the Pothole Patrol

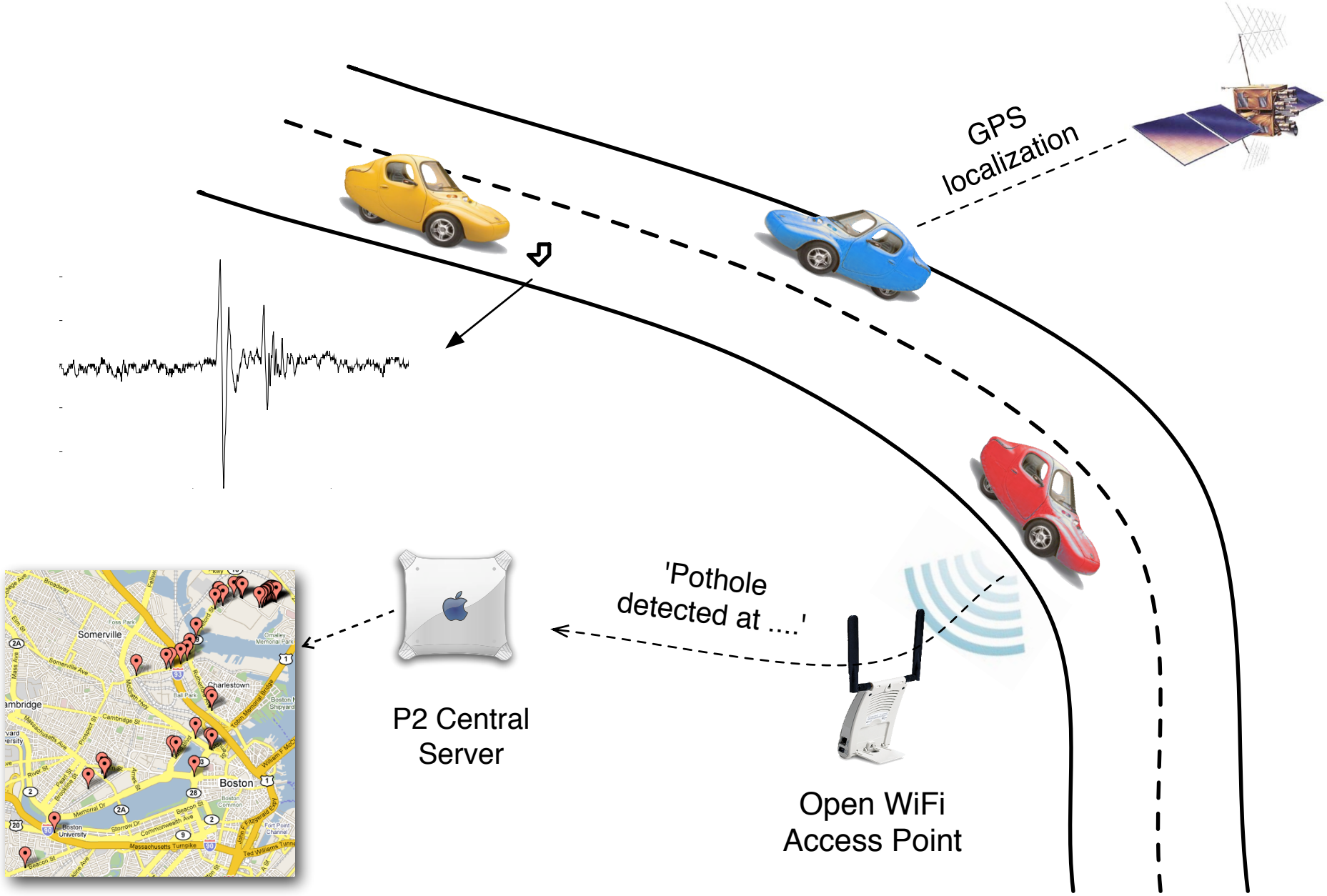
6.S062
(Based on slides from Jakob Eriksson)



