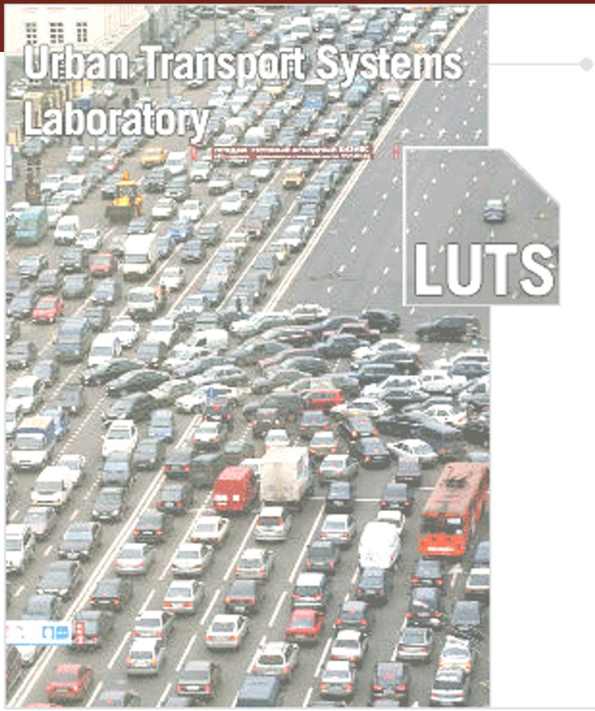


EFFECT OF PARKING IN CITY MOBILITY

Nikolas Geroliminis

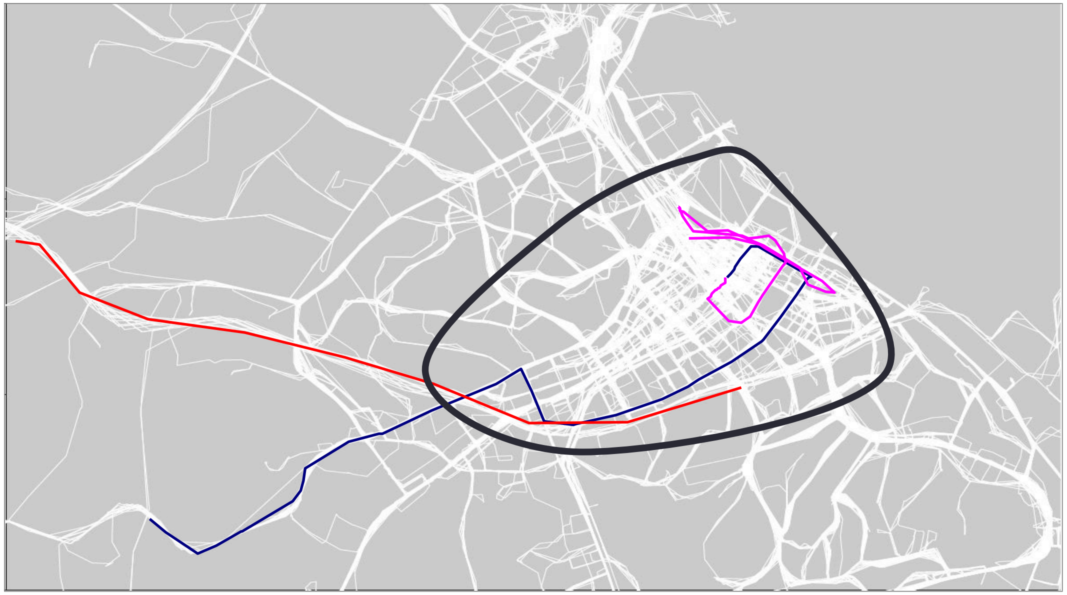
LUTS

EPFL | ENAC
ENVIRONNEMENT NATUREL, ARCHITECTURAL ET CONSTRUIT

Special Thanks to Prof. Mónica Menéndez (NYUAD) for contributions in the slides

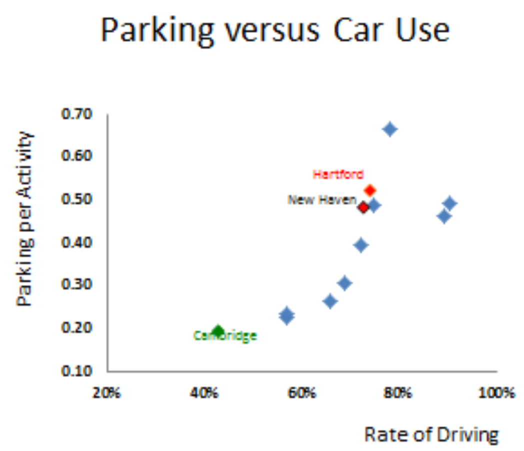
Cruising parking

- Important source of congestion
- Delays ↑
- Output ↓



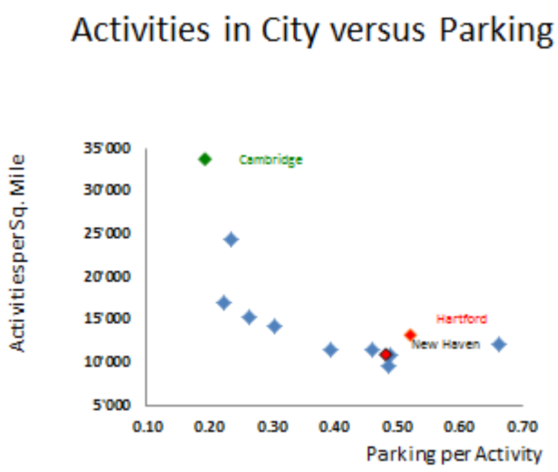
- Moving
- Cruising
- Parked

Why parking is important?



Cities with high driving rates provide up to
3 times more parking for each new job or resident

Very costly, uses lots of land and creates a horrible walking environment



Cities with more parking end up accommodating many fewer jobs and residents per square mile

Source: Norman Garrick (data from US cities)

What are different types of parking facilities?

On-street parking

Off-street parking

What are different types of parking facilities?

Off-street parking

Open lots

Parking garages

What are the effects of parking?

Mode choice

Mobility

What are the effects of parking?

Urban life, space usage

Retail and businesses

What are the effects of parking?

Economics

Traffic, capacity reduction

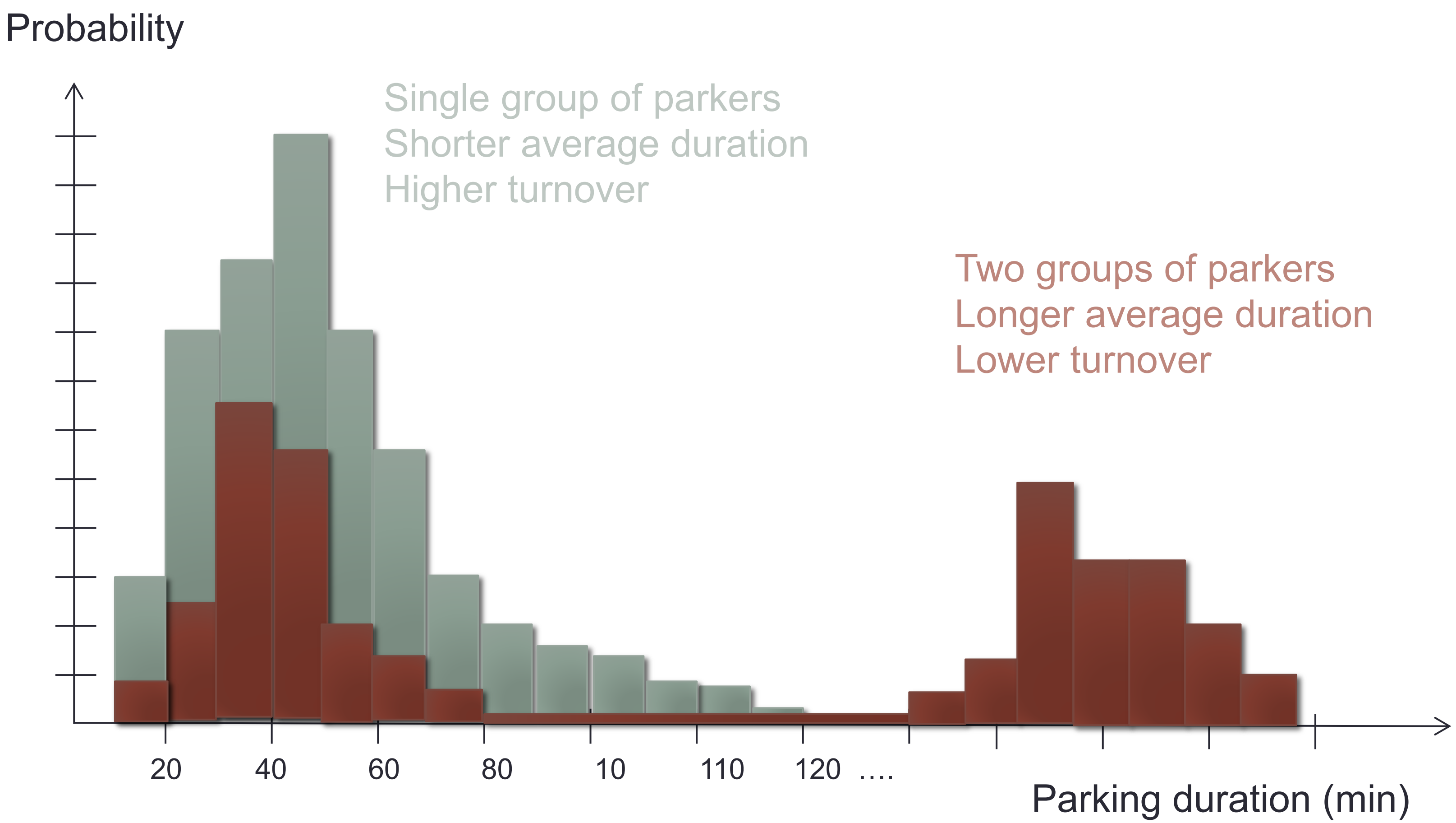
What terminology do we use?

