

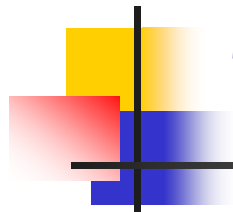
Fundamentals of Traffic Operations and Control WEEK 1b

Traffic Studies & Data Collection
System Monitoring and ITS

Nikolas Geroliminis

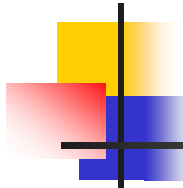


**Urban Transport
Systems Laboratory (LUTS)**



Traffic Studies

- A traffic engineer's laboratory is the surrounding roadway system
- This system must be continually monitored, evaluated, and managed



Guiding Principles

- “If you cannot tell the system performance yesterday, you cannot hope to manage your system today.”
 - Data Collection/Analysis

- “Data are too valuable to only use once.”
 - Data Archive
 - Real Time and Historical



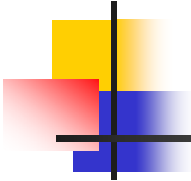
Traffic Studies

- Traffic demand/patterns will change over time, monitoring of system will enable necessary system changes to be identified
- The effects of system “improvements” must be justified, e.g.,
 - Signal timing changes
 - Lane additions or reconfigurations



Traffic Studies

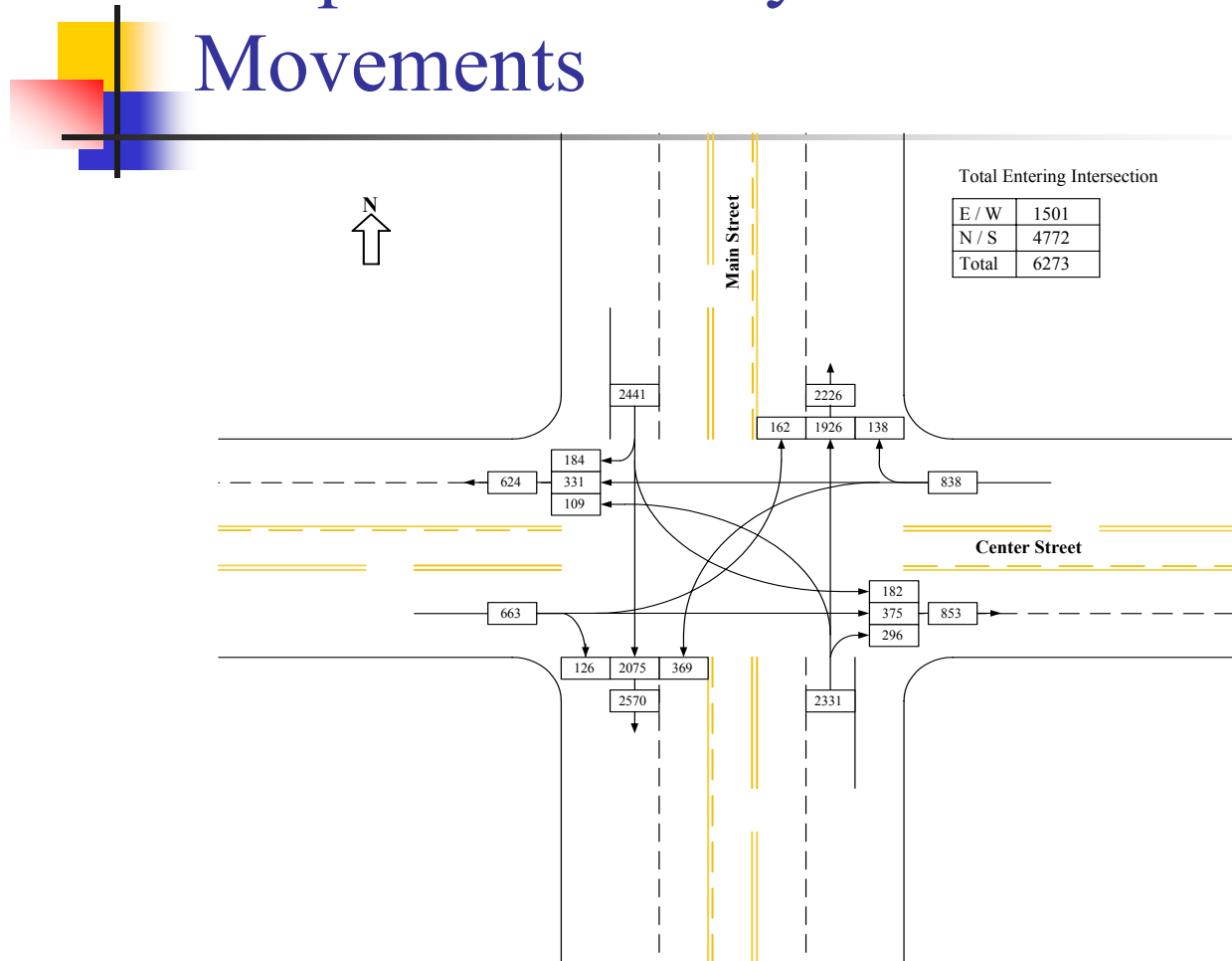
- Data collection is the key foundation
 - What kind of data?
 - How much data?
 - How to collect it?
- The study characteristics must be considered in answering these questions, e.g.,
 - Short-term or long-term study
 - Statistical confidence level