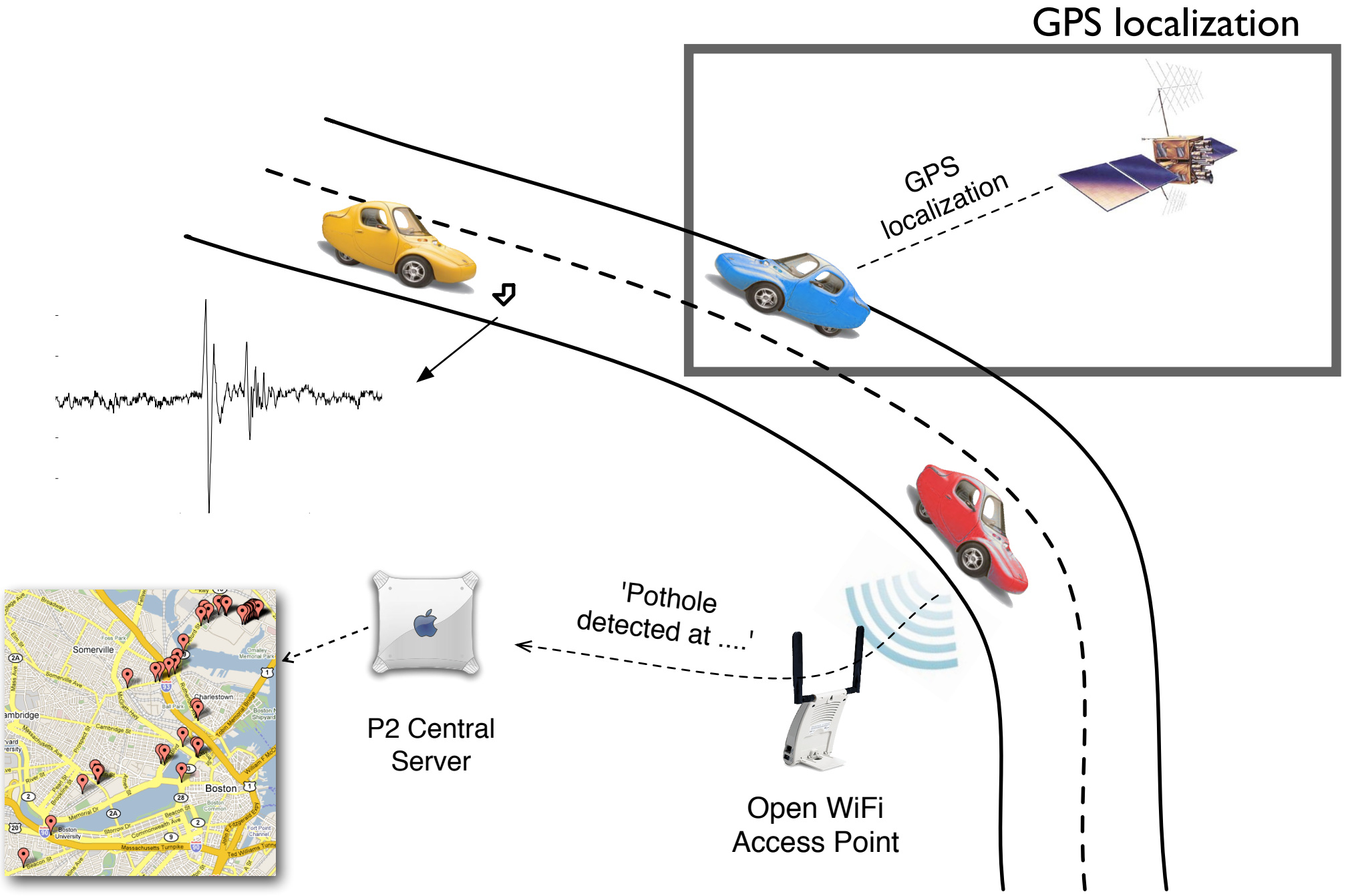
- road decay unavoidable, hard to predict
- current monitoring methods costly/ineffective