Space-hour	unit of parking that defines the use of a single parking space for a period of one hour
Volume	total number of vehicles that park during a specific length of time (often one day)
Accumulation	number of vehicles parked at a given time
Turnover	rate of use of a parking space, i.e., number of vehicles utilizing the same stall over a given period of time

What terminology do we use?

Occupancy	percent of occupied parking spaces at a given time
Load	number of space-hours used during a specified period of time
Peak flows	maximum rates of arrivals and/or departures
Average duration	average length of time that a car is parked at a given parking space

How do we measure it?



How do we measure it?

$$occupancy = 100 \cdot \frac{number\ of\ spaces\ occupied}{total\ spaces\ available}$$

$$turnover = \frac{number\ of\ different\ vehicles\ parked}{number\ of\ parking\ spaces}$$

$$load = \sum_{i=1}^{N} t_i$$

$$average\ duration = \frac{load}{total\ number\ of\ vehicles\ parked} = \frac{\sum_{i=1}^{N} t_i}{N}$$

$$average\ accumulation = \frac{load}{total\ time\ period} = \frac{\sum_{i=1}^{N} t_i}{T}$$

Selected data collection methods

Ins and outs

- Vehicles parked in the focus area counted at the beginning and end of the survey
- Entering and exiting vehicles are counted during survey period

Patrol survey

- Vehicles parked in the focus area counted at fixed time intervals during the survey period

Individual vehicle tracking

- Individual vehicles (or individual parking stalls) are tracked (either continuously or at fixed intervals)

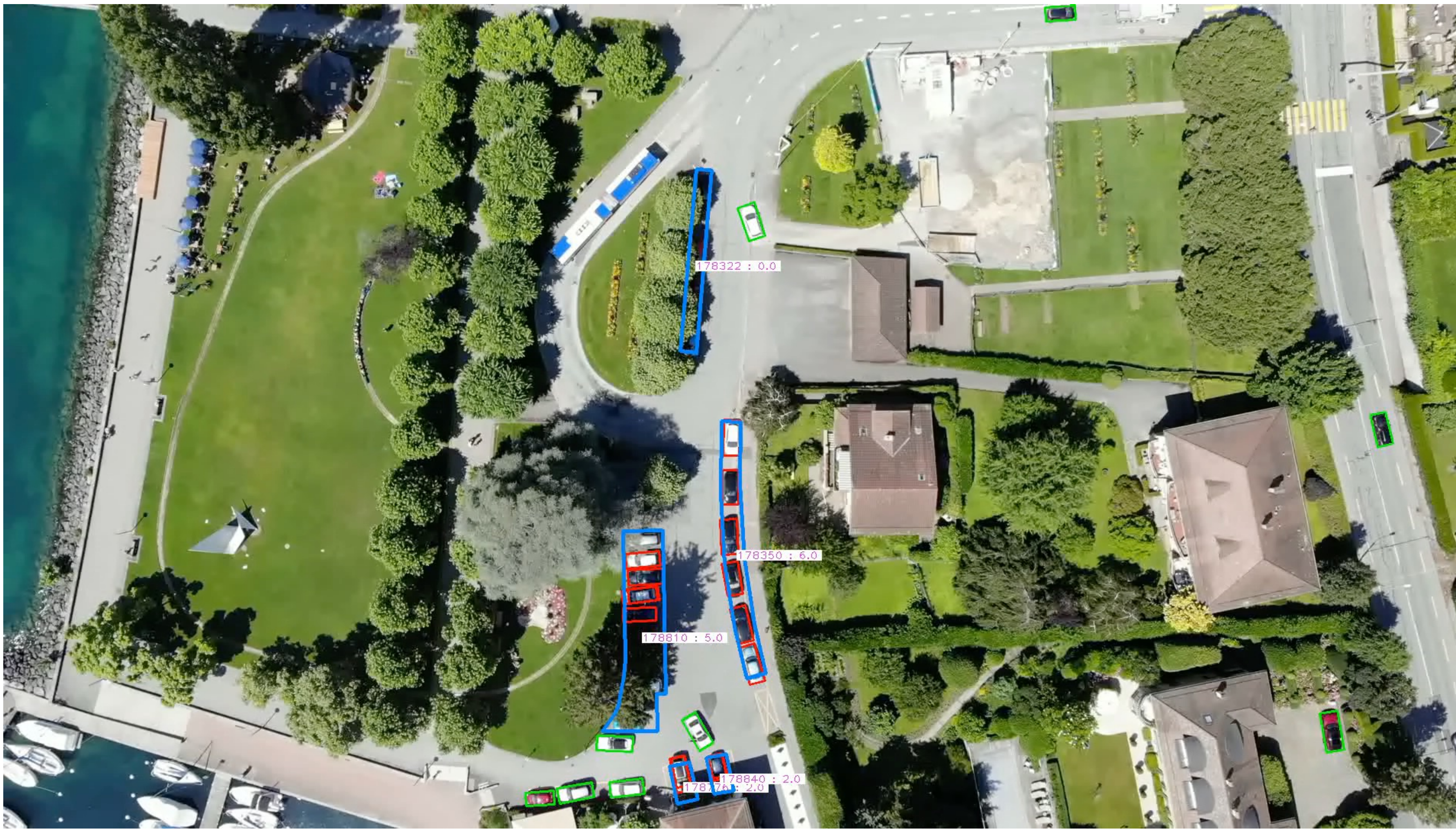
Selected data collection methods

	Pros	Cons
Ins and outs e.g. Loop detectors in entrance/exit, Camera and ticket control at entrance/exit	– Can generate most important data	– Not suitable for on-street or public parking – High cost for facilities – Could generate only queuing diagrams
Patrol survey e.g. Fixed period sampling plate survey	– Easy to conduct – Low cost – No fixed infrastructure required	– Limited and incomplete data (bias) – Labor requirements
Individual vehicle tracking e.g. Sensors, Full view cameras	– Can generate full and complete database	– Expensive to install – High requirements for maintenance – Large database – Hard to extract data

