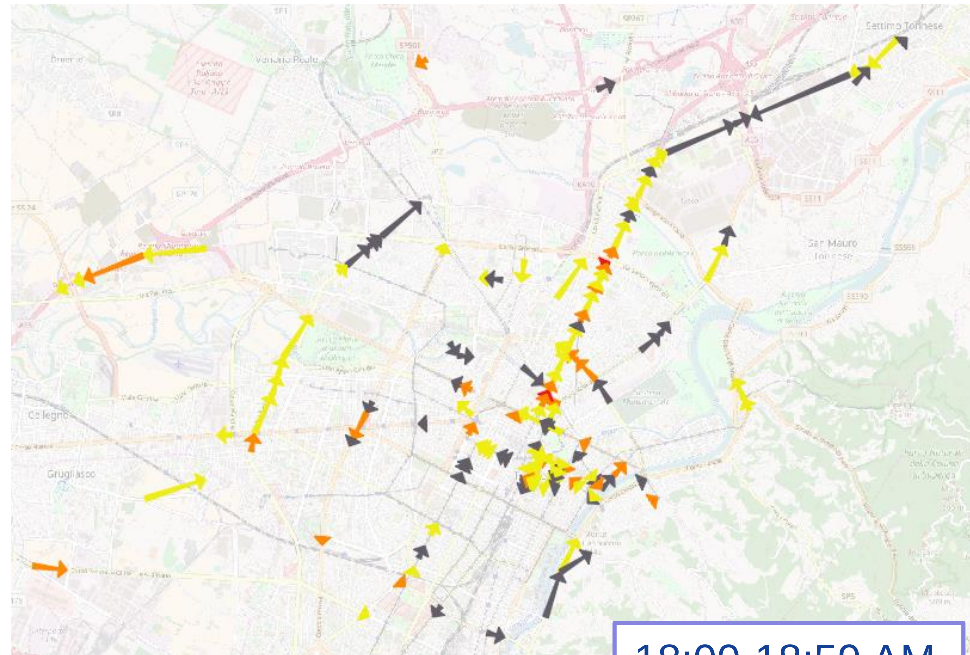
- A common scale is required to allow the **comparison** among different arcs
- **Ratio** of $KPI_{j,k}$ and T_0_j (specific characteristic of the arc) → final KPI **formulation**: $KPI_{j,k} = [T\_0_j - (T\_GPS_{j,k} - T\_GPS\_s_{j,k})] / T\_0_j$



Visualization of results

- Focus on the **whole network**: which is the **worst arc** for the fleet of vehicles (maximum time lost)?