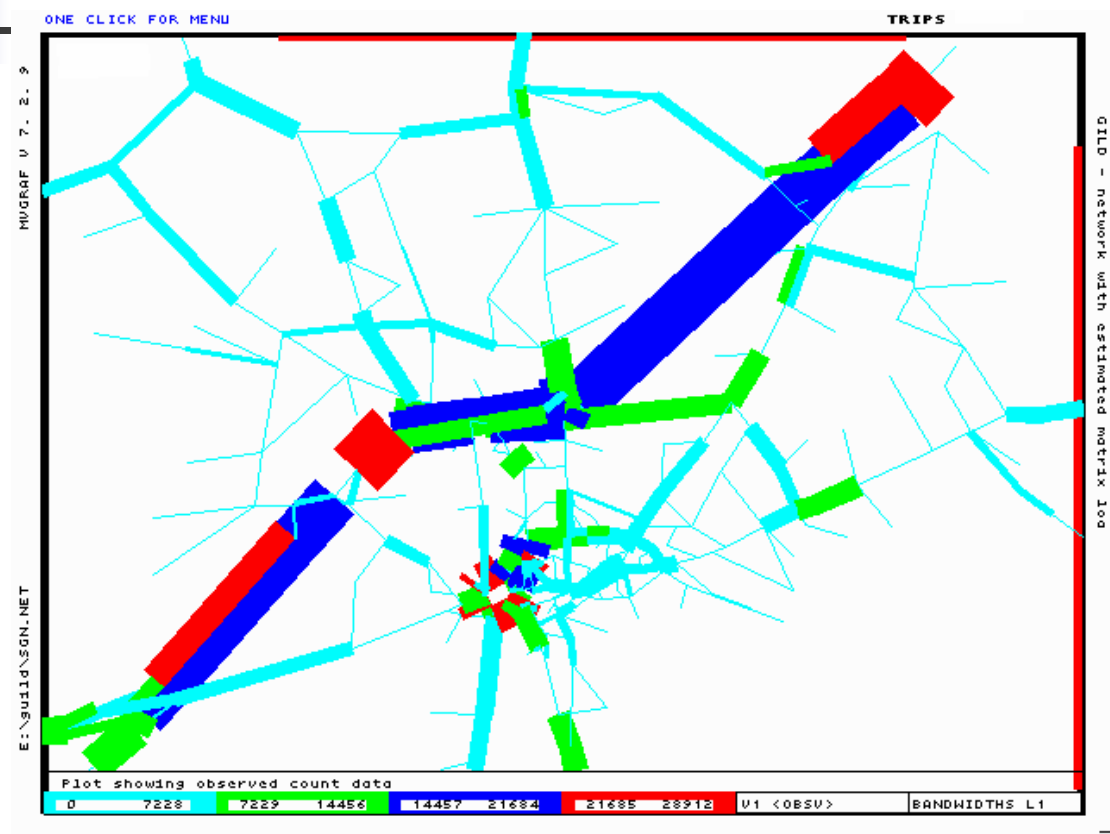
Temporal Variation

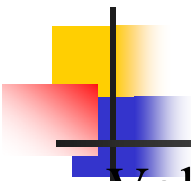
- Monthly (Jan. – Dec.)
- Daily (Sun. – Mon.)
- Hourly (12:00 AM – 11:59 PM)
- K values (e.g., K_{100} , K_{30})
 - The ratio of the X^{th} highest traffic volume hour of the year to the AADT (Average Annual Daily Travel)
 - Historically, 30th has been used in rural planning, design and operations. (generally flatten out from this point)

Graphic Summary of Vehicle Movements



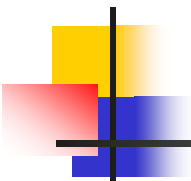
Traffic Counts Displayed in a Network





Vehicle Classification (VC)

- Volume with respect to vehicle type
 - Passenger cars
 - 2 axle trucks
 - 3 axle trucks
 - Public service vehicle (PSV)
 - Emergency vehicle
 - 2 wheel vehicles
- Applications
 - Geometric design (e.g., turning radii, max. grade, lane width)
 - Capacity Analysis (e.g., PCU conversions)
 - Automated counts
 - Pavement & Structure design



Vehicle Mile Travel (VMT)

- AADT x roadway length
- Applications:
 - Economic evaluation
 - Resource allocation (maintenance & improvement)
 - Planning

Measurement methods

- measurements at a (cross-sectional) point
- measurements along a short distance
- measurements along a length
- measurements along an arterial or small area (by e.g. moving observer method)
- other realtime large-scale monitoring methods

Measuring means

Measuring passage times, time headways, and flow

- manual counting, using a form and a stopwatch. Advantage: simple method; Disadvantage: labour costs and inaccuracies.
- Pneumatic tubes. Advantage: can accurately determine passage times and time headways; Disadvantage: relatively short time survival.
- Induction loops.
- Infrared detector.
- Instrumented vehicles (moving observer method).

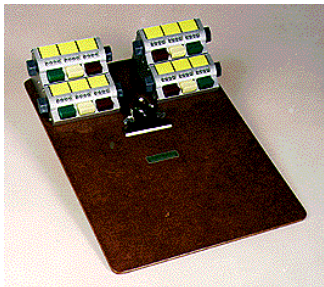
Individual speeds, instantaneous, and local mean speed

- Radar speedometers at a cross-section.
- Induction loops or double pneumatic tubes.
- vehicle recognition.
- Probe vehicles.
- Remote-sensing techniques.

