EPFL LUTS

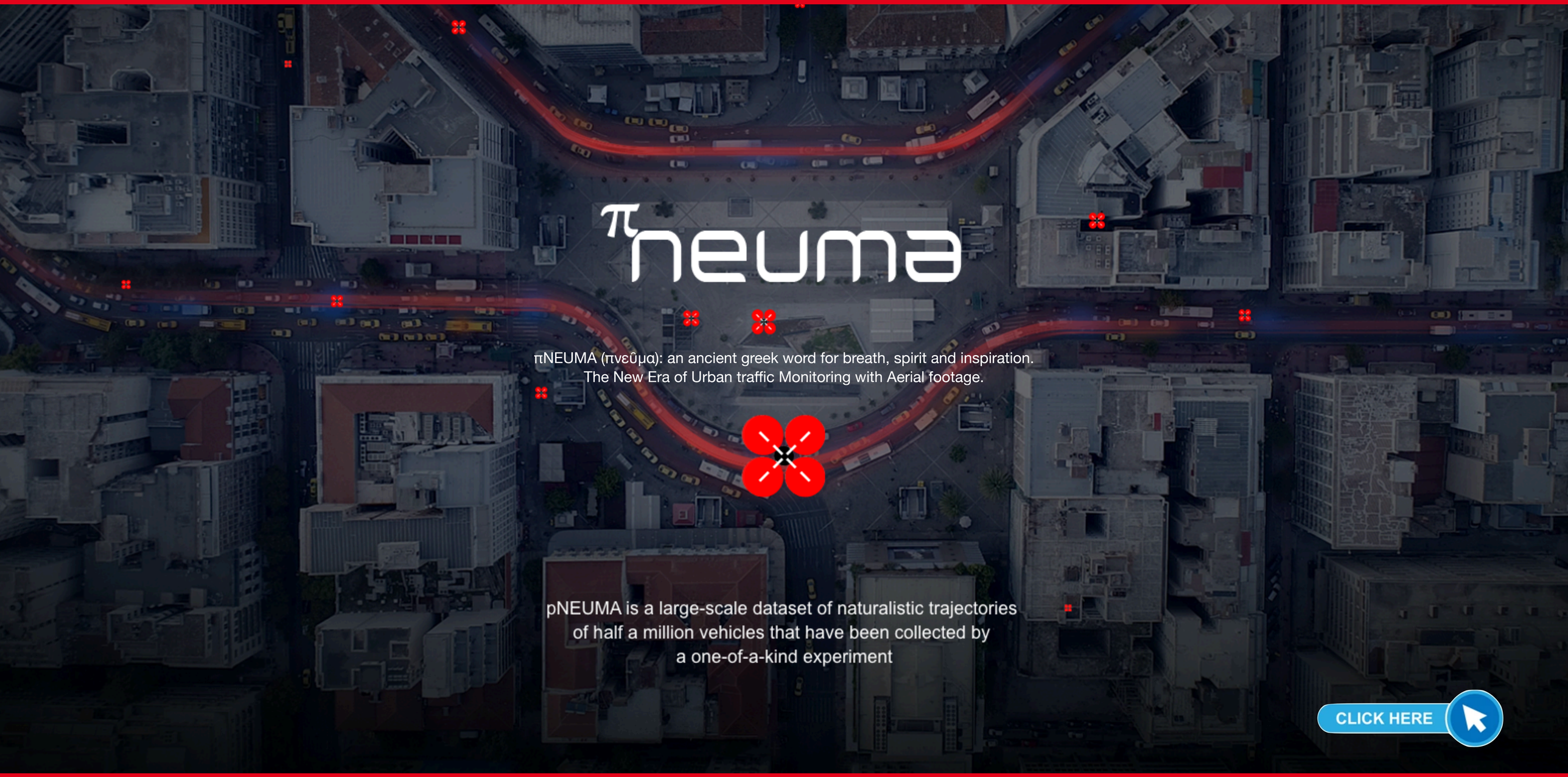
Traffic Monitoring with Drones

Nikolas Geroliminis

why do we use drones?

- Current monitoring methods have significant drawbacks
  - *reduced coverage*
  - *hidden points in video due to point-of-view*
- For monitoring large areas other methods are chosen *(Smartphones or GPS devices)*
  - *privacy concerns*
  - *reduced penetration in traffic*
  - *lack of naturalistic data*
- Drones' technical characteristic can overcome these limitations
  - *Existing experiments at very small scale (one-two intersections or minor roads)*
  - *Simulation studies - mainly path optimisation algorithms*

Pragmatizing an actual swarm of drones for massive data collection had not been conducted before


πneuma
πNEUMA (πνεῦμα): an ancient greek word for breath, spirit and inspiration.
The New Era of Urban traffic Monitoring with Aerial footage.
pNEUMA is a large-scale dataset of naturalistic trajectories
of half a million vehicles that have been collected by
a one-of-a-kind experiment
CLICK HERE

Designing the experiment

📍 Athens, Greece 🇬🇷

one of the most congested European cities
dense urban environment
queues, spillbacks
multimodal traffic

Morning Peak Hours [8:00 - 10:30]
5 days
10 drones
5 flights per day

10 km road network
Low | Medium | High Volume Arterials
More than 60 intersections (signalised or not)
30 bus stops

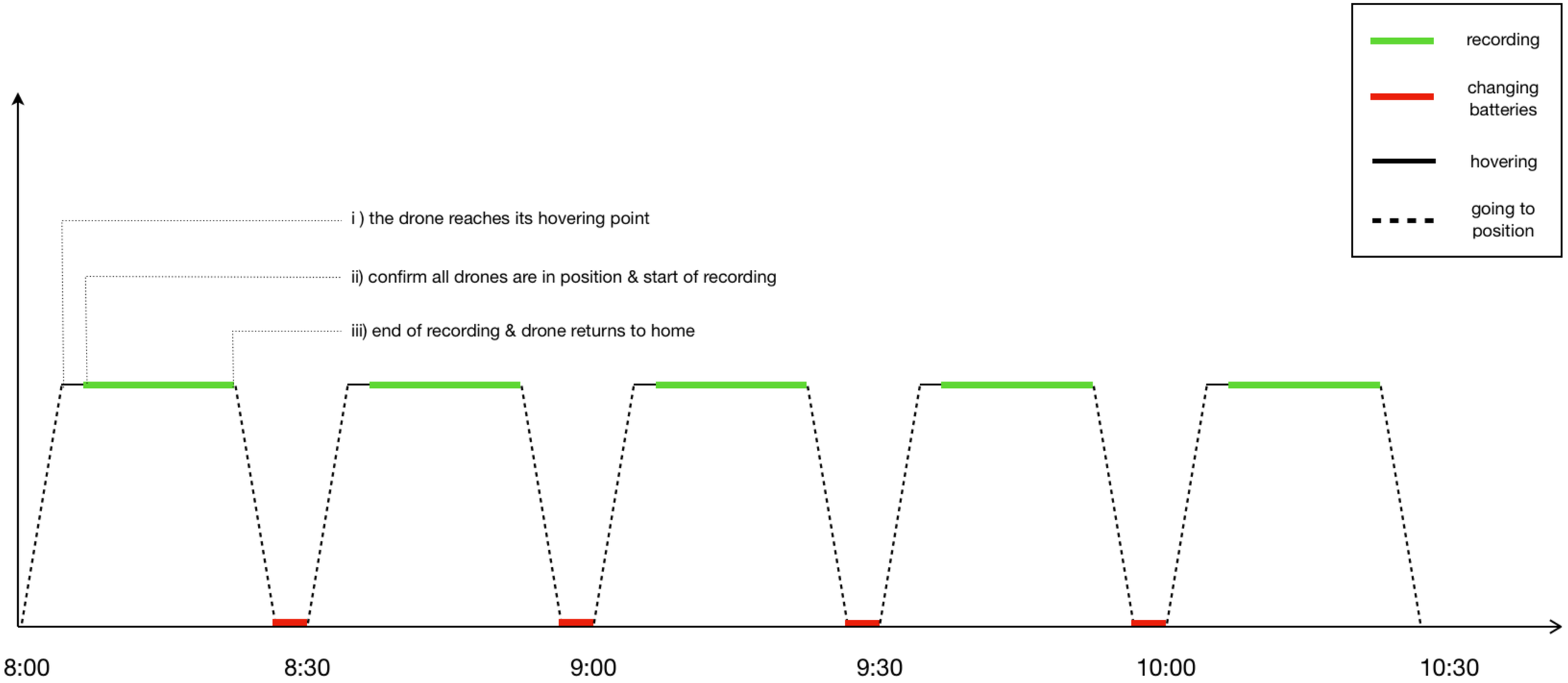
Over 500.000 trajectories!