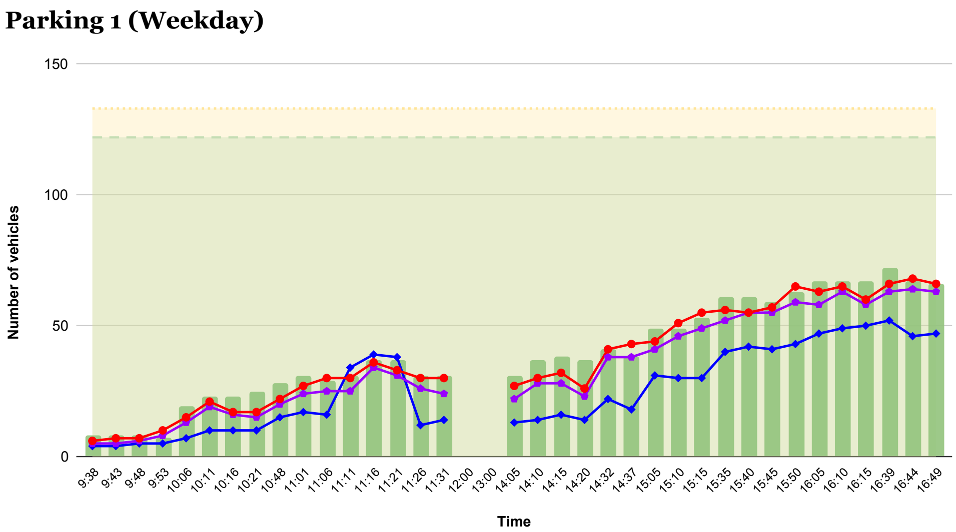
Example – Parking Study with UAV

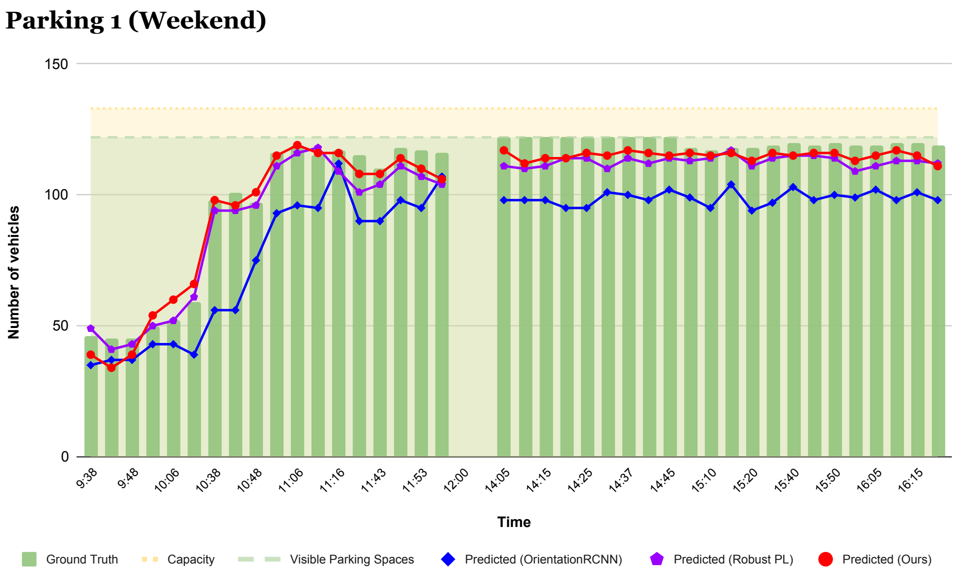
Every 5-6min UAV would fly over one of the off-street parking lots for duration of 25min

Example – Parking Study with UAV



Example – Parking Study with UAV

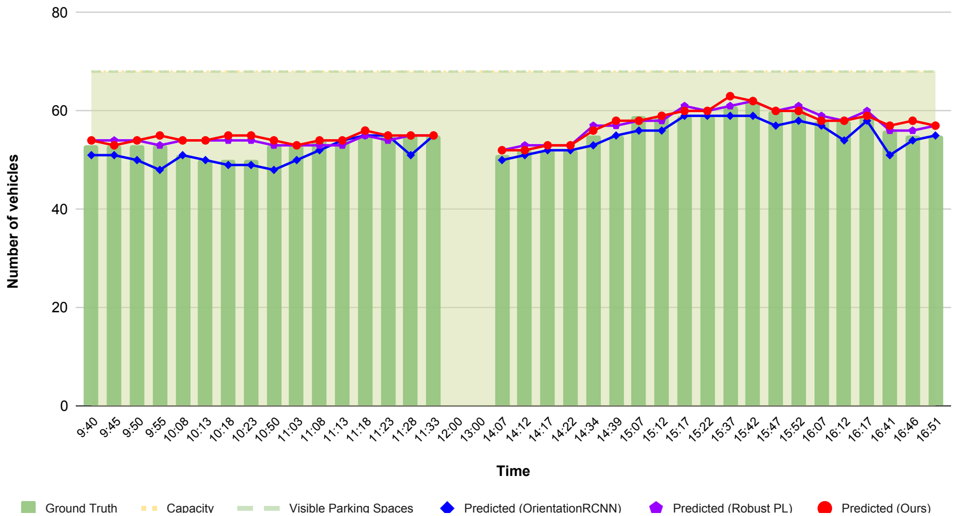




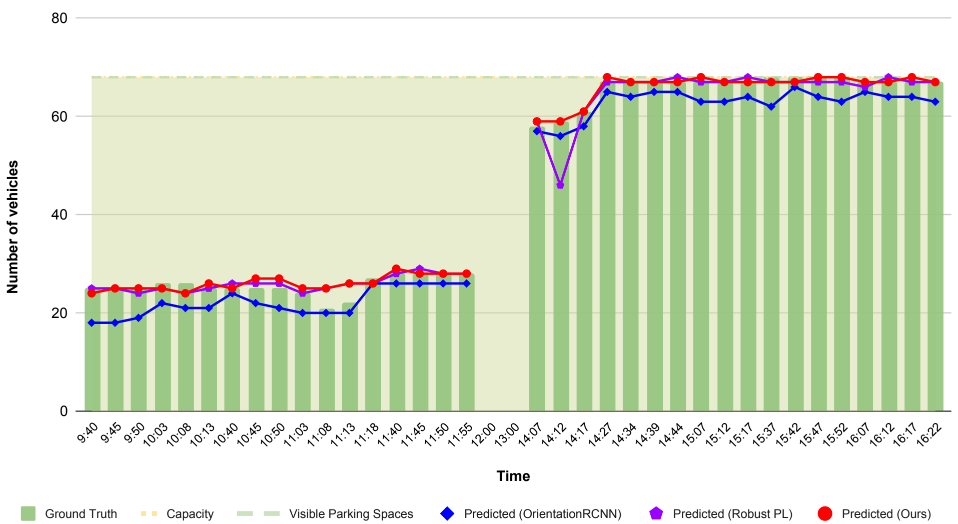
Parking Lot 1

Example – Parking Study with UAV

Parking 2 (Weekday)



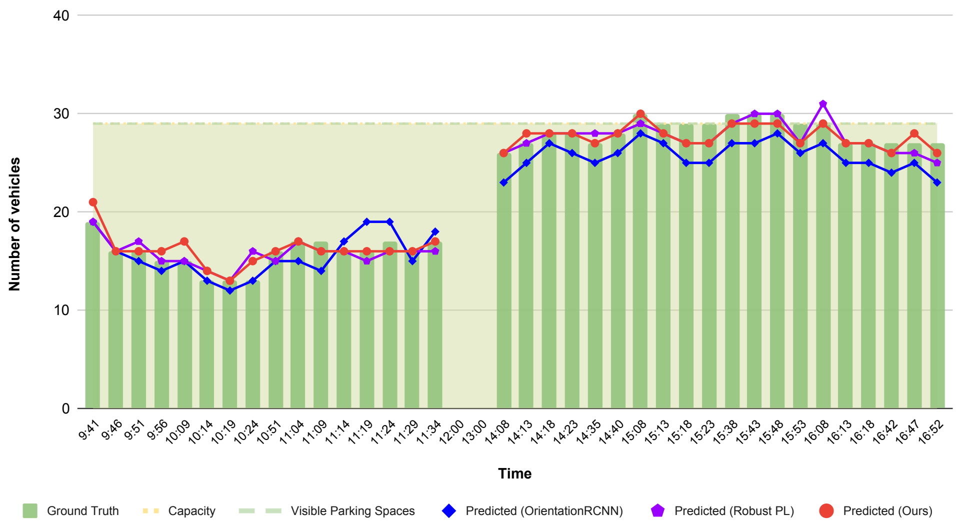
Parking 2 (Weekend)