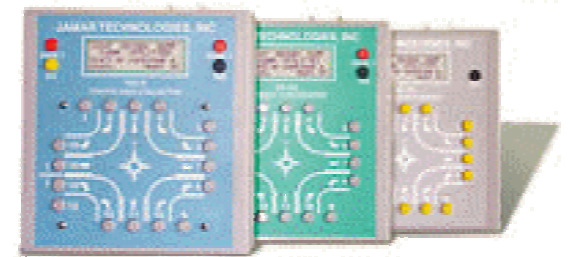
“Manual” counting



Manual Count Board



JAMAR Handheld Devices



Pneumatic tube



Pneumatic Road Tubes



Inductance Loops

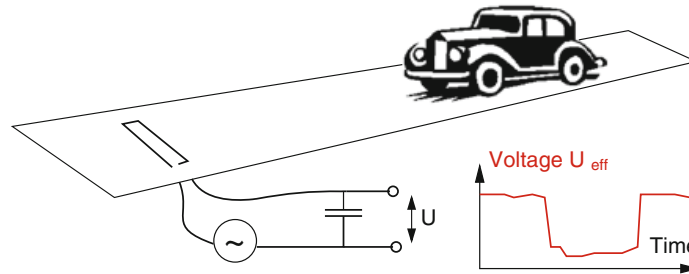
Vehicle Loops



Bike Loops



Microscopic measurement at induction loops



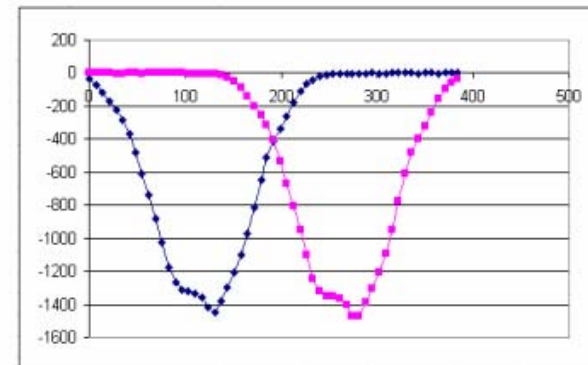
A single-loop detector can directly measure (only):

- The time t_{α}^0 at which the front of vehicle α passes the detector (voltage drop),
- The time t_{α}^1 at which the rear end of the vehicle passes the detector (voltage rise)

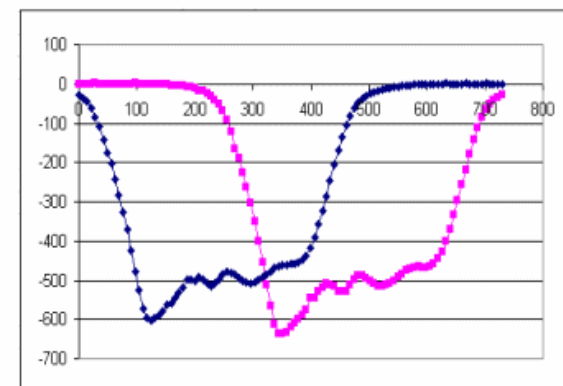


Inductance Loop Signatures (1)

Sport Car

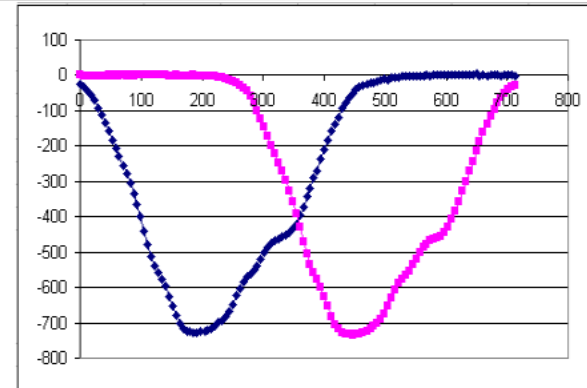


Truck

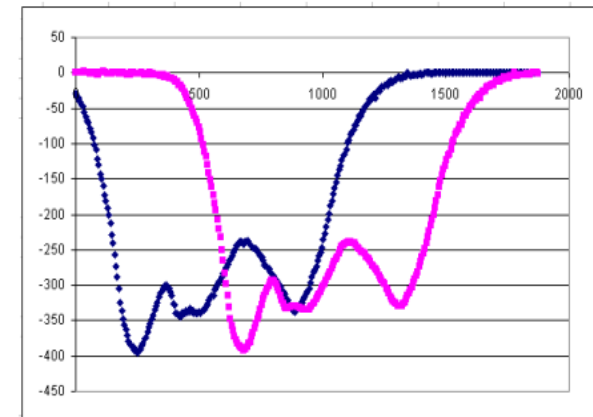


Inductance Loop Signatures (2)

Pickup Truck

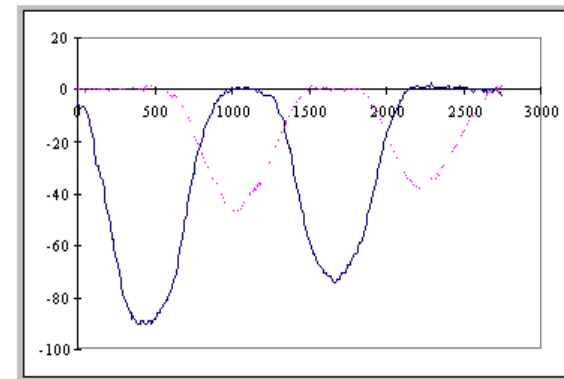


Trash Truck

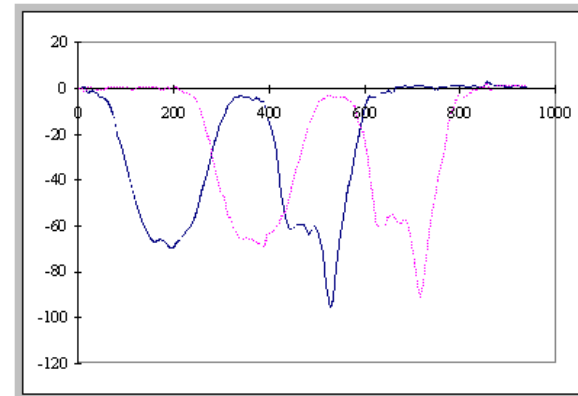


Inductance Loop Signatures (3)