2

the Pothole Patrol

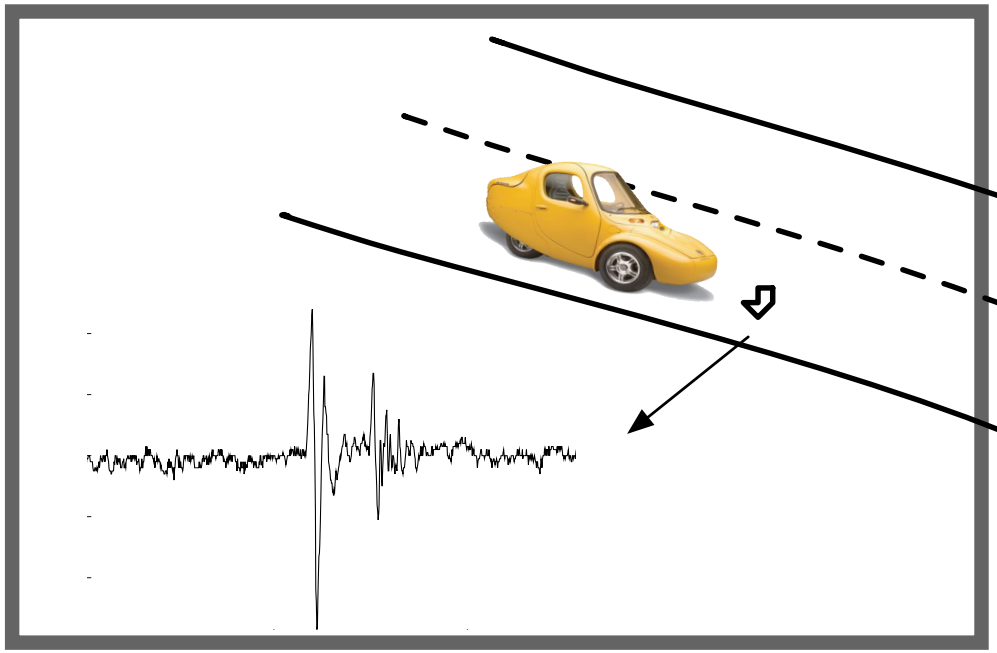


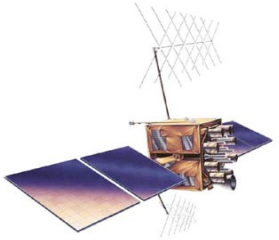
the Pothole Patrol



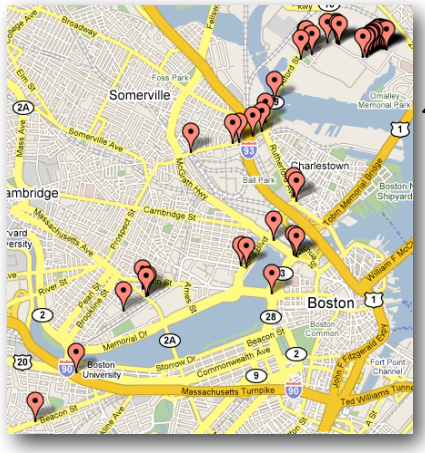
the Pothole Patrol

opportunistic accelerometer sensing





GPS
localization





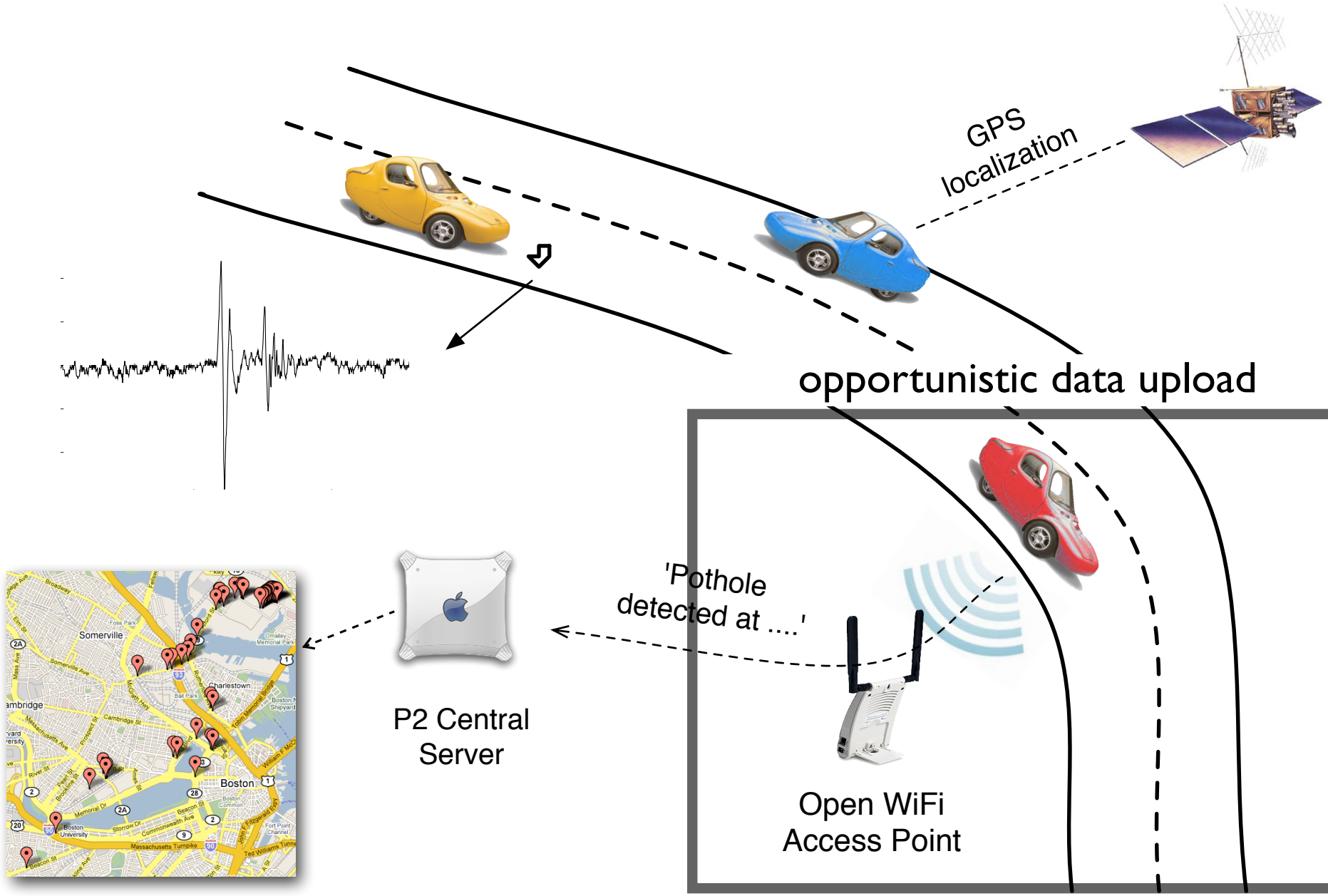
P2 Central
Server

'Pothole
detected at ....'