Challenges

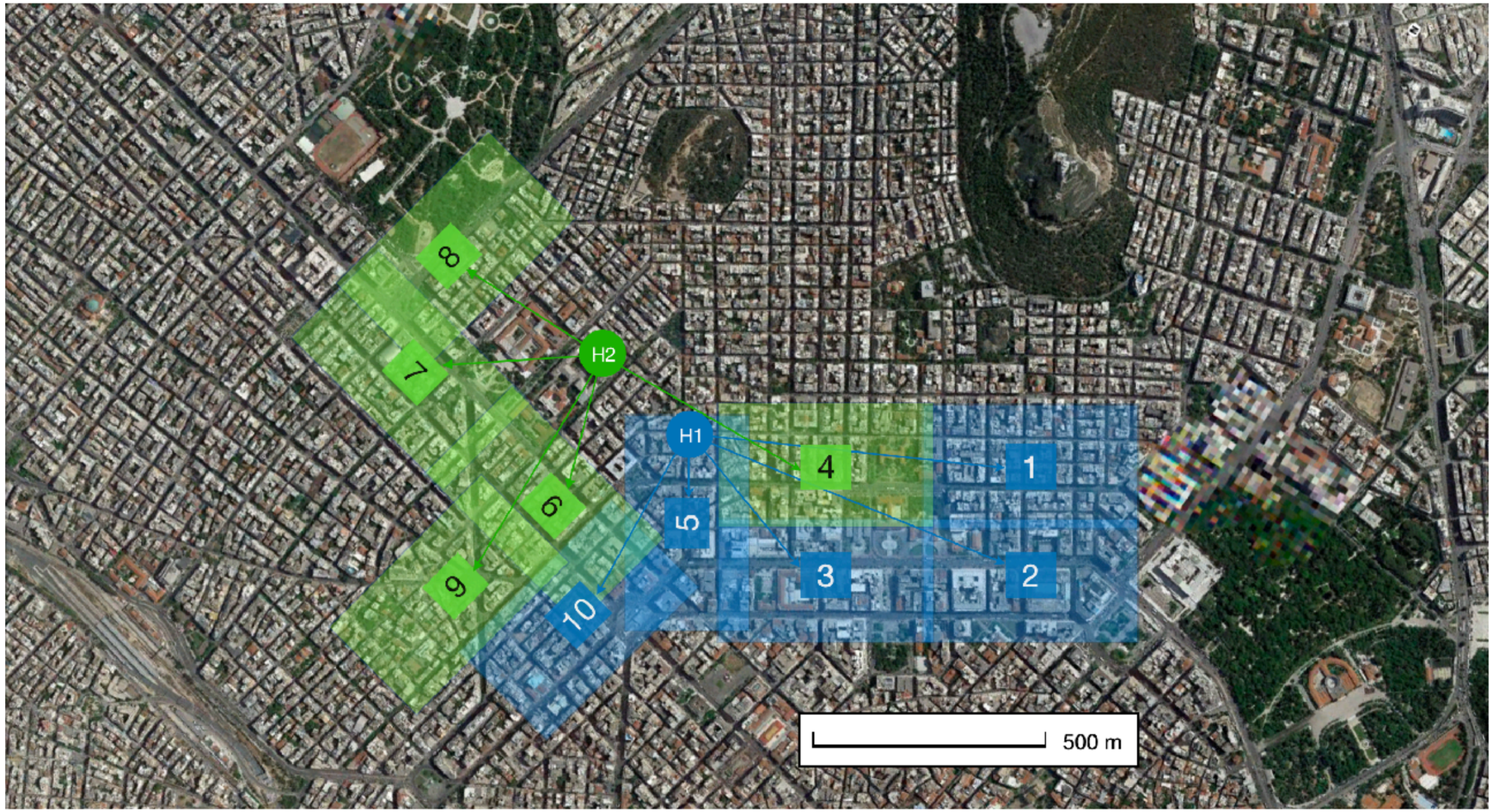
- Find & Commit 10 authorized pilots for 5 working days
    a. Understand requirements and tasks
- Find safe locations to use as take-off/landing areas
- Special authorization to fly 10 drones over the city centre
- Choose the best hovering points
    a. Test flight to scan the study area based on original flight plan
    b. Identify points where traffic is visible at the arterials of interest
    c. Swarm reaching the hovering point at the same time
    d. Not far from take-off/landing areas
    e. Connectivity Issues
- Synchronize recording
- Unpredictable factors
    a. Weather Conditions
    b. Strikes
    c. Drone failures