Tailgating vehicles



Vehicle with a boat





Density

- Aerial photographs
- Volume / Speed
- Surrogate measure from inductance loop detectors
 - Ratio of occupied time to total observation time, expressed as a percent, is termed ‘lane occupancy’, denoted by ϕ (phi)

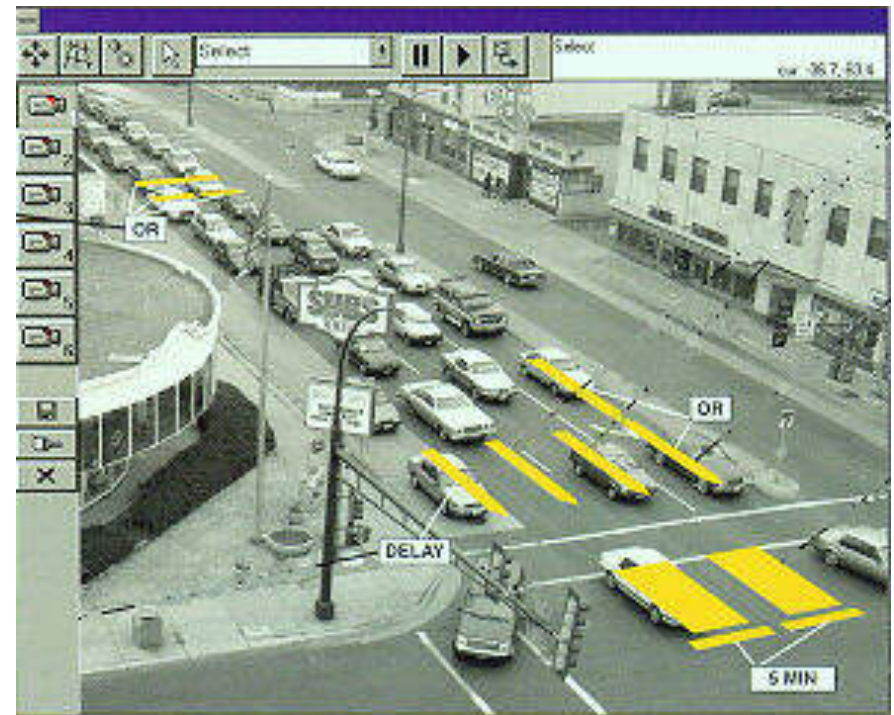
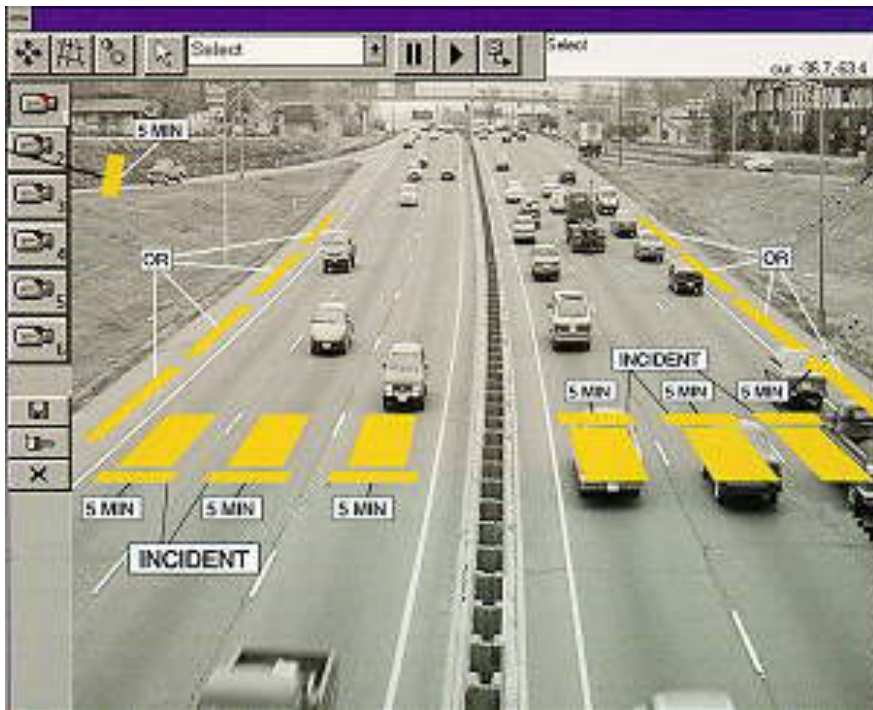
$$\phi = \frac{\text{total occupied time}}{\text{total observation time}} * 100$$

- To use lane occupancy for estimation of density, we must know vehicle length, then density can be estimated by