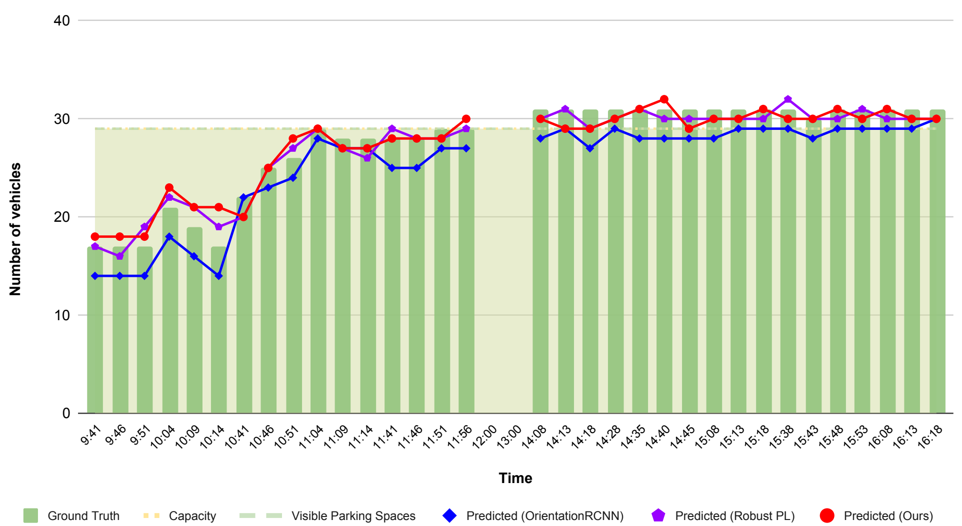
Parking Lot 2

Example – Parking Study with UAV

Parking 3 (Weekday)



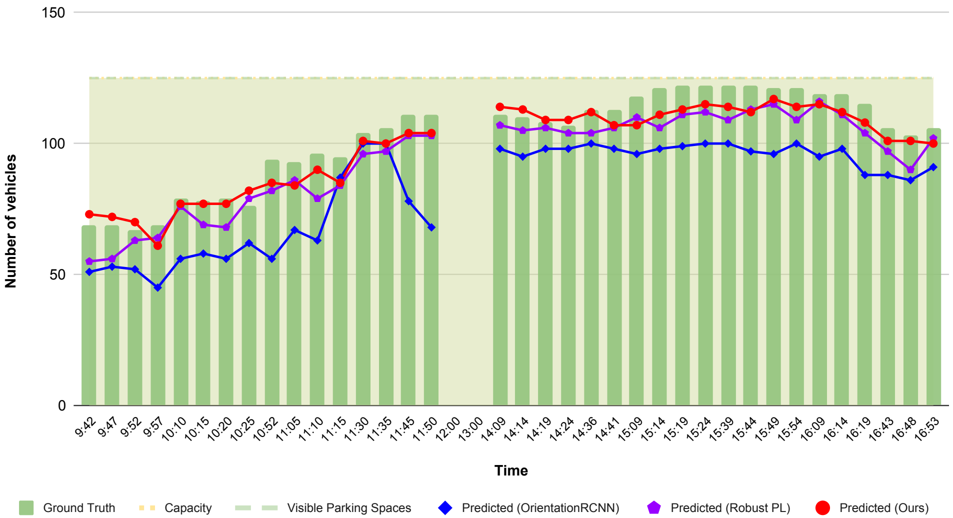
Parking 3 (Weekend)



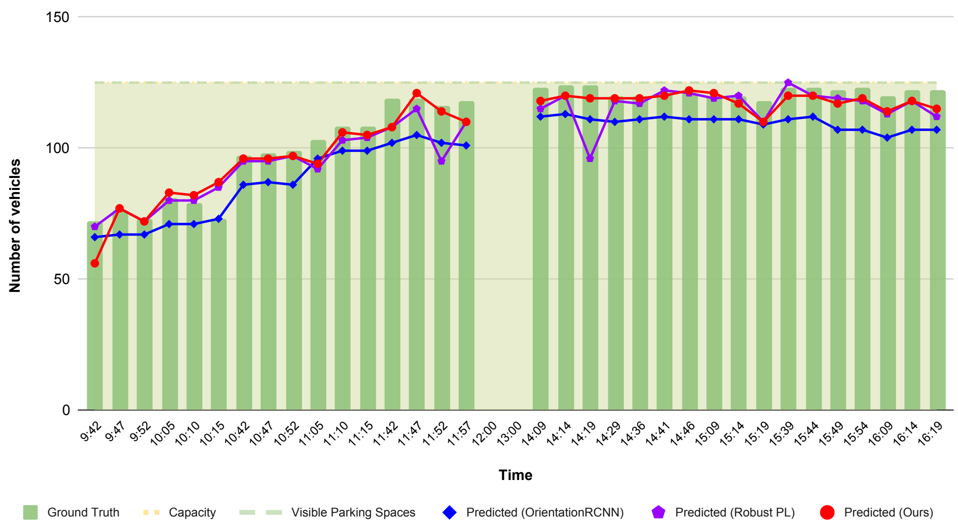
Parking Lot 3

Example – Parking Study with UAV

Parking 4 (Weekday)

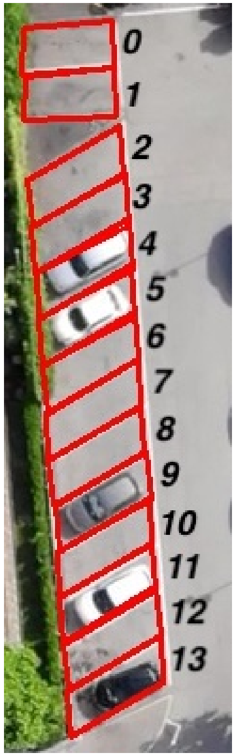


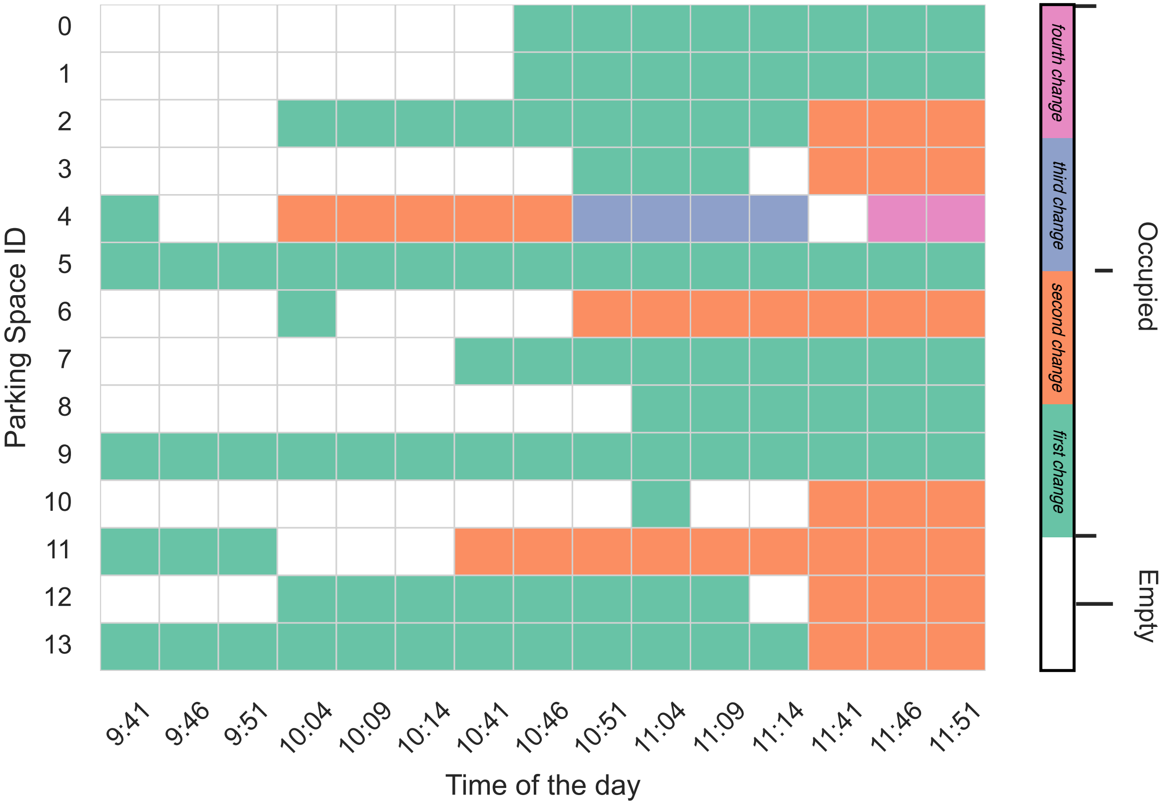
Parking 4 (Weekend)