Challenges

Limited Drones' Flight Duration



The Flight Plan

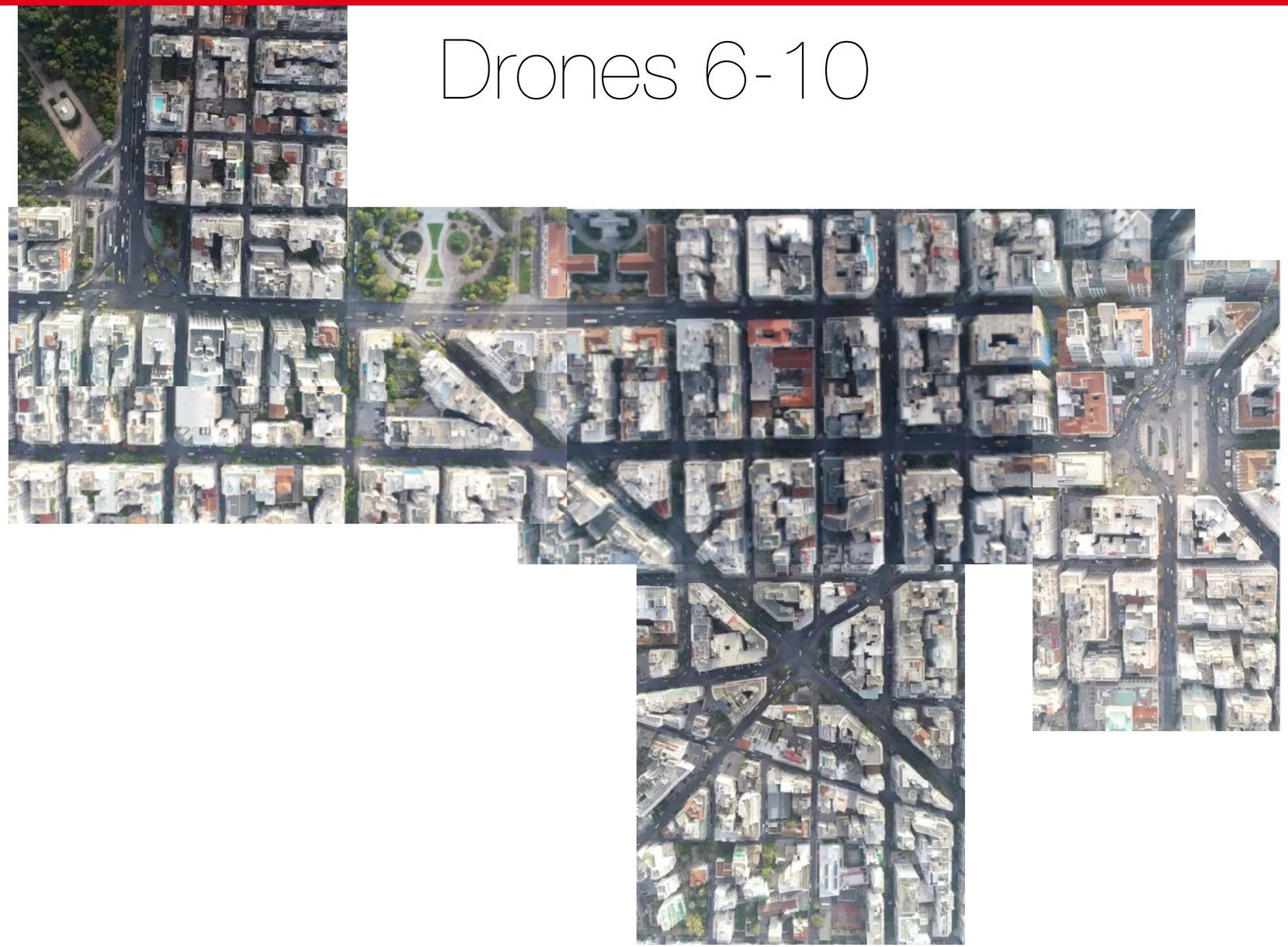


Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

Drone 10

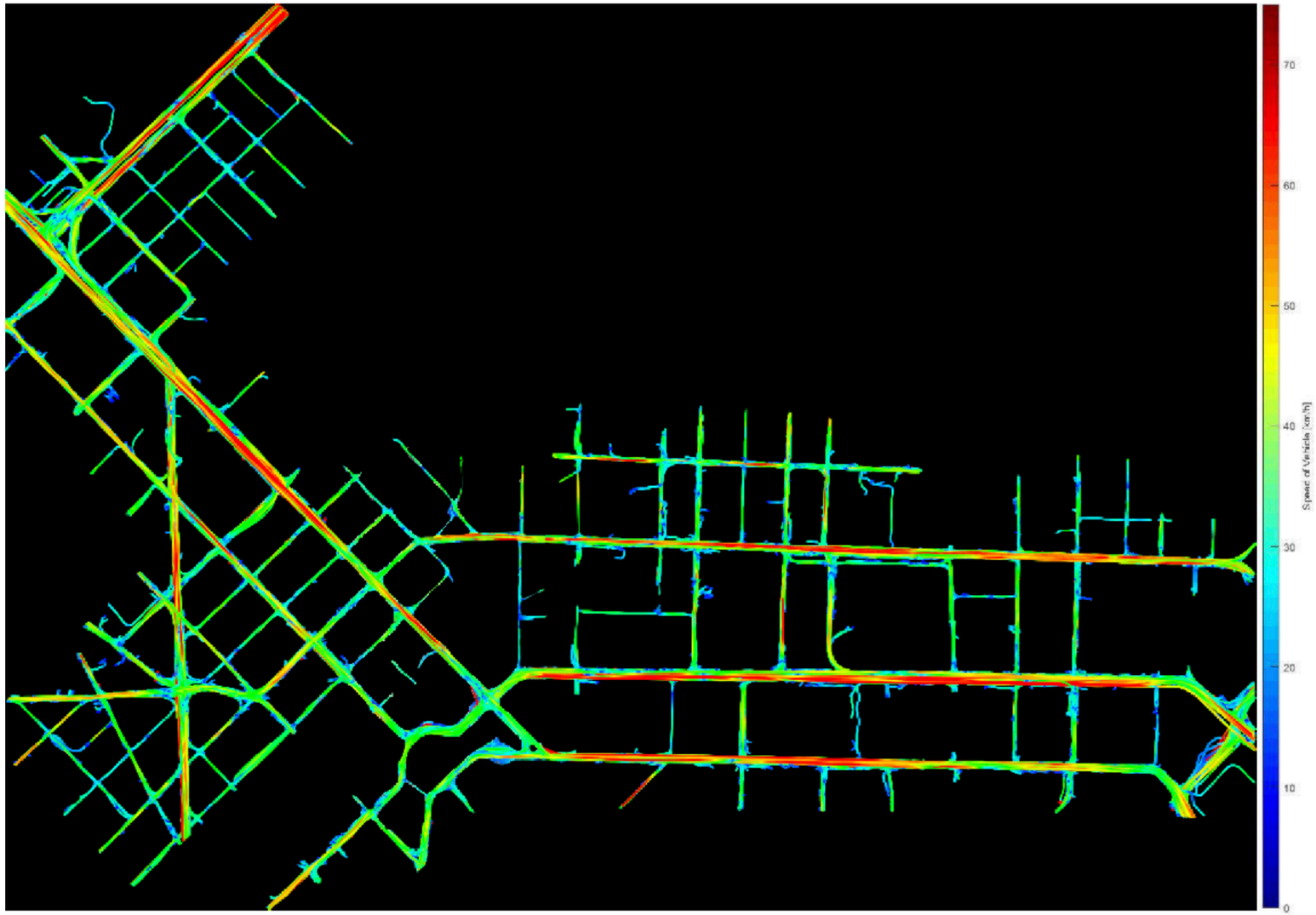
Drones 1-5

Drones 6-10



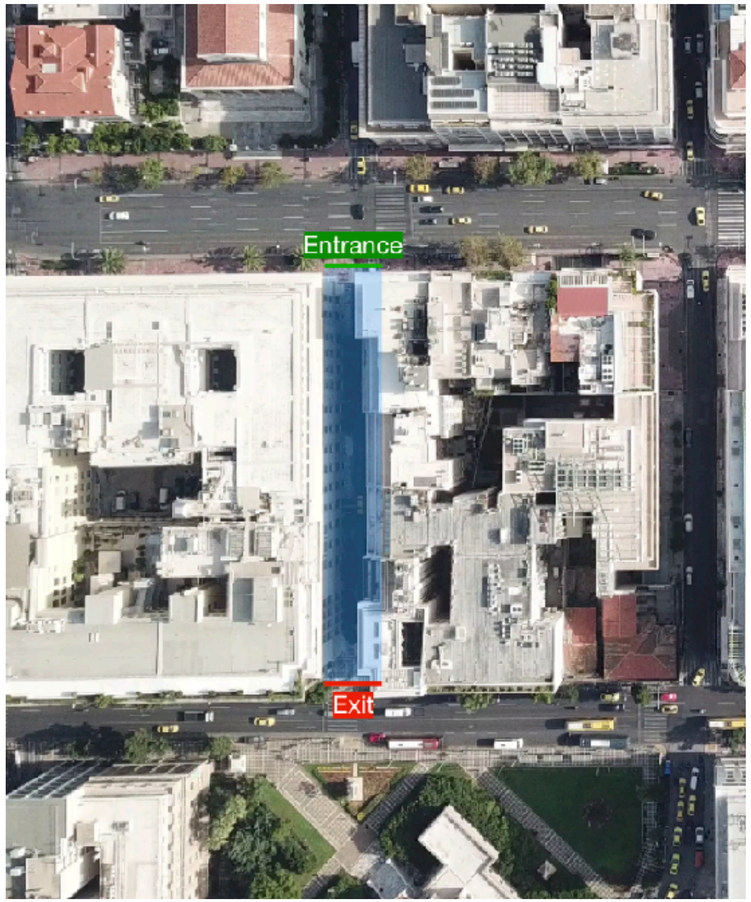
Vehicle Reidentification

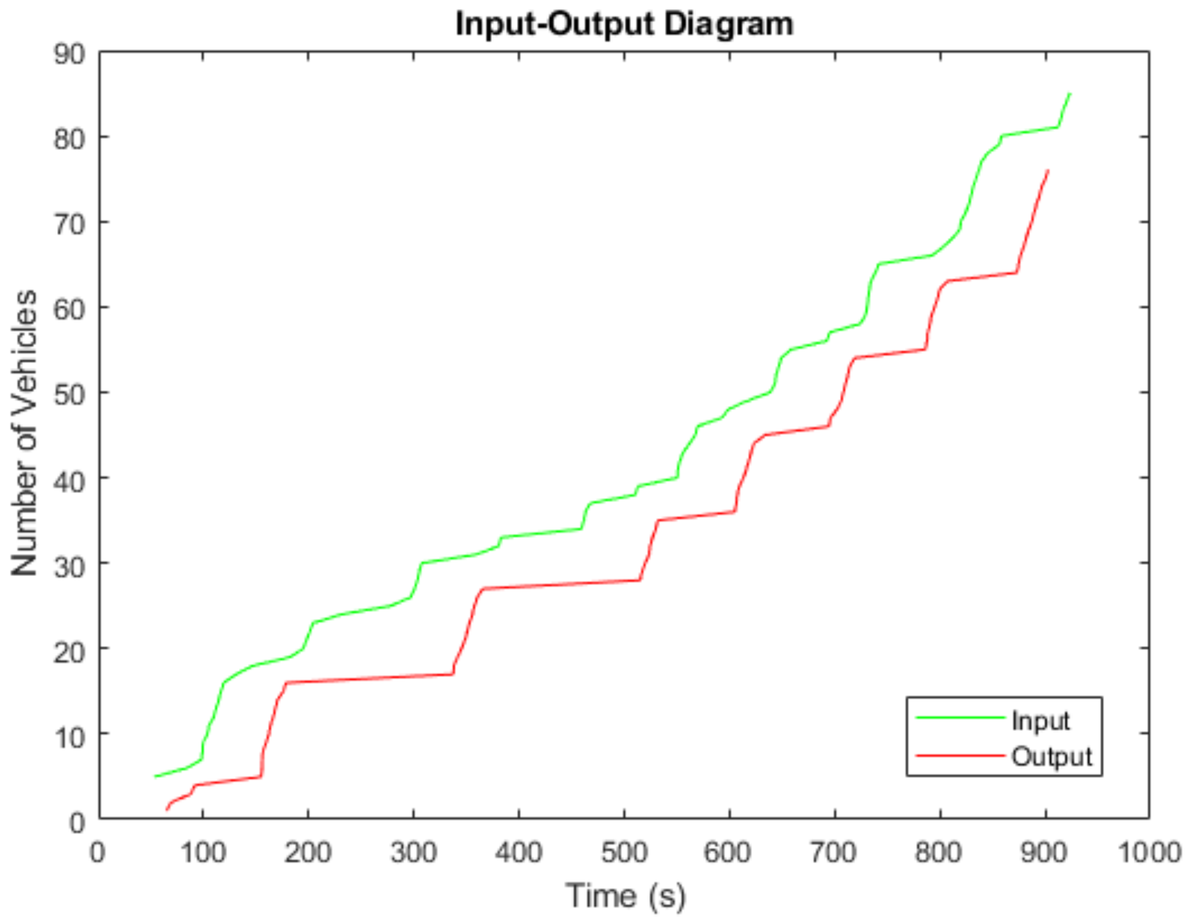
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.



Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

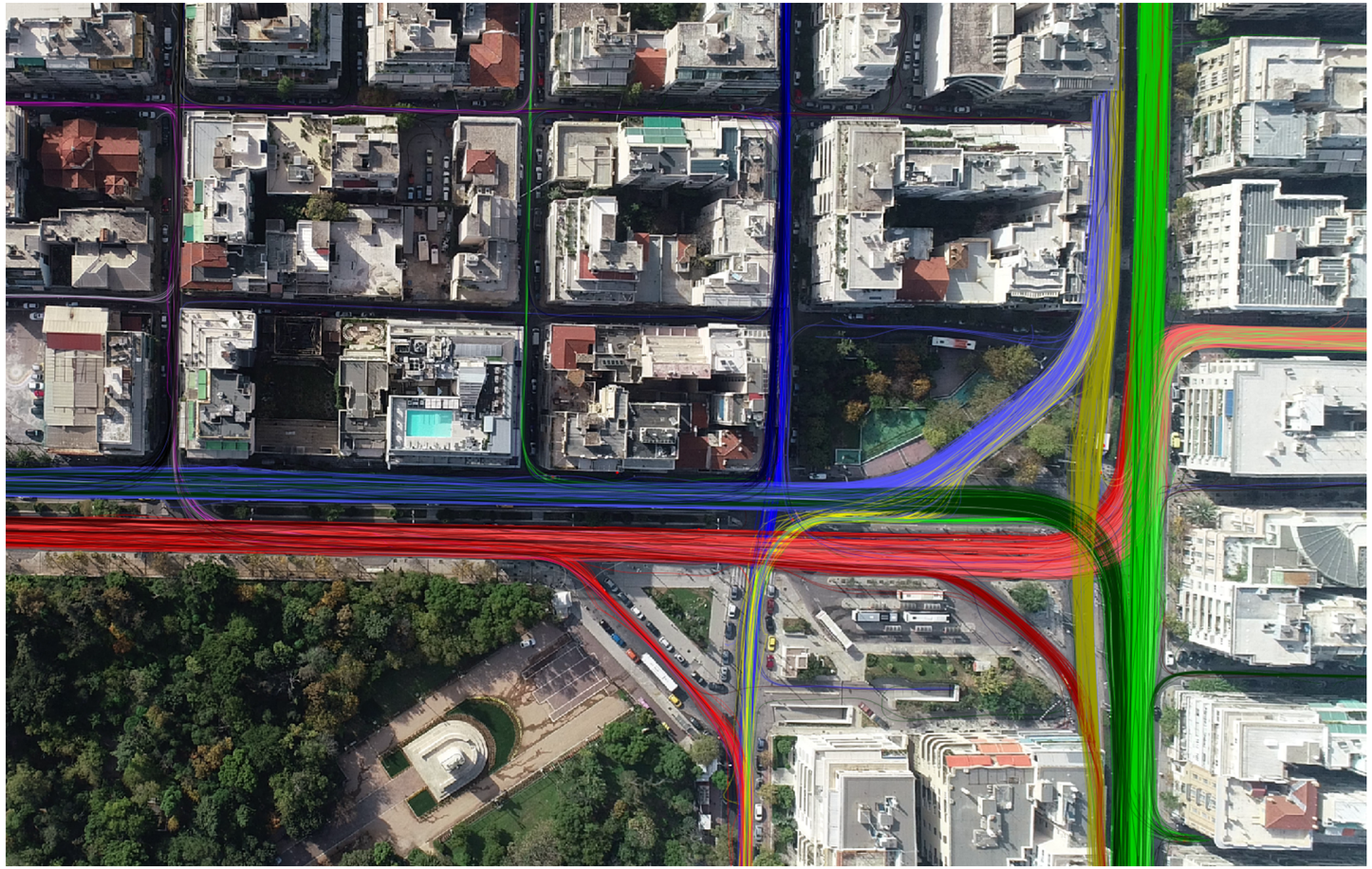
Minor Roads - I/O Diagrams





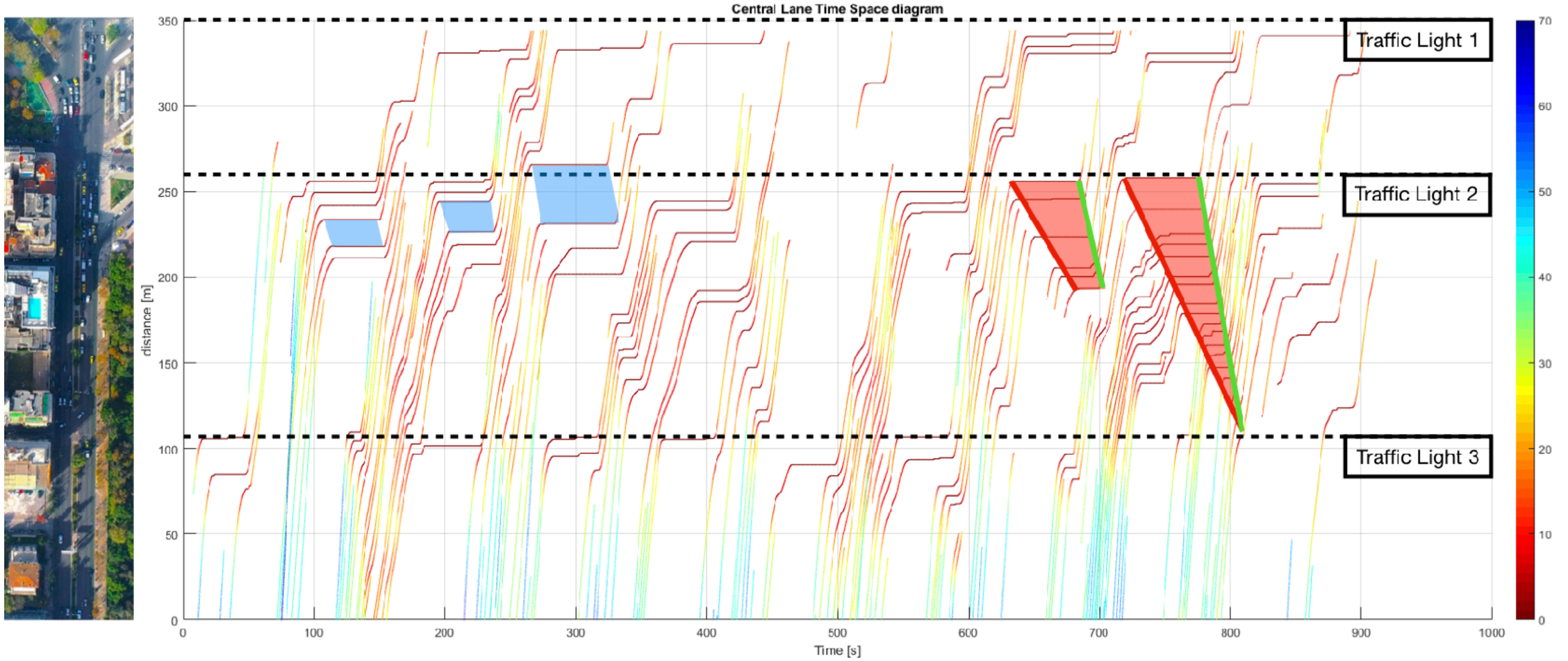
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

OD Information (Intersections)