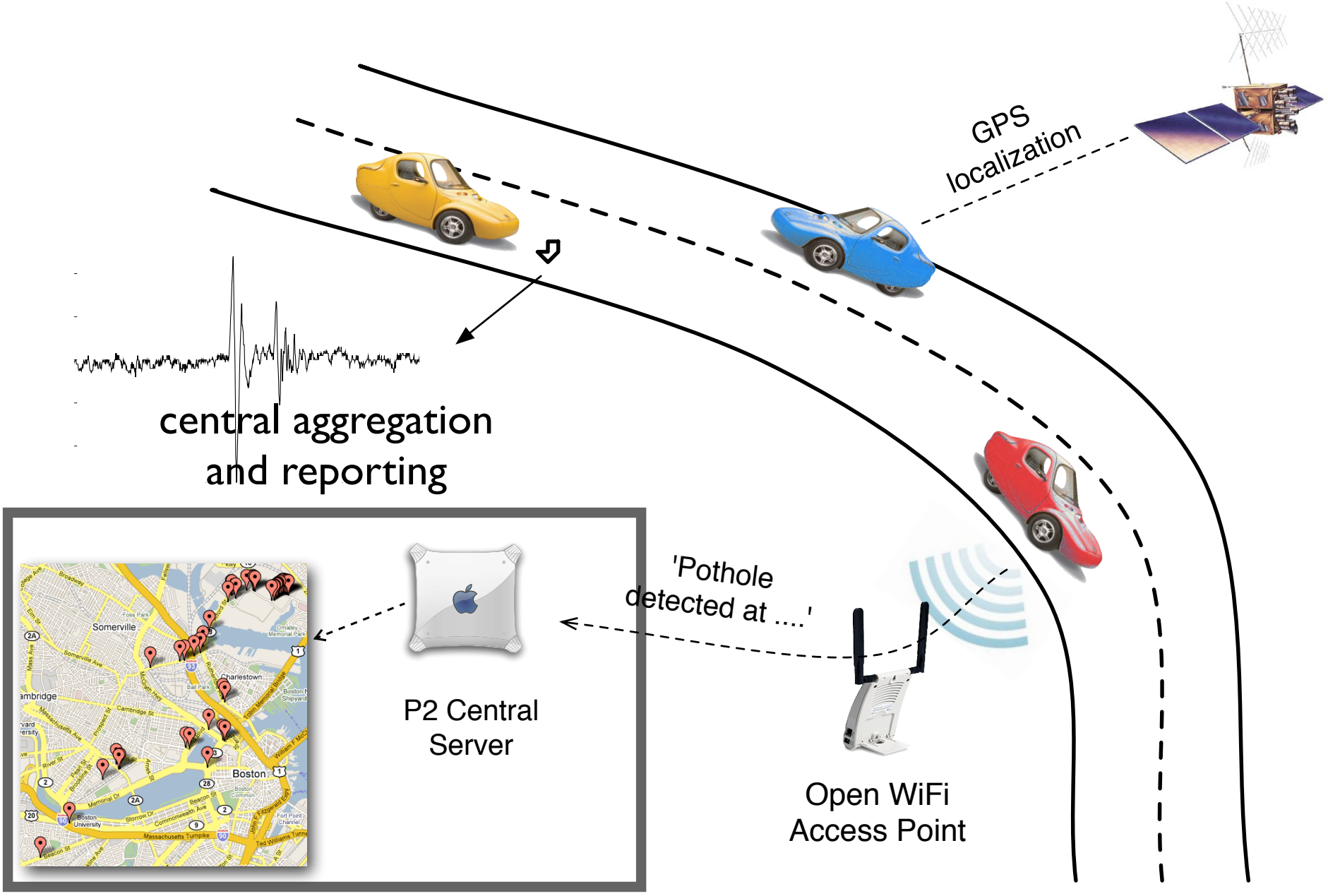


Open WiFi
Access Point

the Pothole Patrol



the Pothole Patrol



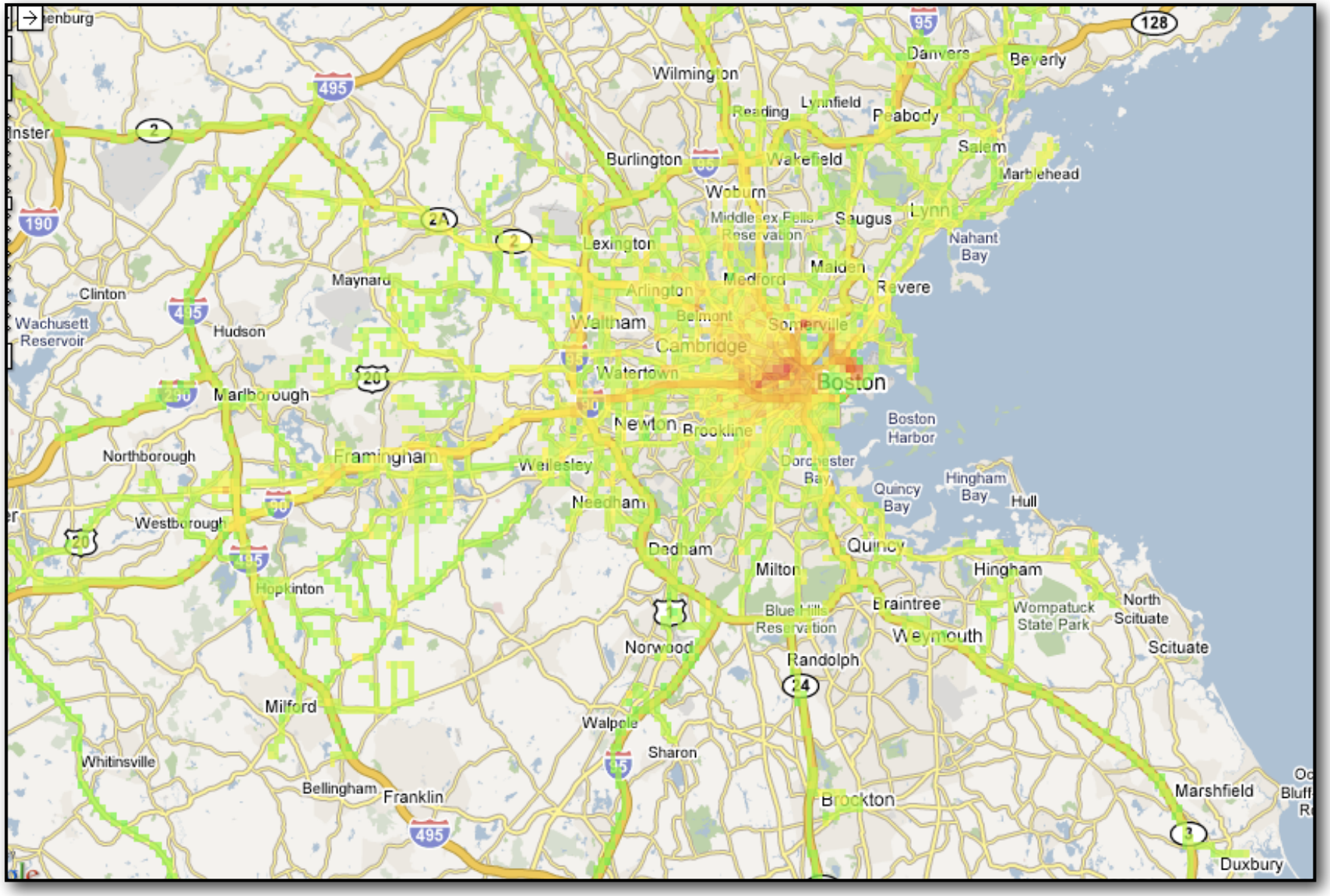
experimental platform

- 7 Boston/Cambridge taxis
- small computer in glove box
- 400 Hz 3-axis accelerometer
- 802.11a/b/g wireless interface
- GPS receiver on roof