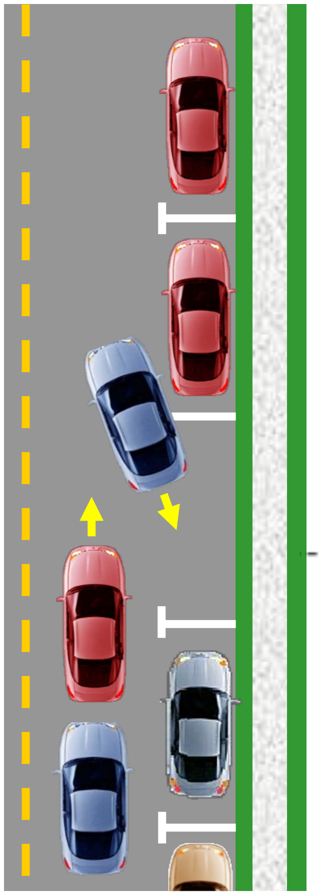
Parking Lot 4

Example – Parking Study with UAV



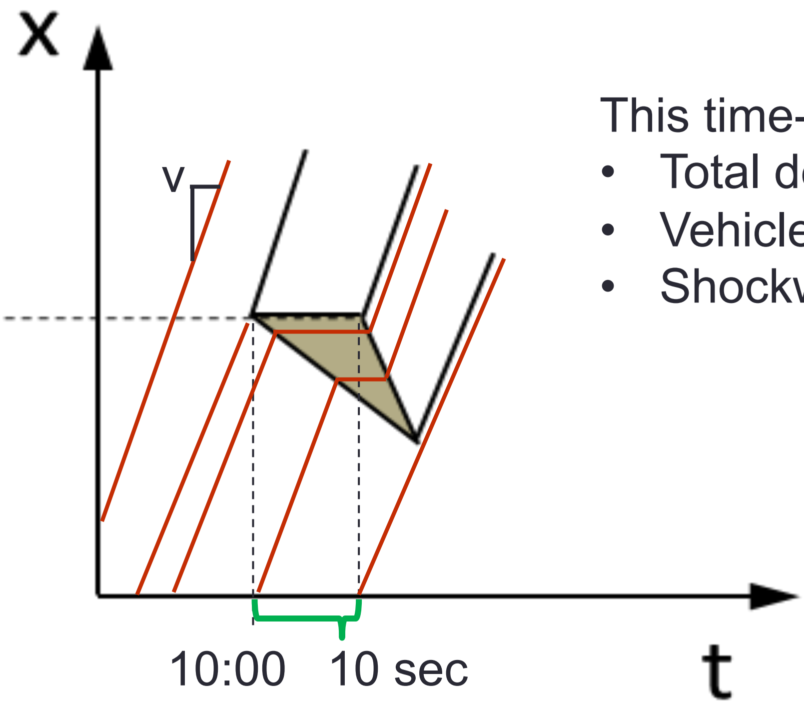


Parking and traffic (microscopic level): Example



Example:

- At 10:00
- At a given location
- A parking maneuver blocks traffic for 10 sec



This time-space diagram shows:

- Total delay
- Vehicles' trajectories
- Shockwaves

Source: J. Cao and M. Menendez (2013) hEART Conference

Parking and traffic

Little parking supply

- More searching traffic
- Longer travel time/distance, lower speeds
- More lane changing maneuvers
- Queuing for parking
- Illegal parking behavior
- …
- May reduce traffic in the long term, but it can really disturb traffic in the short term

Growing parking supply

- More space used for parking in limited urban areas
- Bottlenecks caused by on-street parking behavior, queuing
- Accidents???
- …
- **Will generate more traffic and parking demand in long term**

What is the right balance?
Planning / Policy / Control

Is parking a demand management tool?

Could parking become the equivalent of road pricing?

Parking supply inventory

Pricing and time controls

Parking supply inventory

- Function of:
  - Parking demand or generation rates (e.g., size of retail space, number of residential units)
  - Local policies (e.g., car free zones)
  - Availability of alternative transportation modes (e.g., an airport with limited access to public transportation must offer more parking)
  - Permitted land uses (e.g., parking lots might be encouraged (or discouraged) in certain areas)
  - …

Pricing / Time control schemes

Encourage high turnover (i.e., short stays)

e.g., downtown area, specific stores

Encourage low turnover (i.e., long stays)

e.g., airport parking, large retail surfaces

Variable pricing, time controls…

e.g., 2CHF for up to ½ hr, 8CHF per hr thereafter; or maximum of 1-hr parking

e.g., 4CHF for up to 1 hr, 0.50CHF per hr thereafter; or minimum of 1-day parking

Case study: Zurich - Jelmoli area

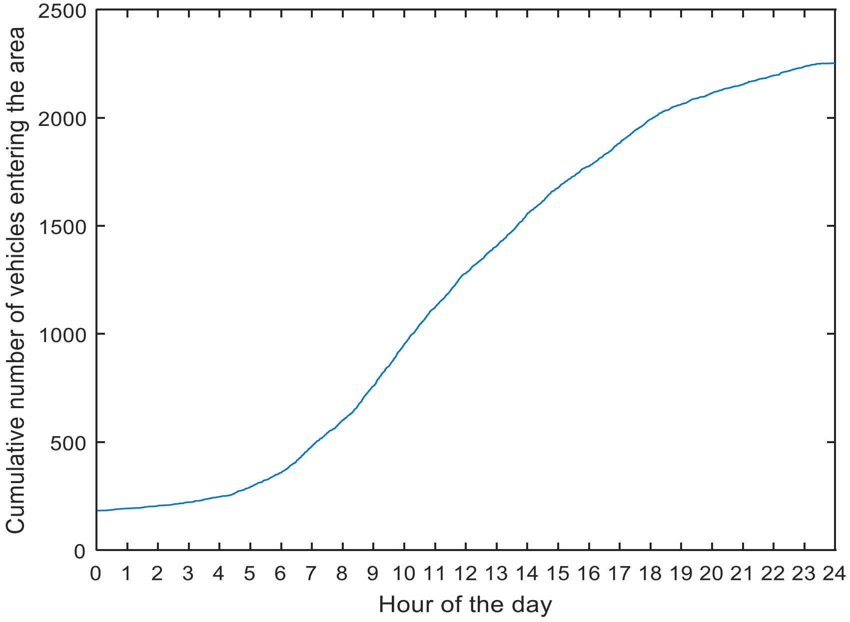
332 off-street parking spaces

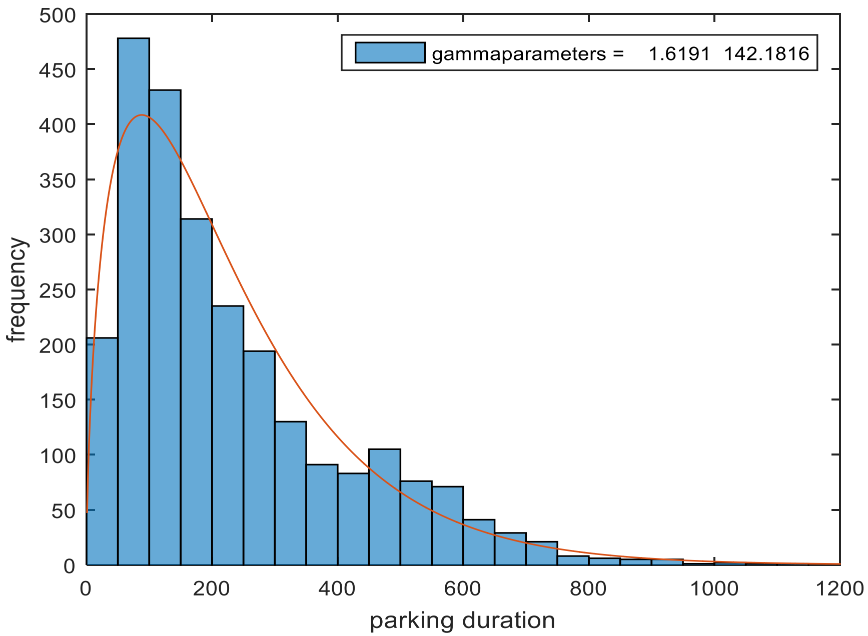
207 on-street parking spaces

106 links
7.7 kilometers

Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).