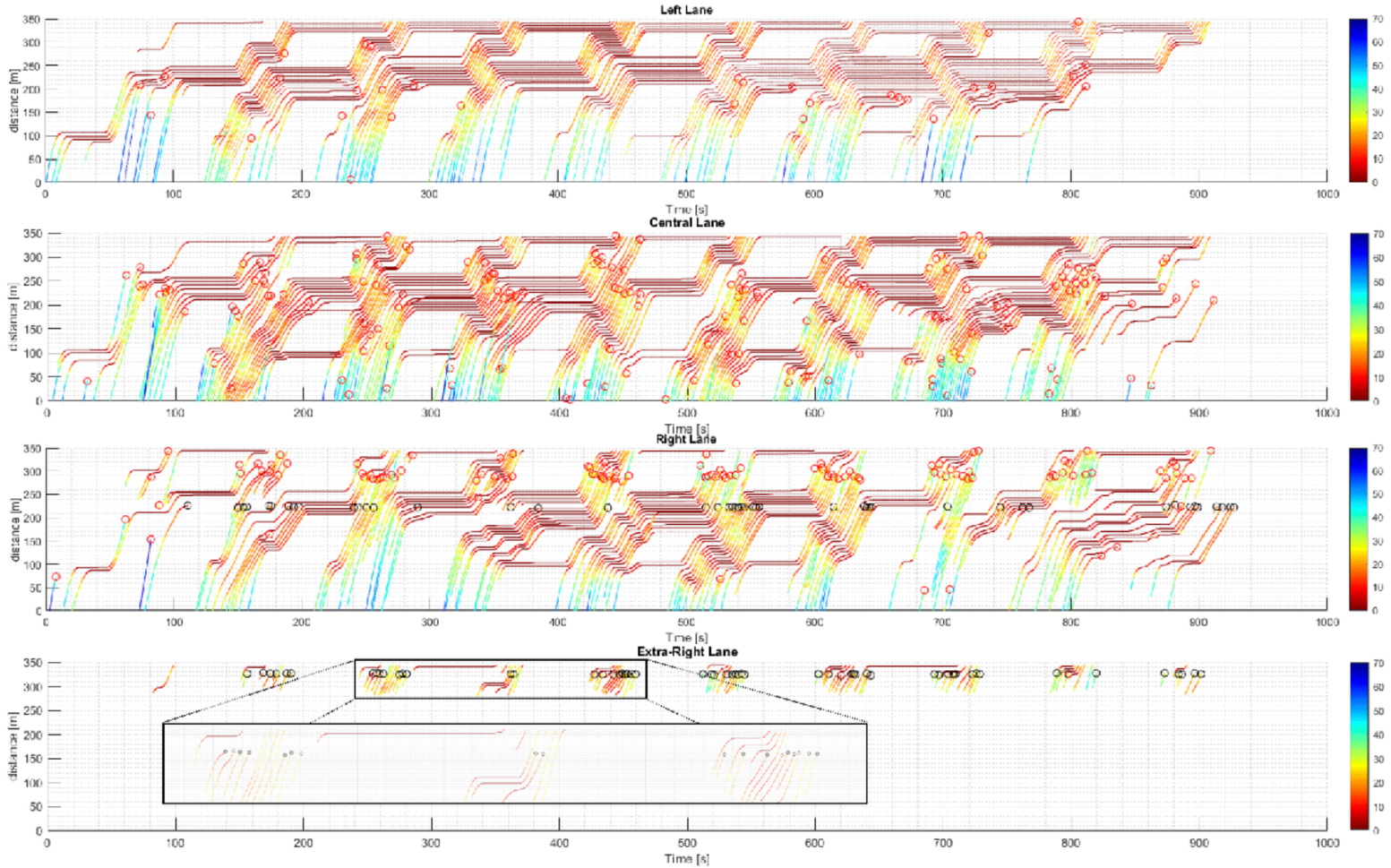
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

Time Space Diagrams



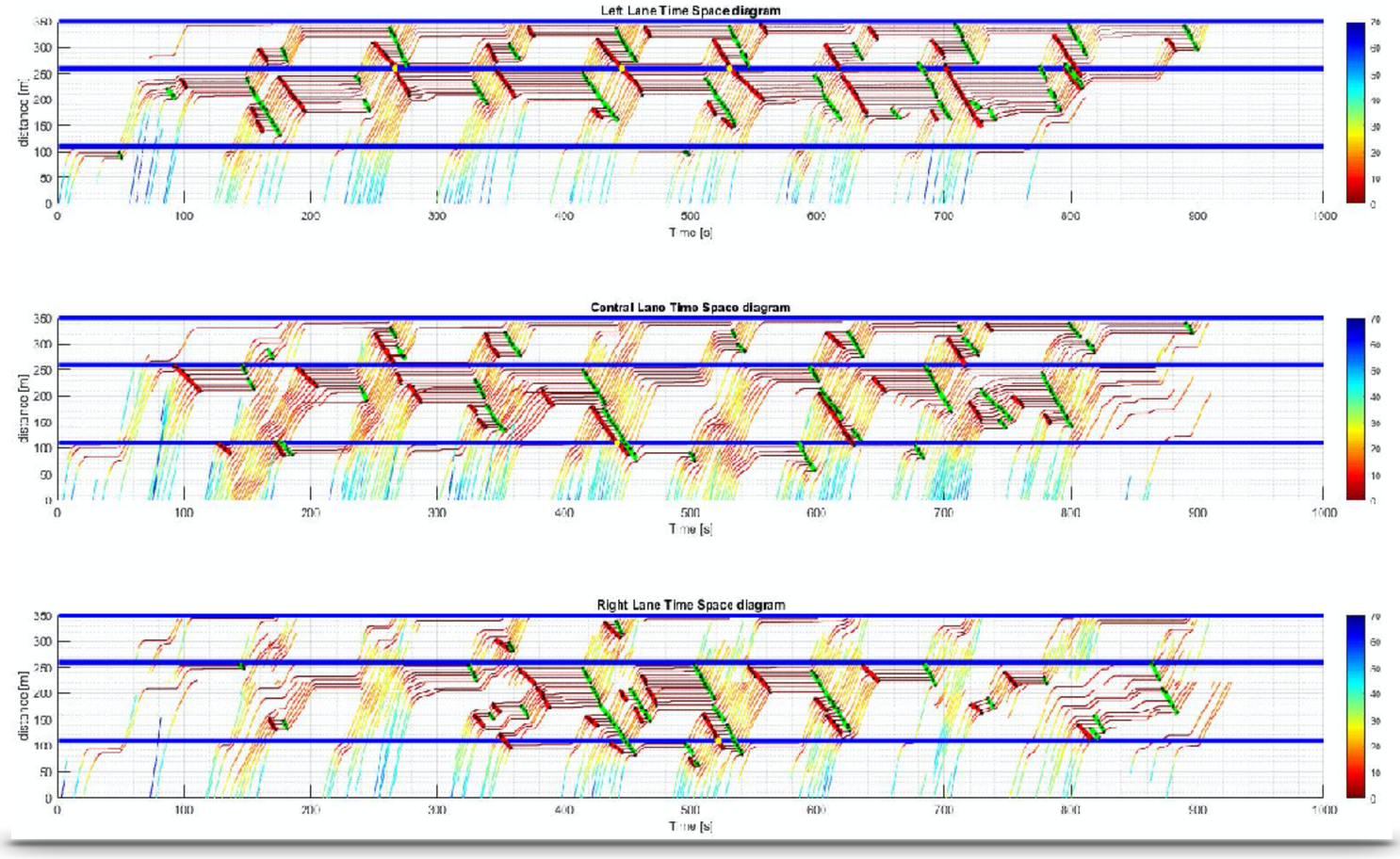
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

Multilane Time Space Diagrams



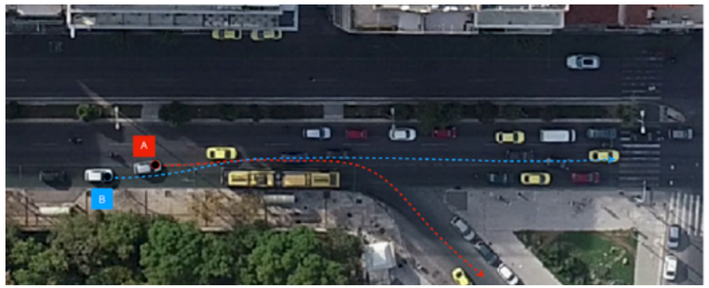
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