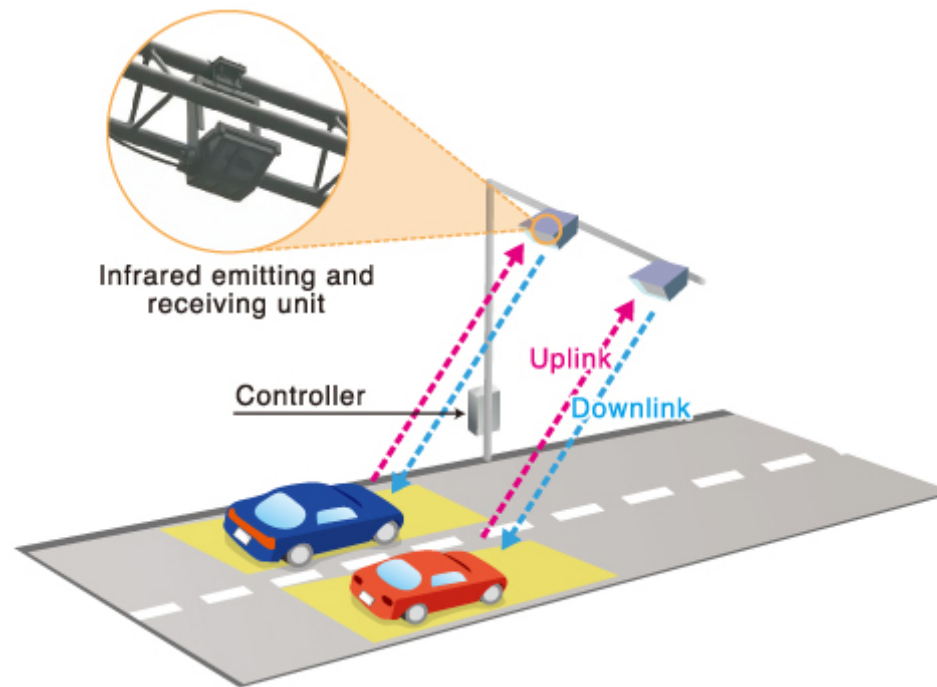
$$k = \frac{\phi}{100} \cdot \frac{1}{L_e} \quad L_e \text{ is the effective vehicle length}$$

Video Imaging

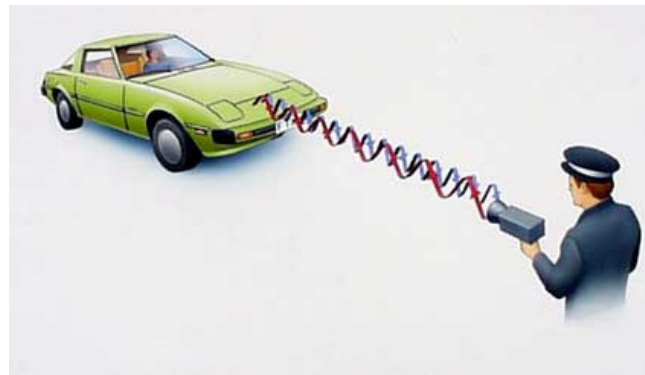
- Autoscope software



Infra-red sensors



Laser guns



Travel times

- Comparable for different traffic modes
- easy to be used in traffic models
- can be perceived easily

measurement sensors

- Vehicle Plate Recognition
- GPS receivers
- Cellular antennas

Vehicle Plate Recognition

The screenshot displays the Aimetis Symphony Client interface, which is used for vehicle plate recognition and surveillance. The interface is divided into several sections:

- Servers Devices:** A sidebar on the left showing the connection to 'csr-dev2'.
- Search:** A search bar with filters for Start At, End At, and Camera Nr. The search results are displayed in a table below.
- Table:** A table showing search results for vehicle plate recognition. The table has columns for ID, Time Stamp, Plate Number, and Camera.
- Video Feed:** A large central window showing a live video feed from a camera. A red box highlights a vehicle, and a yellow line indicates its movement path.
- Alarm Log:** A list of alarms on the right side, showing details like Date, Time, Alarm, Camera, and User.
- Server List:** A list of servers at the bottom right, showing the status of 'csr-dev2' as 'Connected'.

Table Data:

ID	ts	plateNr	idCamera
9615118	4/14/2011 9:45 ...	B55UO[ws]	1
9615117	4/14/2011 9:45 ...	B55UO[ws]	1
9615116	4/14/2011 9:45 ...	B55UO[ws]	1
9615115	4/14/2011 9:40 ...	B43CSX[ws]	1
9615114	4/14/2011 9:40 ...	B43CSX[ws]	1
9615113	4/14/2011 9:40 ...	B43CSX[ws]	1
9615112	4/14/2011 9:40 ...	B43CSX[ws]	1
9615111	4/14/2011 9:40 ...	B43CSX[ws]	1

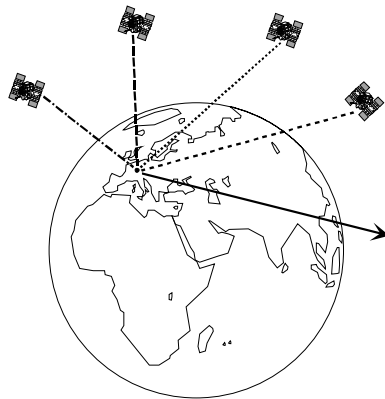
Alarm Log:

Date	Time	Alarm	Camera	User
04/14	12:1...	csr-dev2	Camera1	
04/14	12:1...	csr-d...	Camera1	
04/14	12:1...	csr-d...	Camera1	
04/14	12:0...	csr-d...	Camera1	
04/14	12:0...	csr-d...	Camera1	
04/14	12:0...	csr-d...	Camera1	
04/14	11:4...	csr-dev2	Camera1	

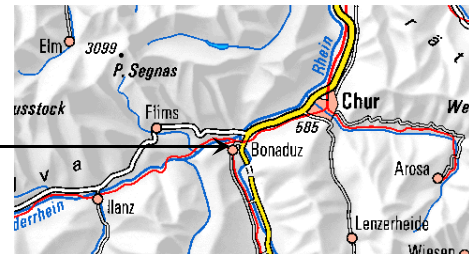
Server List:

Server	State
csr-dev2	Connected

GPS receivers

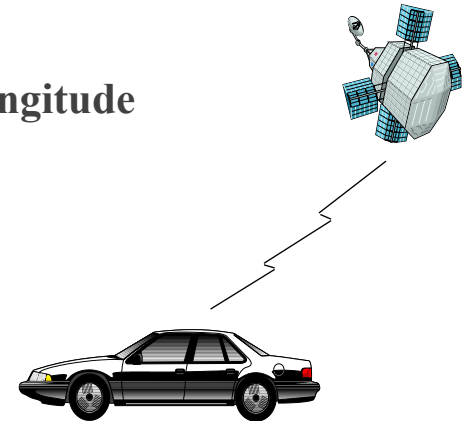


Longitude: 9°24'23,43"
Latitude: 46°48'37,20"
Altitude: 709,1m
Time: 12h33'07"