Car demand and desired parking durations



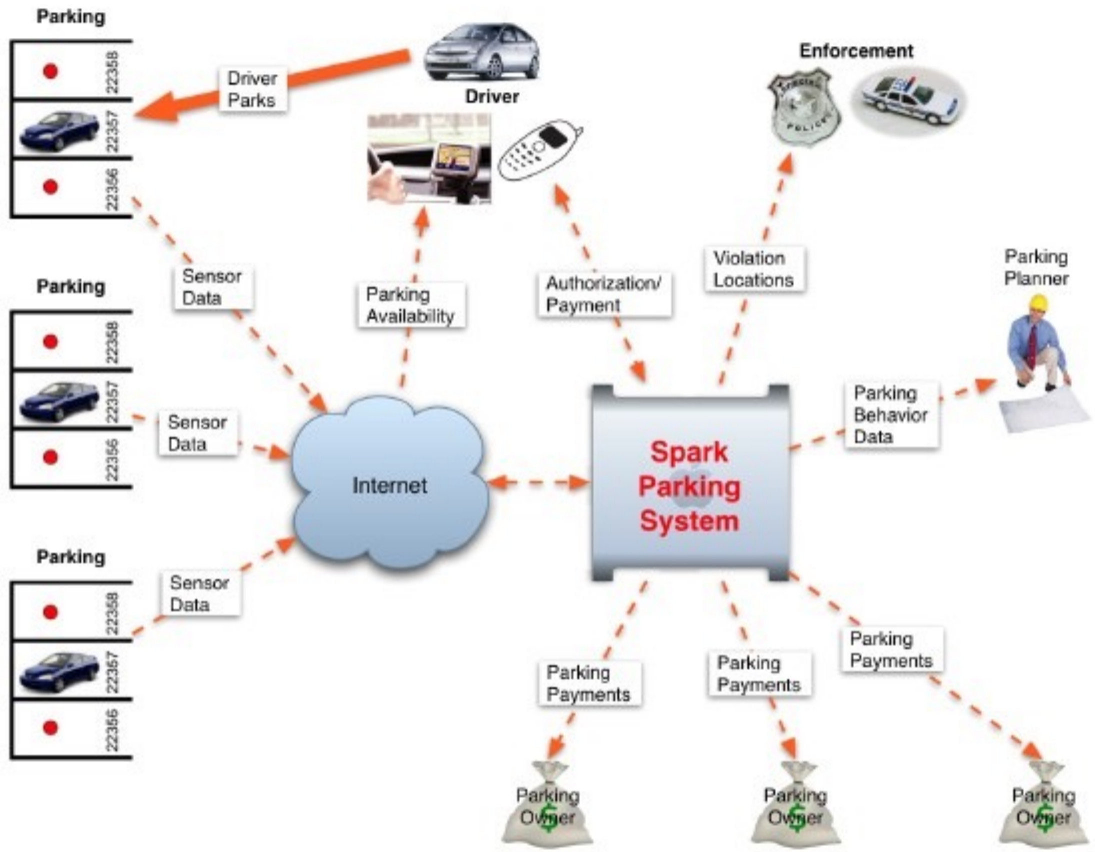


Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).

More advanced parking technology

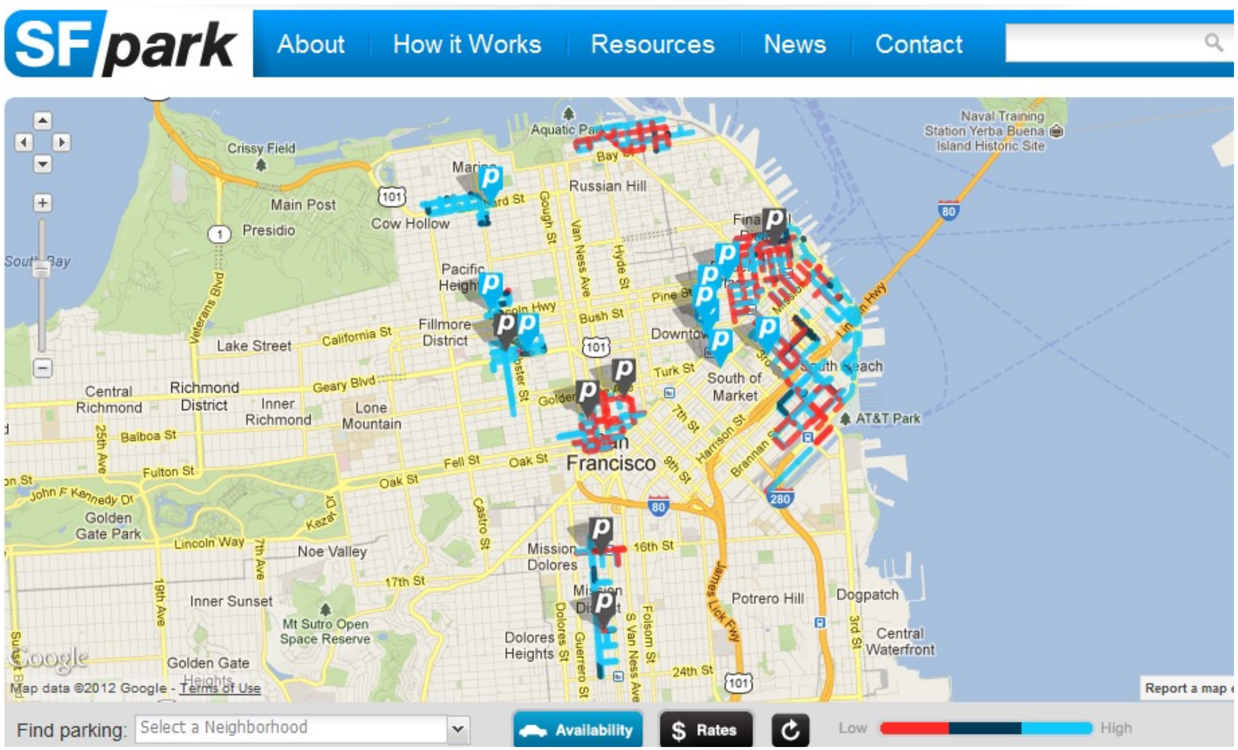
- Occupancy detectors
- Automatic linkage between occupancy detectors and fee collection systems
- Real time information about parking availability (e.g., for on-street parking)
- …