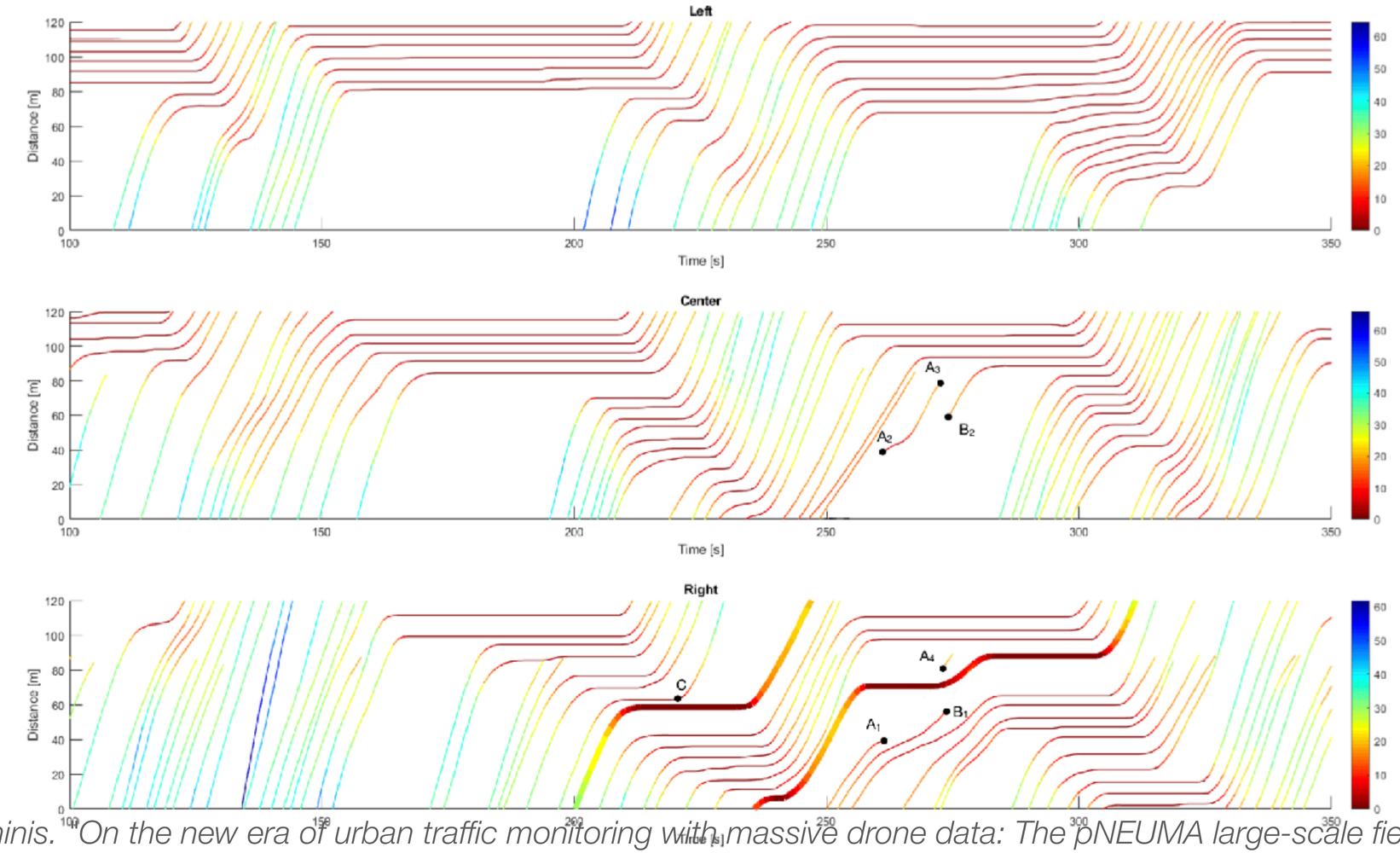
Shockwave Identification



Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

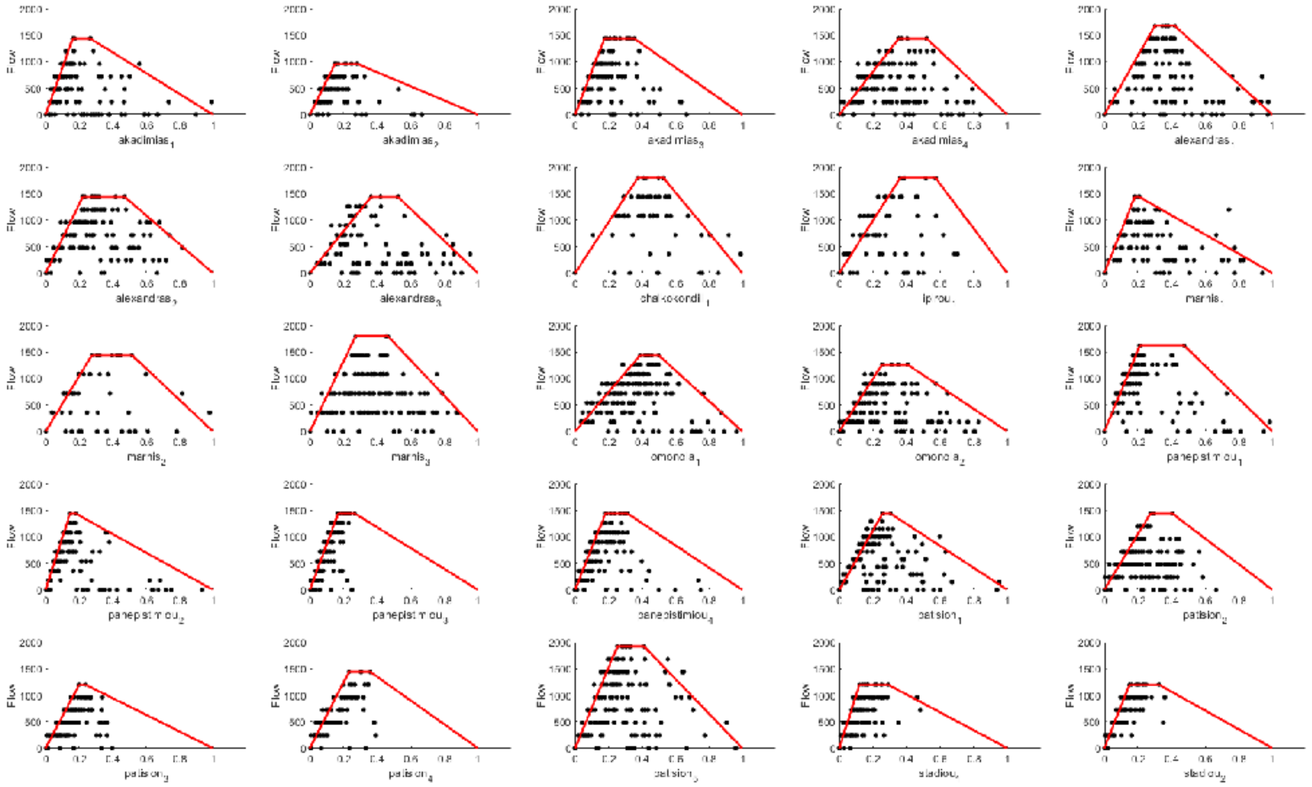
Multimodal Interactions (Bus Stops)





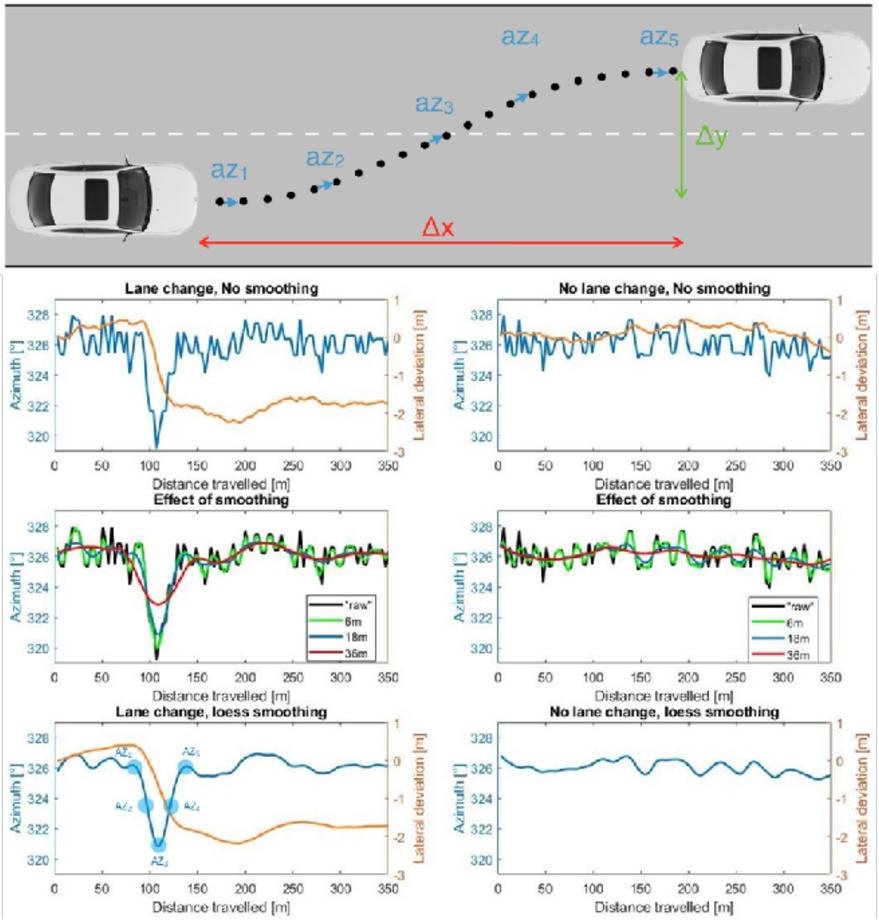
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

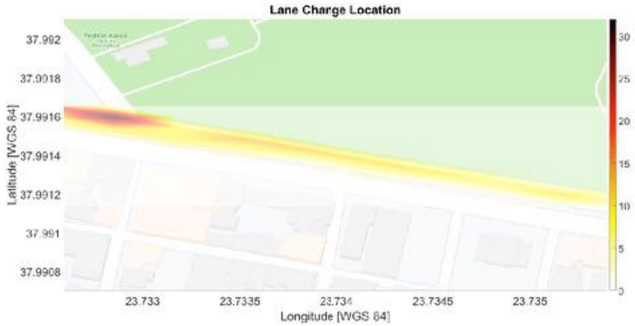
Fundamental Diagrams (FDs)