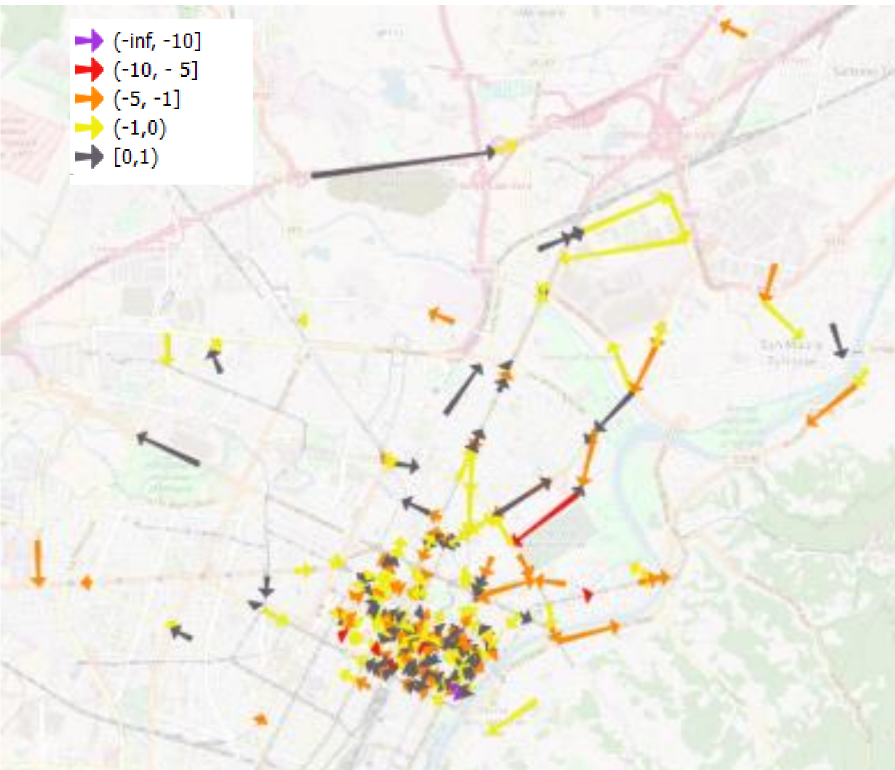


18:00-18:59 AM

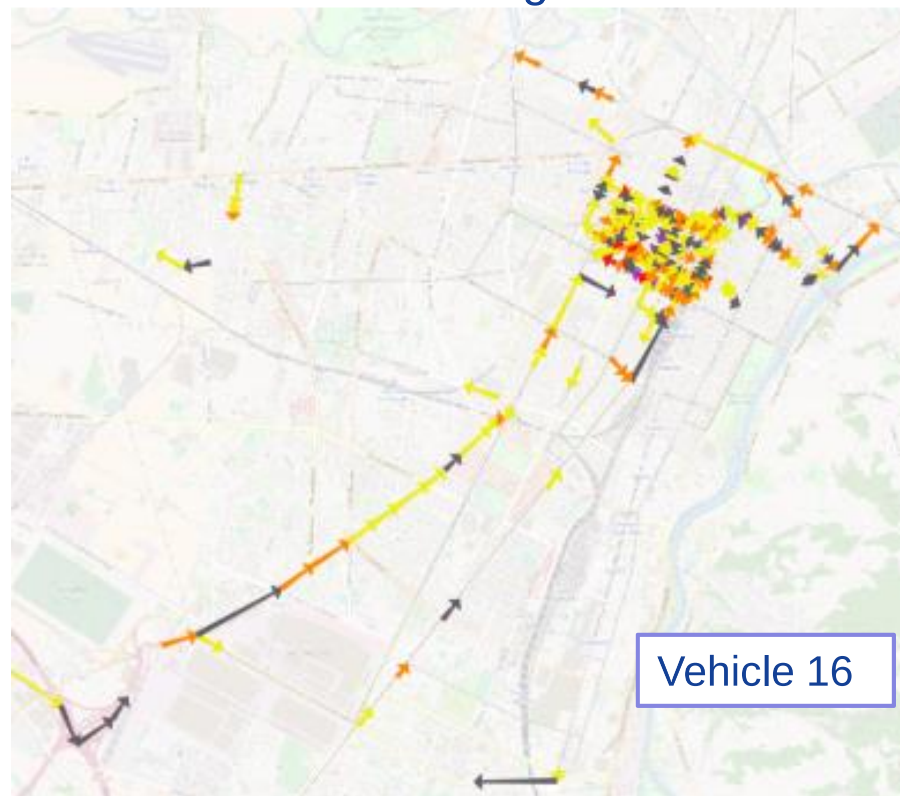
Maps show where the vehicles lose time due to congestion, with the most critical arcs identified in red and purple. Different direction during the day are found.

Visualization of results

- Focus on the vehicles of the **fleet**: which **vehicle** is loosing most time in congestion?



Vehicle 31



Vehicle 16

Maps show how the vehicles travelled in different part of the city and where the vehicles lose time due to congestion

Strengths of the method

- **Innovative** data integration method (no examples found so far in the scientific literature or in previous projects)
- Rather **flexible**: it can work also with different datasets according to local availability of data. The basic idea is to integrate traffic flows (e.g. from cell phones traces if no traffic counts are available) with GPS traces from fleets of vehicles
- Potentially useful inform a wide range of **policy actions**:
  - most critical arcs for given travel purposes (parcel services, commuting)
  - most congested areas in relation with specific user groups (if related metadata are associated with GPS traces)
  - most congested lines in a public transport network
- Insights relevant for **different stakeholders:** city administrations, transport services operators, social groups…

Thank you!

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