More advanced parking technology



Source: www.sparkparking.com

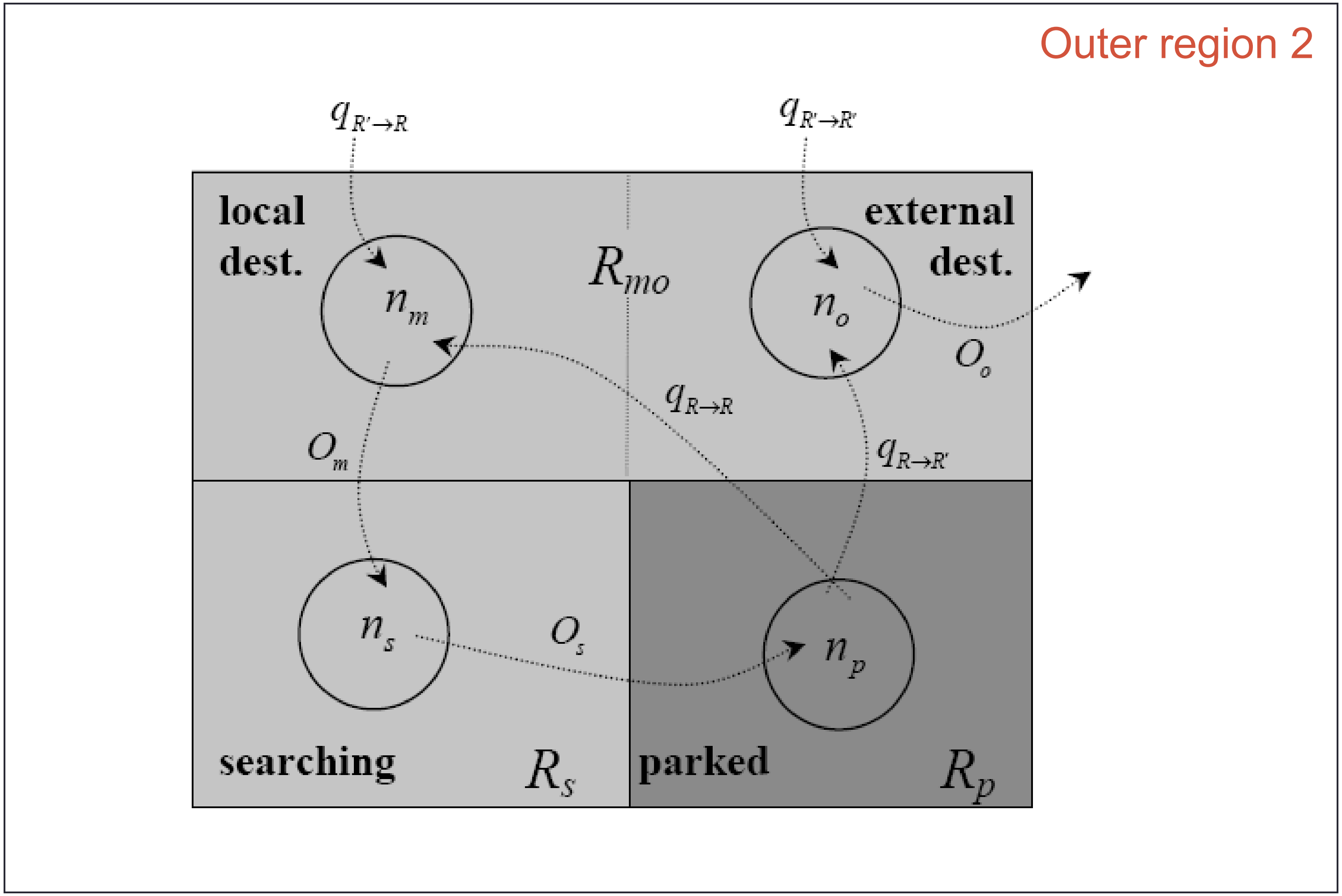
More advanced parking technology



- Pricing (demand responsive pricing per block, time of day, and day of week), both for on-street and garage parking
- Wireless pavement sensors (to track parking availability)
- Meters (accepting different types of payment, incl. credit)
- Open source data for developers
- PayByPhone (add time without returning to meter, reminder messages for expiring meters, online receipts)
- Computer apps (real time information on cells, text messages, computer maps, variable signs)

Source: www.sfpark.org

Parking Dynamics



Parking Dynamics

The output for sub-reservoirs m, s, o, is (Little's formula):

$$O_x\left(n_x,n\right)=\frac{n_x}{n}\cdot\frac{P\left(n\right)}{l_x},\quad x\in\left\{m,s,o\right\}$$

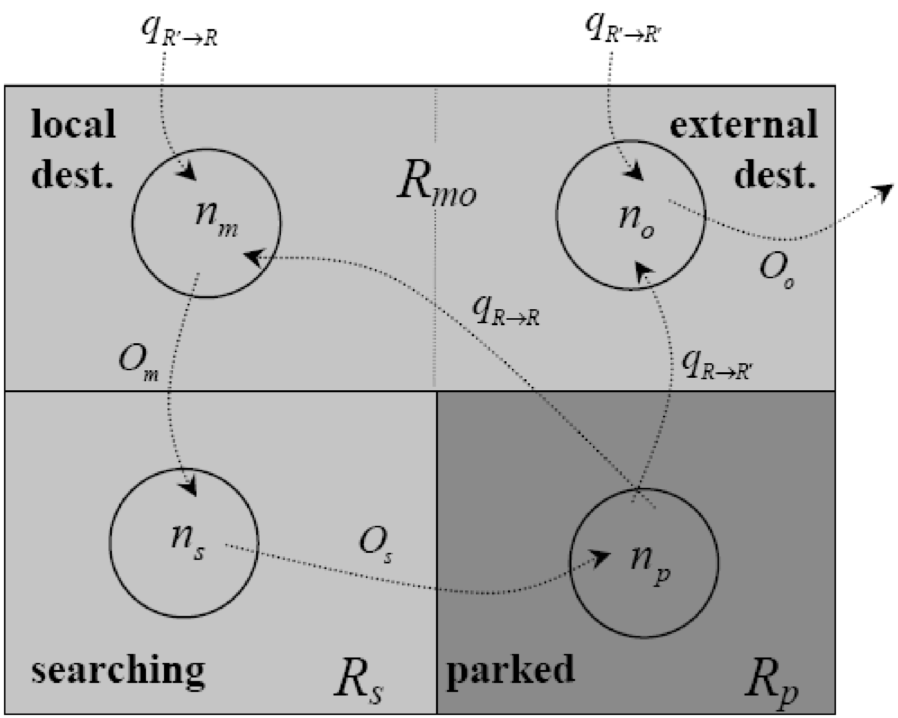
Dynamic equations:

$$\frac{dn_m}{dt}=q_{R'\to R}+q_{R\to R}-O_m\left(n_m,n\right)$$

$$\frac{dn_s}{dt}=O_m\left(n_m,n\right)-O_s\left(n_s,n\right)$$

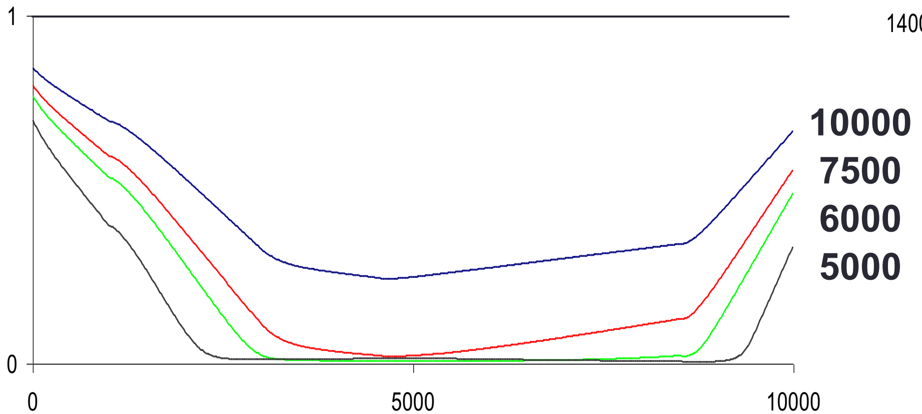
$$\frac{dn_o}{dt}=q_{R'\to R'}+q_{R\to R'}-O_o\left(n_o,n\right)$$