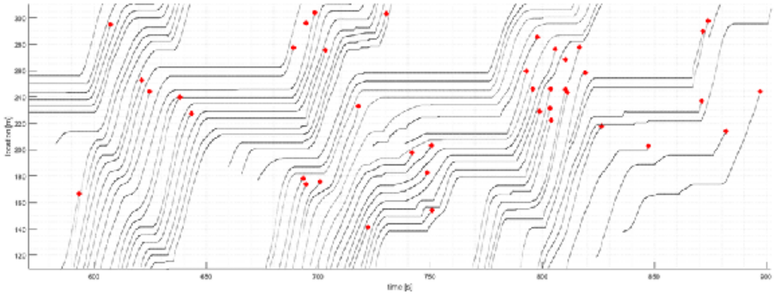


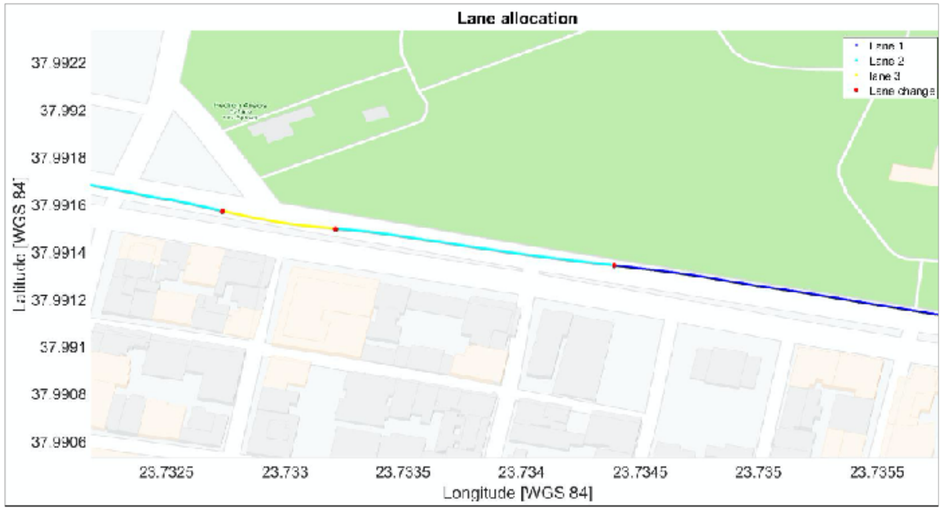
Barmpounakis, Emmanouil, and Nikolas Geroliminis. "On the new era of urban traffic monitoring with massive drone data: The pNEUMA large-scale field experiment." Transportation research part C: emerging technologies 111 (2020): 50-71.

Lane Changing Identification



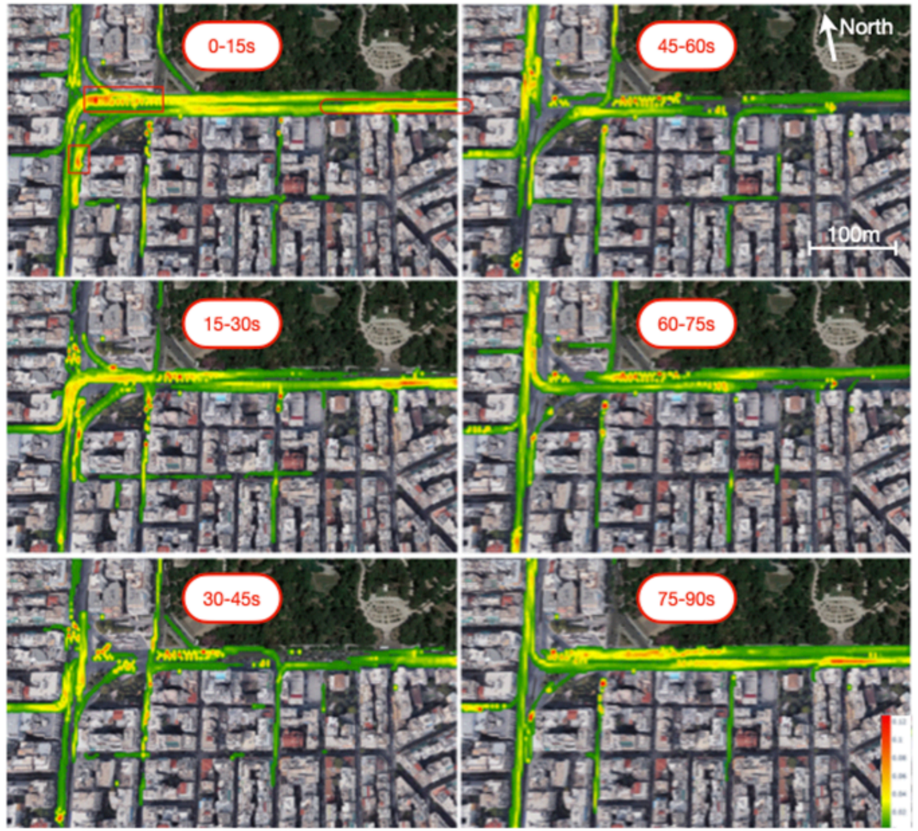


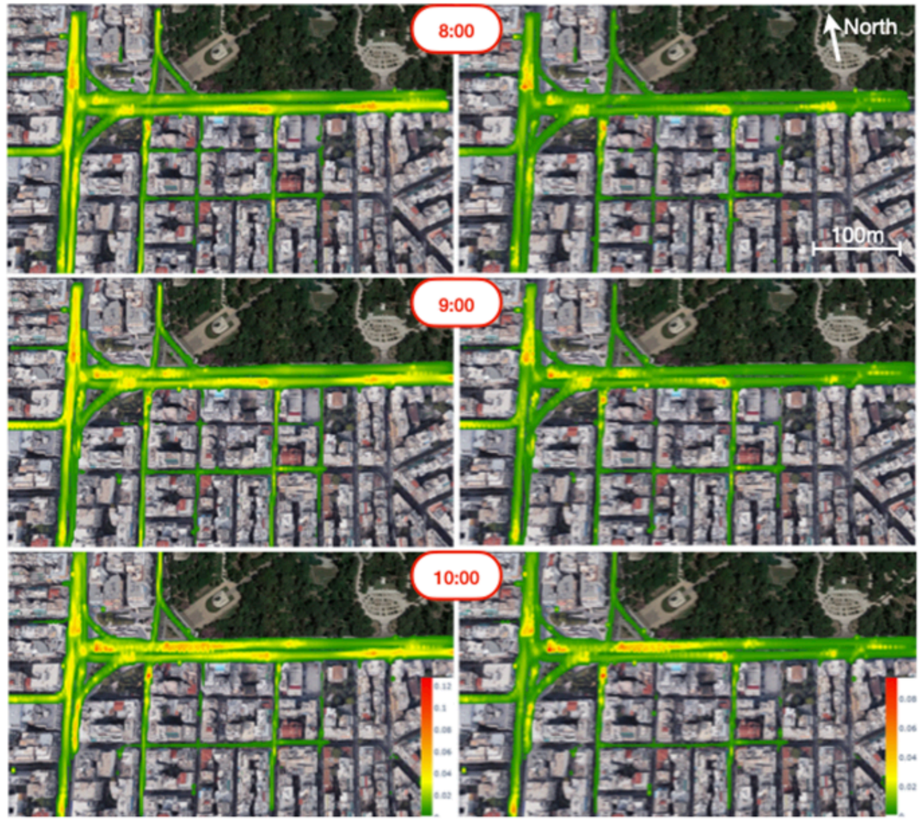




Barmpounakis, E., Sauvin, G.M., Geroliminis, N., 2020. Lane Detection and Lane-Changing Identification with High-Resolution Data from a Swarm of Drones. Transp. Res. Rec. J. Transp. Res. Board 2674, 1–15. https://doi.org/10.1177/0361198120920627