4

wide-area sensing



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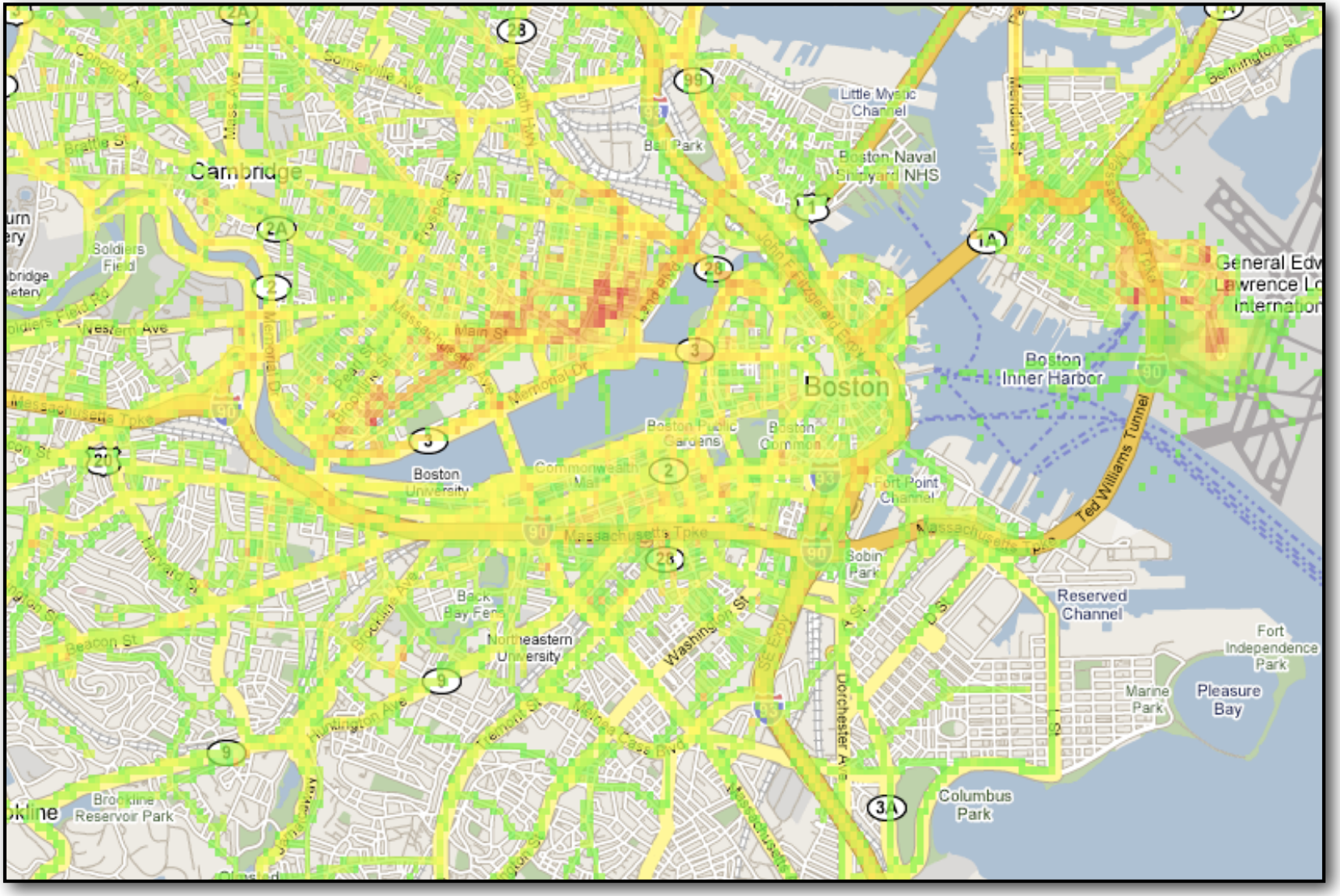
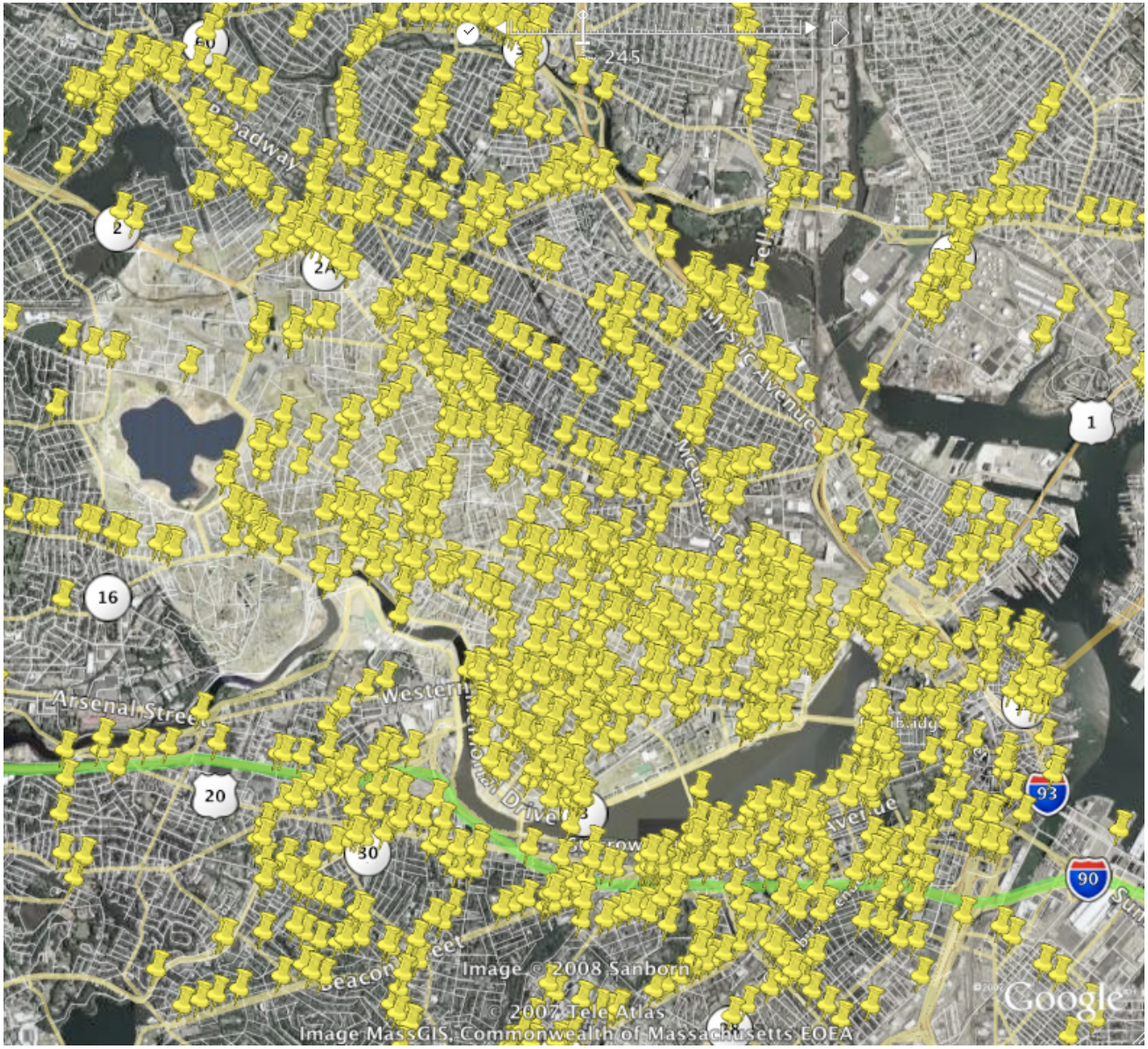

Cambridge
Boston
Boston Inner Harbor
Boston Naval Shipyard NHS
Little Mystic Channel
Bell Park
Soldiers Field
Boston University
Boston Public Gardens
Boston Common
Commonwealth Mall
Fort Point Channel
Ted Williams Tunnel
Massachusetts Turnpike
Back Bay Fens
Northeastern University
Reserved Channel
Fort Independence Park
Pleasure Bay
Marine Park
Columbus Park
Brookline Reservoir Park
Main St
Western Ave
Memorial Dr
Beacon St
Harvard St
Washington St
Dorchester Ave
Soldiers Field Rd
Massachusetts Tpke