$$\frac{dn_p}{dt}=O_s\left(n_s,n\right)-q_{R\to R}-q_{R\to R'}$$

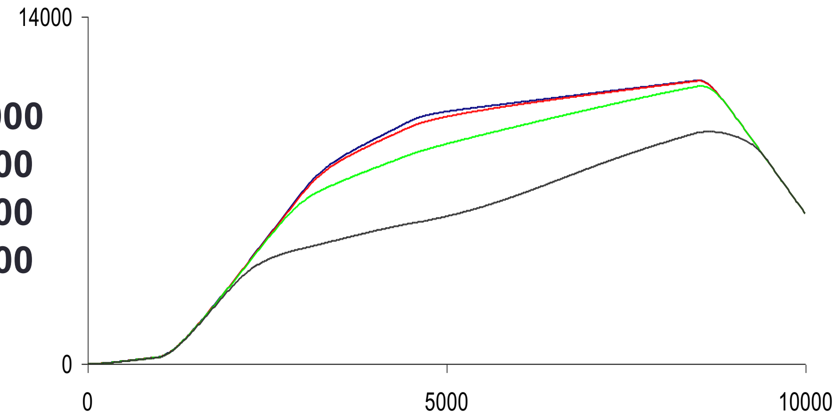


A “Cruising for Parking” Simulation

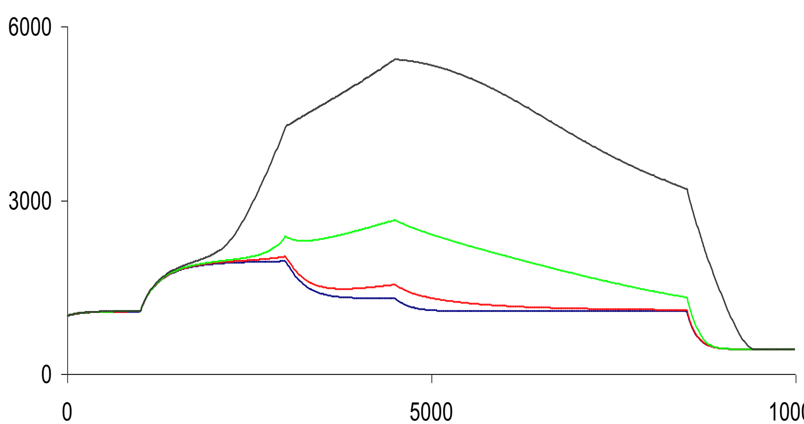
PARKING AVAILABILITY



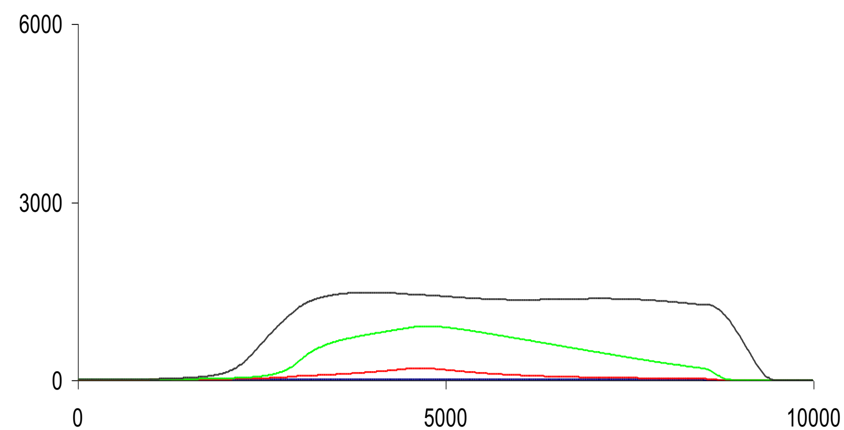
TOTAL # OF TRIPS ENDED



TOTAL # OF VEHICLES

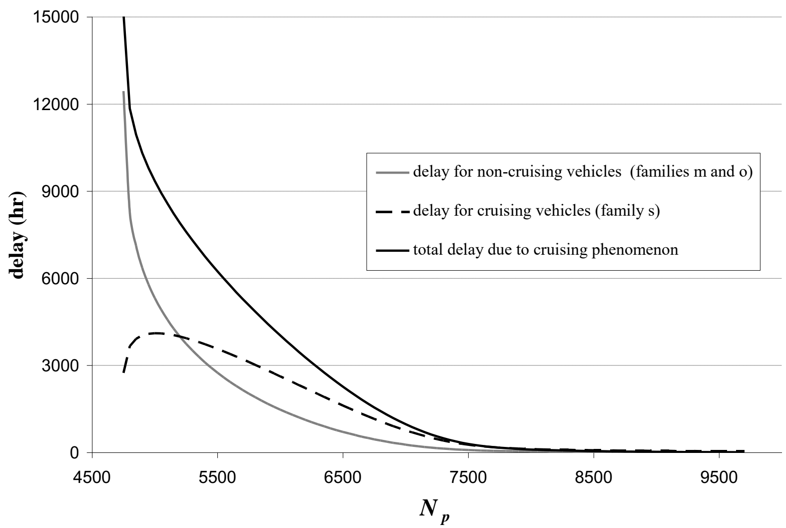


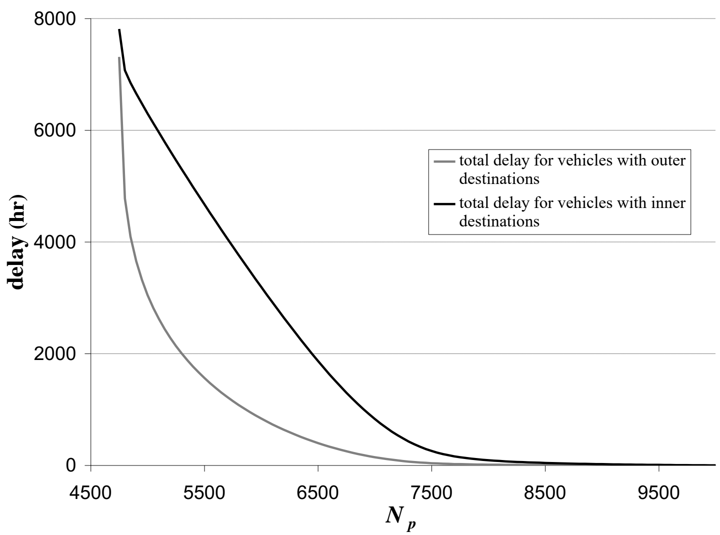
OF VEHICLES SEARCHING



HORIZONTAL AXES : TIME

Interesting observations



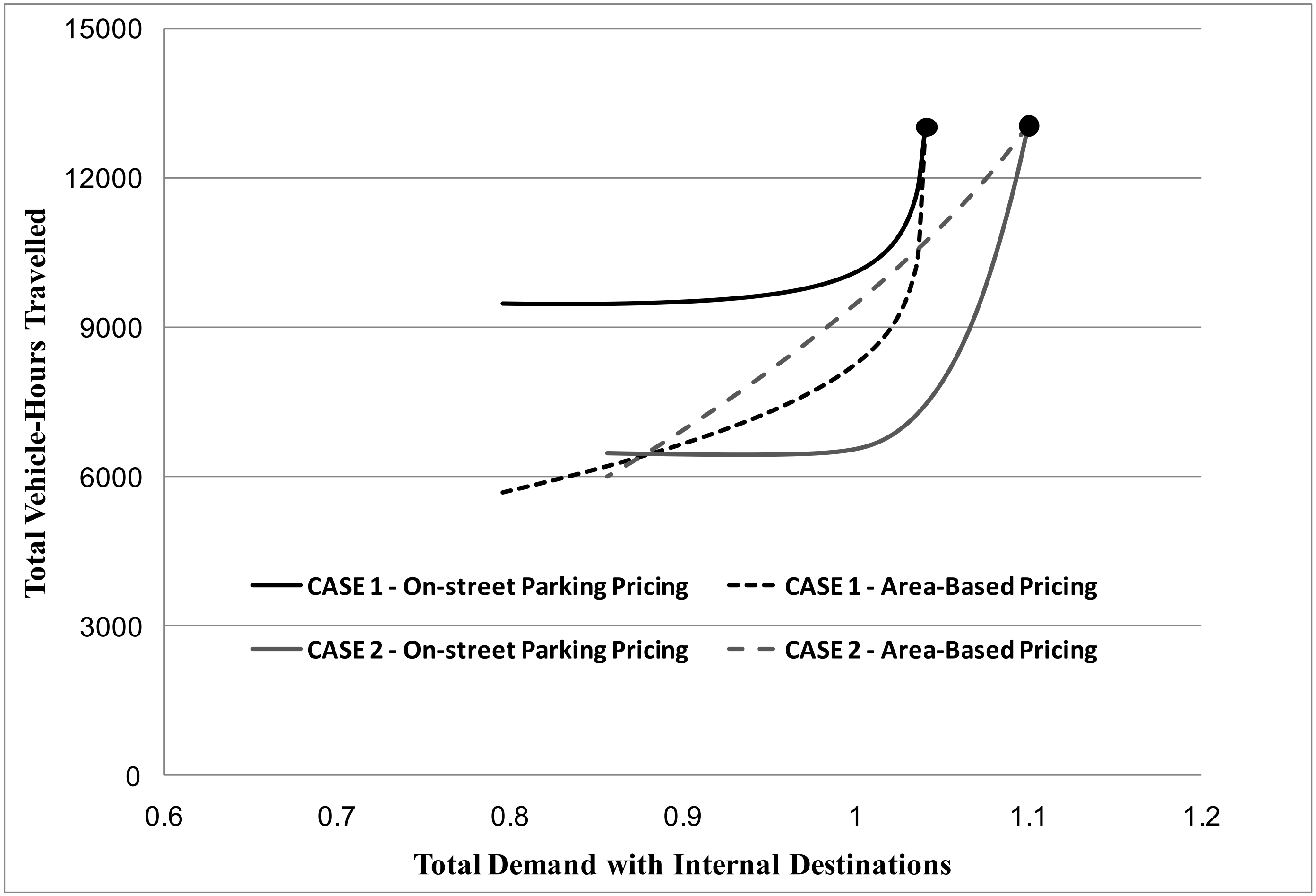


- The marginal cost of an additional user with external destination is smaller than that of a user who will cruise for parking

- An additional user with internal destination, causes more delays in the non-cruising vehicles, than the cruising ones.

- The delay for vehicles with outer destinations can be a significant part of the delay.

Area-Based Pricing vs. On-Street Parking Pricing



CASE 1: f_{in}=1.04, f_{ex}=1.46; CASE 2: f_{in}=1.1, f_{ex}=1.1