Global Positioning System (GPS)

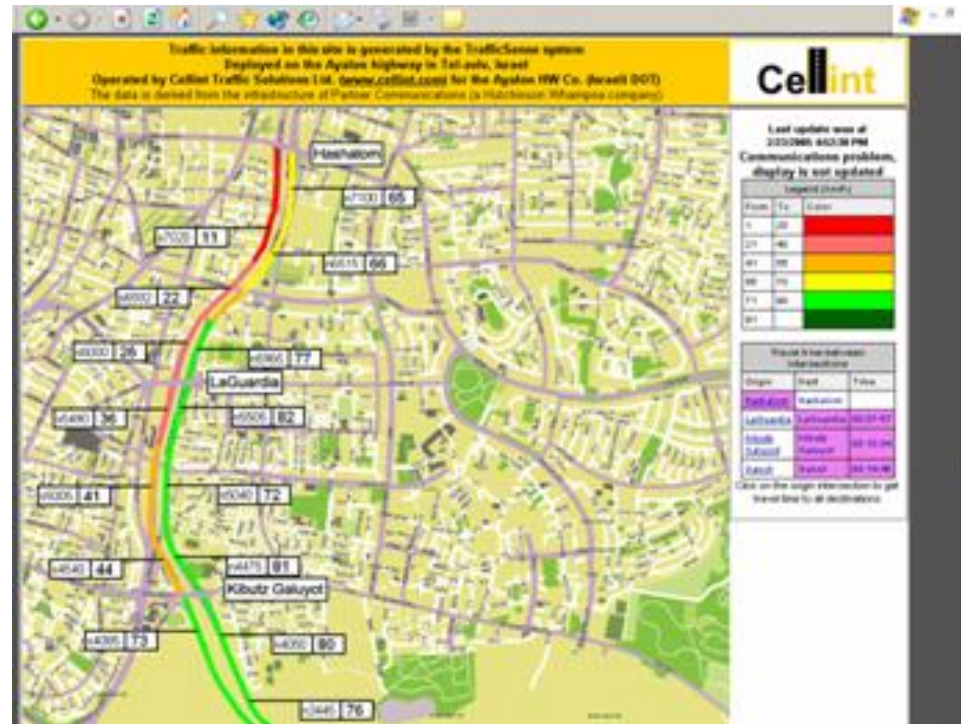
- GPS Time
- Latitude and Longitude
- Speed



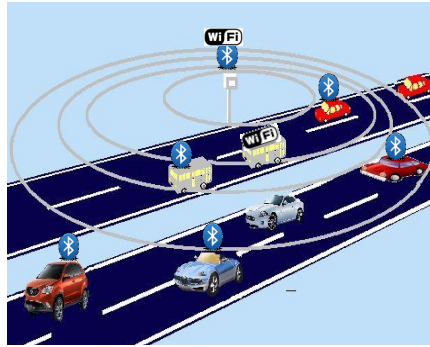
Typical GPS Data

Time (UTC)	Latitude (°)	Longitude (°)	Speed (mph)
16:27:39	30.389885	-91.242426	40.0
16:27:40	30.390090	-91.242276	40.6
16:27:41	30.390159	-91.242225	40.7
16:27:42	30.390298	-91.242122	41.0
16:27:43	30.390507	-91.241966	41.8