6

open WiFi connectivity



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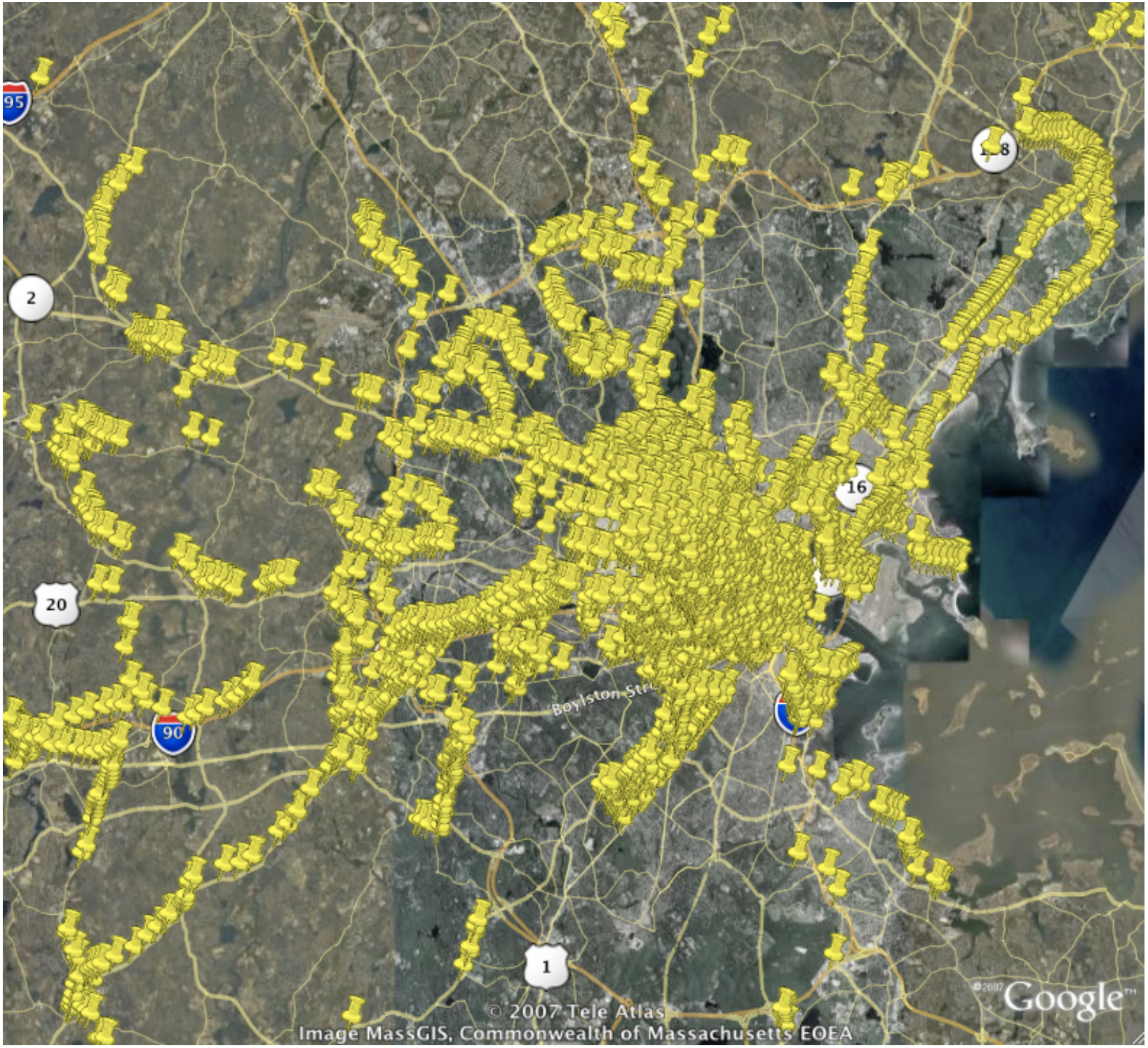
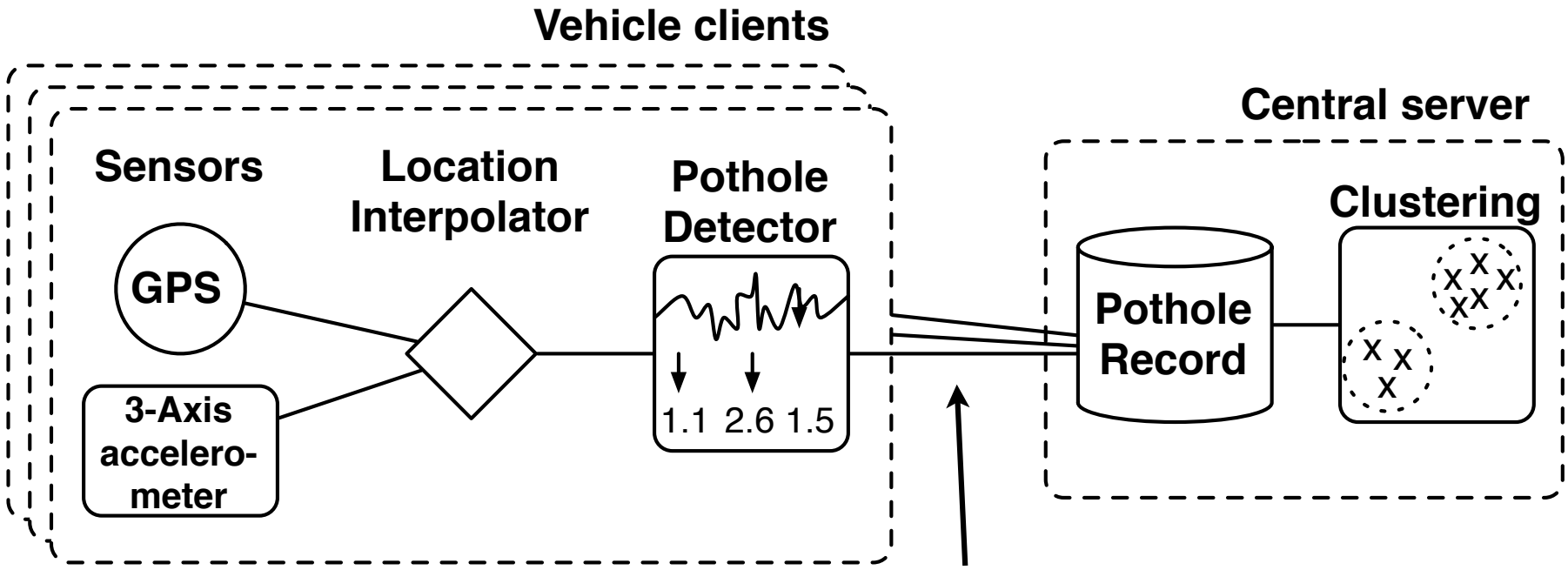