Emission Estimation





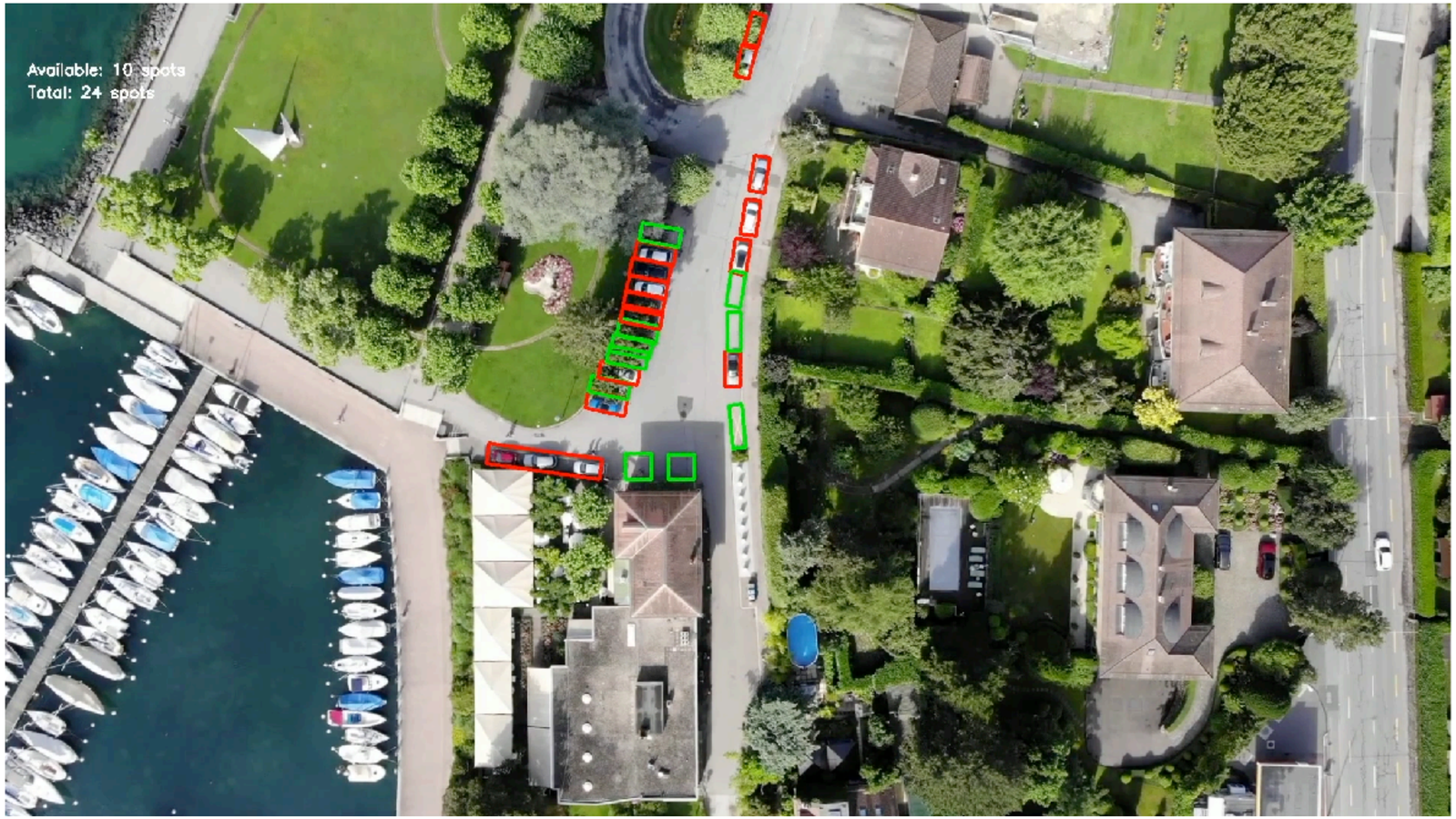
Barmpounakis, E., Montesinos, M., Gonzalez, E. and Geroliminis, N. (2021), Empirical investigation of the emission-macroscopic fundamental diagram, Transportation Research Part D: Transport and Environment

Experiment in Pully, VD, Switzerland

July 2021

Experiment in Pully, VD, Switzerland

Experiment in Pully, VD, Switzerland

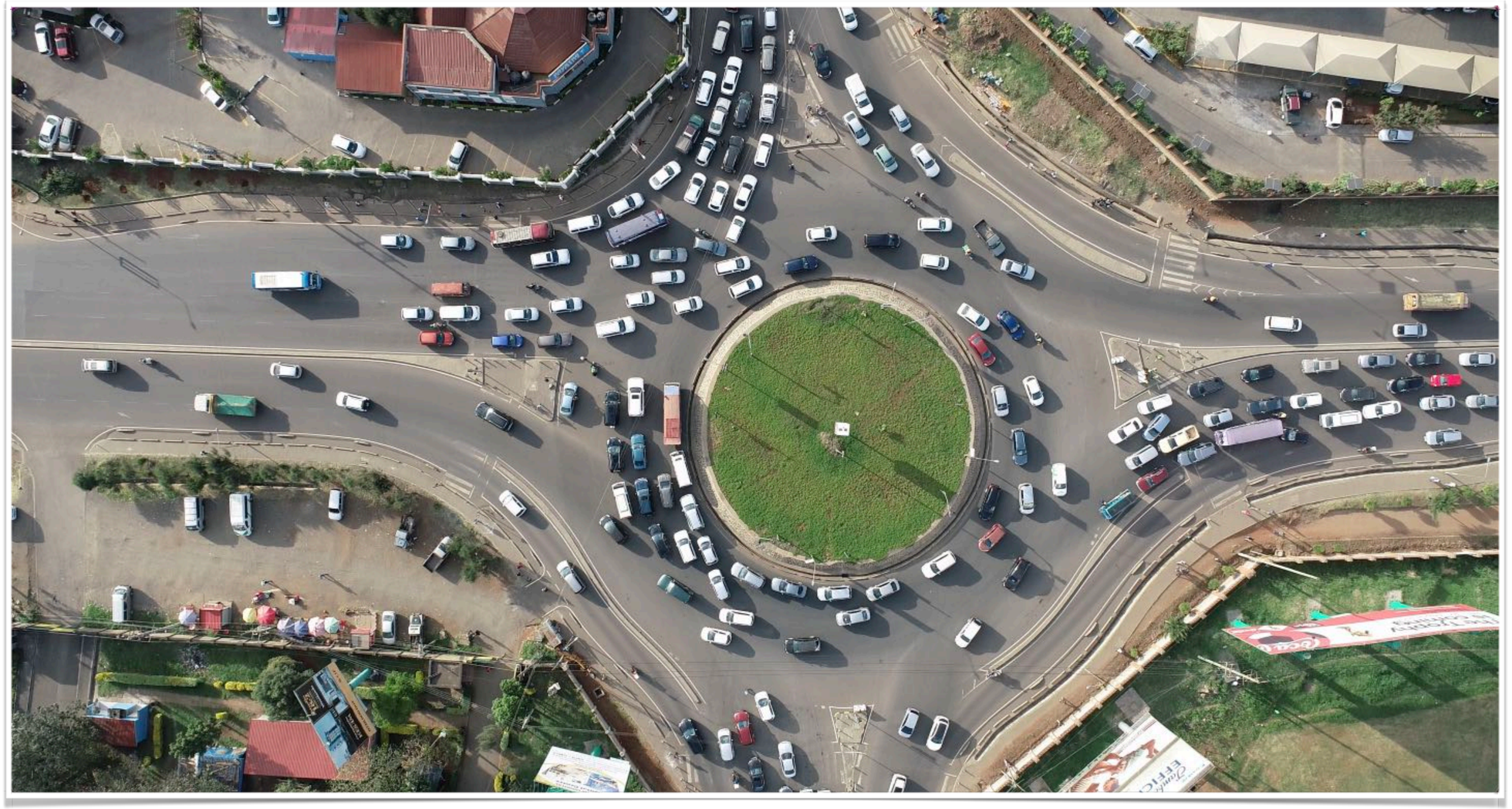


Kim, S., Tak, Y., Barmpounakis, E., & Geroliminis, N. (2024). Monitoring Outdoor Parking in Urban Areas With Unmanned Aerial Vehicles. IEEE Transactions on Intelligent Transportation Systems

Experiment in Nairobi, Kenya

May 2022

Experiment in Nairobi, Kenya



Experiment in Nairobi, Kenya

Experiment in Nairobi, Kenya

Experiment in Nairobi, Kenya

Experiment in Songdo, South Korea

September 2022

Experiment in Manchester, United Kingdom

November 2022

Espadaler Clapés, J., Fonnod, R. , Barmpounakis, E. and Geroliminis, N. (2023), Continuous Monitoring of a Signalized Intersection Using Unmanned Aerial Vehicles, In the 26th IEEE International Conference on Intelligent Transportation Systems, September 24-28, Bilbao, Spain - Best Paper Award

Experiment in Manchester, United Kingdom

November 2022

Espadaler Clapés, J., Fonnod, R. , Barmpounakis, E. and Geroliminis, N. (2023), Continuous Monitoring of a Signalized Intersection Using Unmanned Aerial Vehicles, In the 26th IEEE International Conference on Intelligent Transportation Systems, September 24-28, Bilbao, Spain - Best Paper Award

EPFL LUTS

Traffic Monitoring with Drones

Nikolas Geroliminis