Cellular antennas



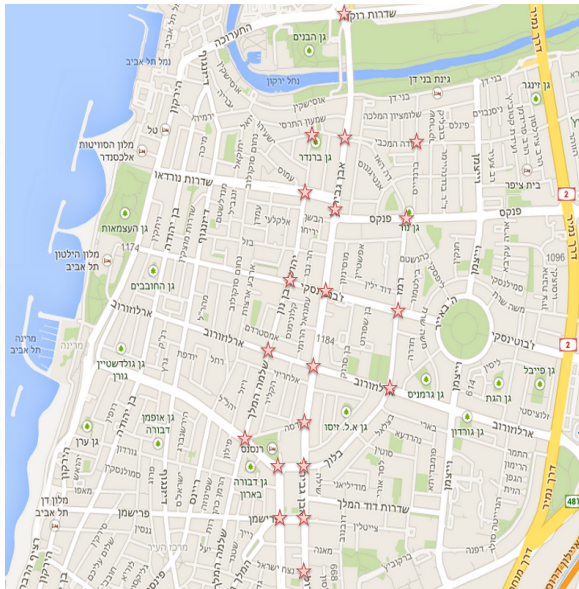
Bluetooth sensors



Estimate travel times between sensor points

Estimate O-D tables

Estimate average speeds

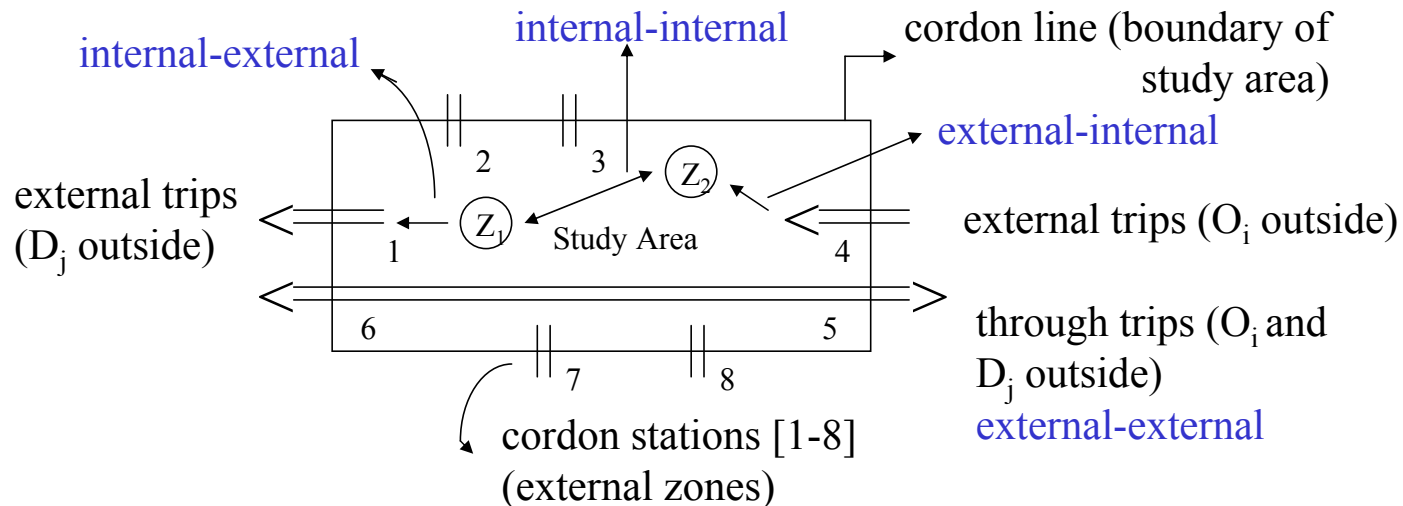


Electronic Toll Collection (AVI)



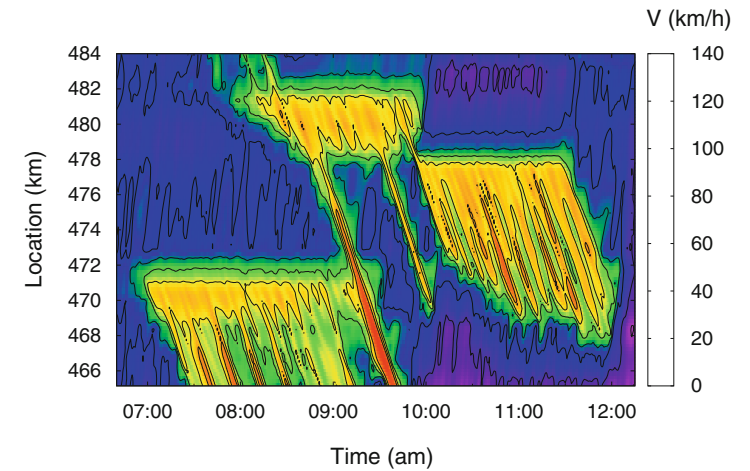
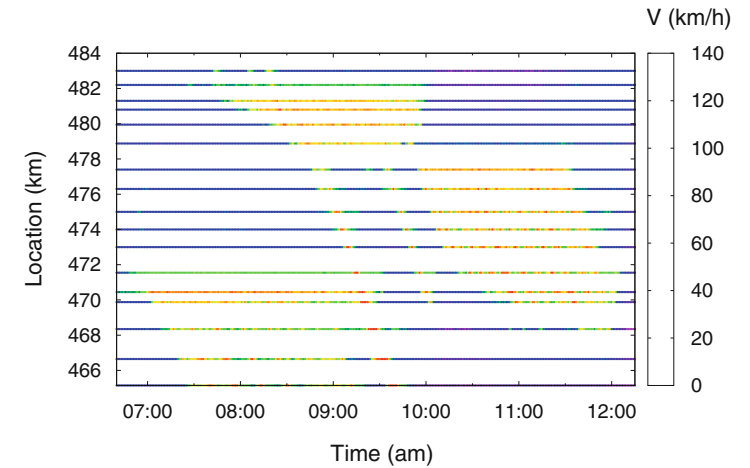
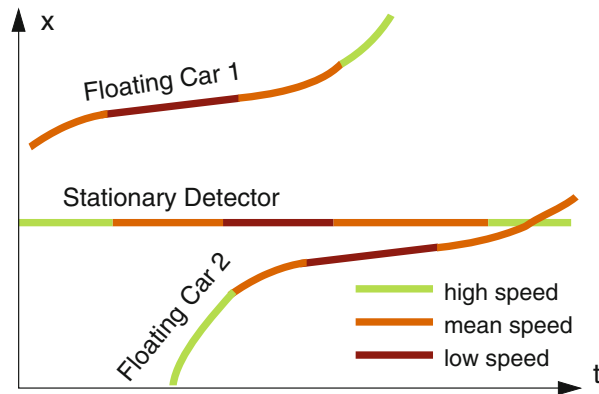
Origin-Destination (O-D) Studies

- Determining the percentage of all traffic traveling from each origin point of interest to each destination point of interest



Data Fusion

- the process of combining data from multiple, heterogeneous data sources such as cross-sectional data, floating-car data, police reports, etc.
- each of these categories of data describes different aspects of the traffic situation and might even contradict each other.
- the goal of data fusion is to maximize the utility of the available information.



Data: Autobahn A5 near Frankfurt/Main, Germany (source: [1])

Collecting traffic data with drones

Complex interactions

- Multimodality
- Components adapt
- Competing operators
- Spreading phenomena



Limits to predictability

Limits to centralization

Limits to cooperation

Bird-eye view



Athens, GR

open-traffic.epfl.ch | π NEUMA dataset

 TEN DRONES

Hovering simultaneously over
different areas

 5 DAYS

Monday to Friday

π neuma  at a glance

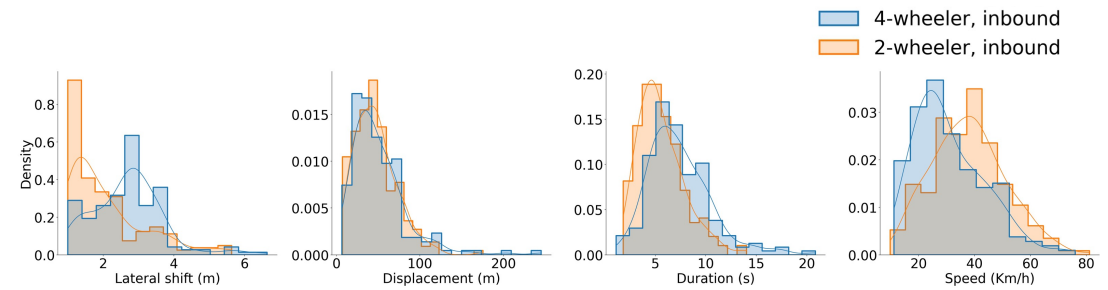
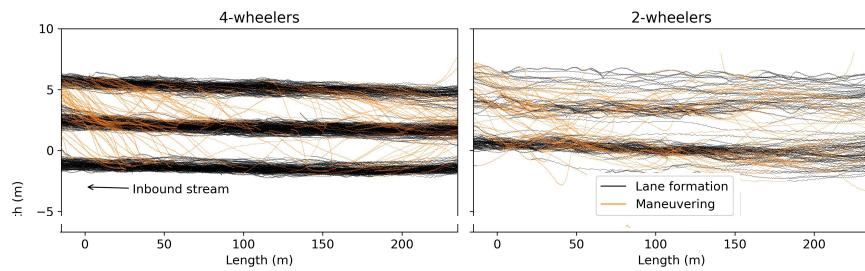
 MORNING PEAK-HOUR

Five flight sessions for 2.5 hours per
day

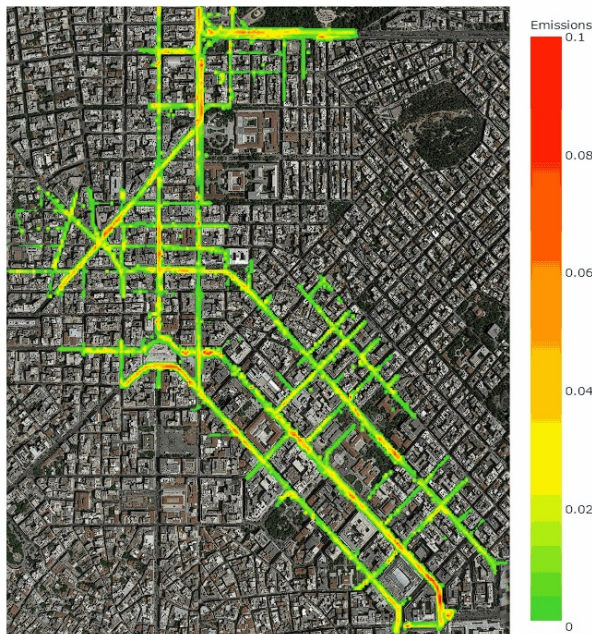
 100+ INTERSECTIONS

Signalised or not

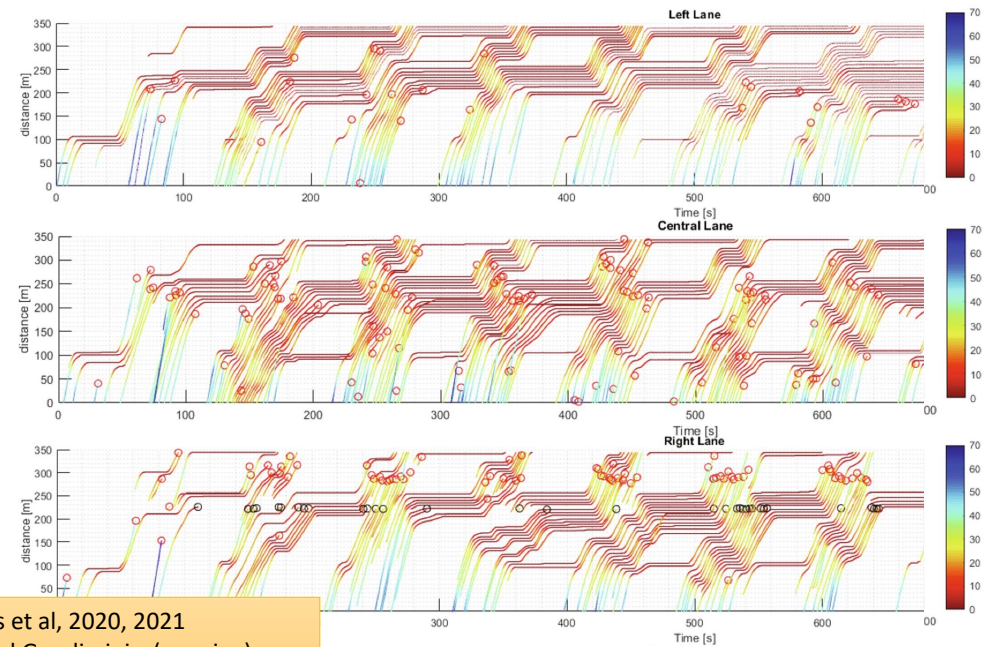
Complex traffic interactions



Maneuvering distributions



Emission Distribution



Lane Time-space diagrams

Barmounakis et al, 2020, 2021
Anagnostopoulos and Geroliminis, (ongoing)

A new experiment