95
2
20
90
1
16
Boylston Str
© 2007 Tele Atlas
Image MassGIS, Commonwealth of Massachusetts EOEA
Google™

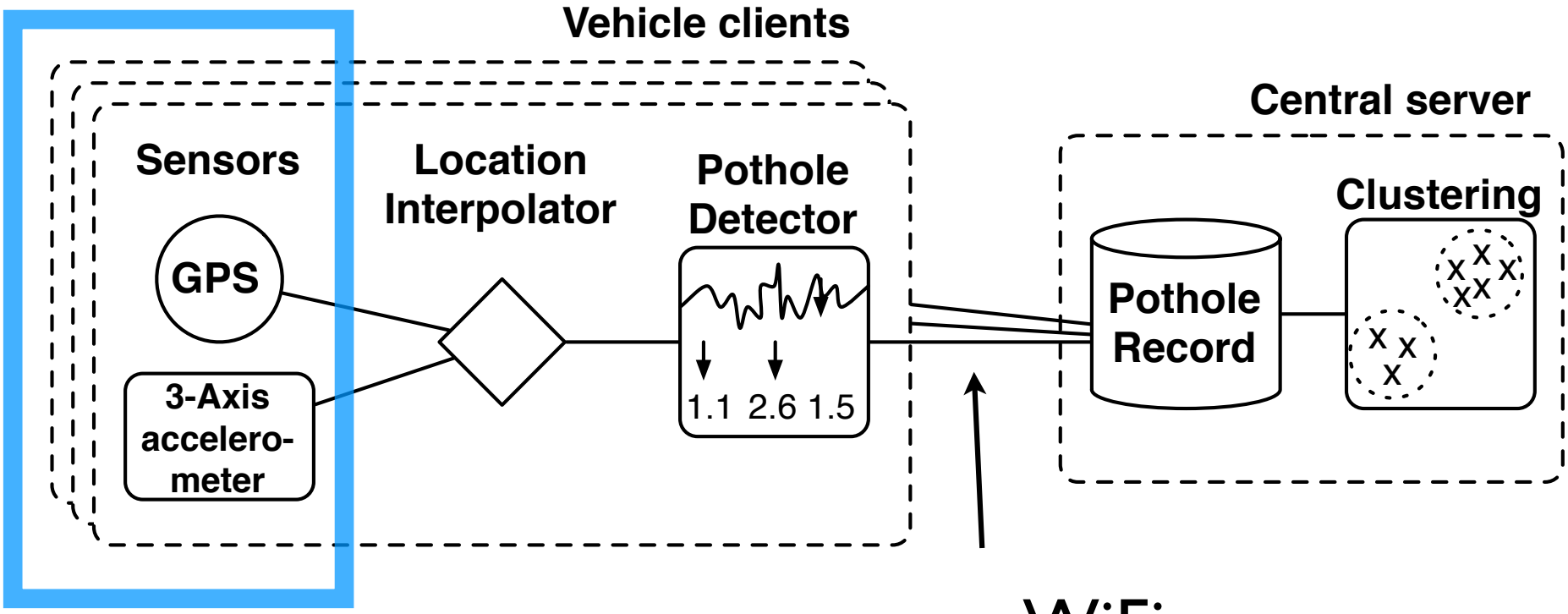
8

P² architecture

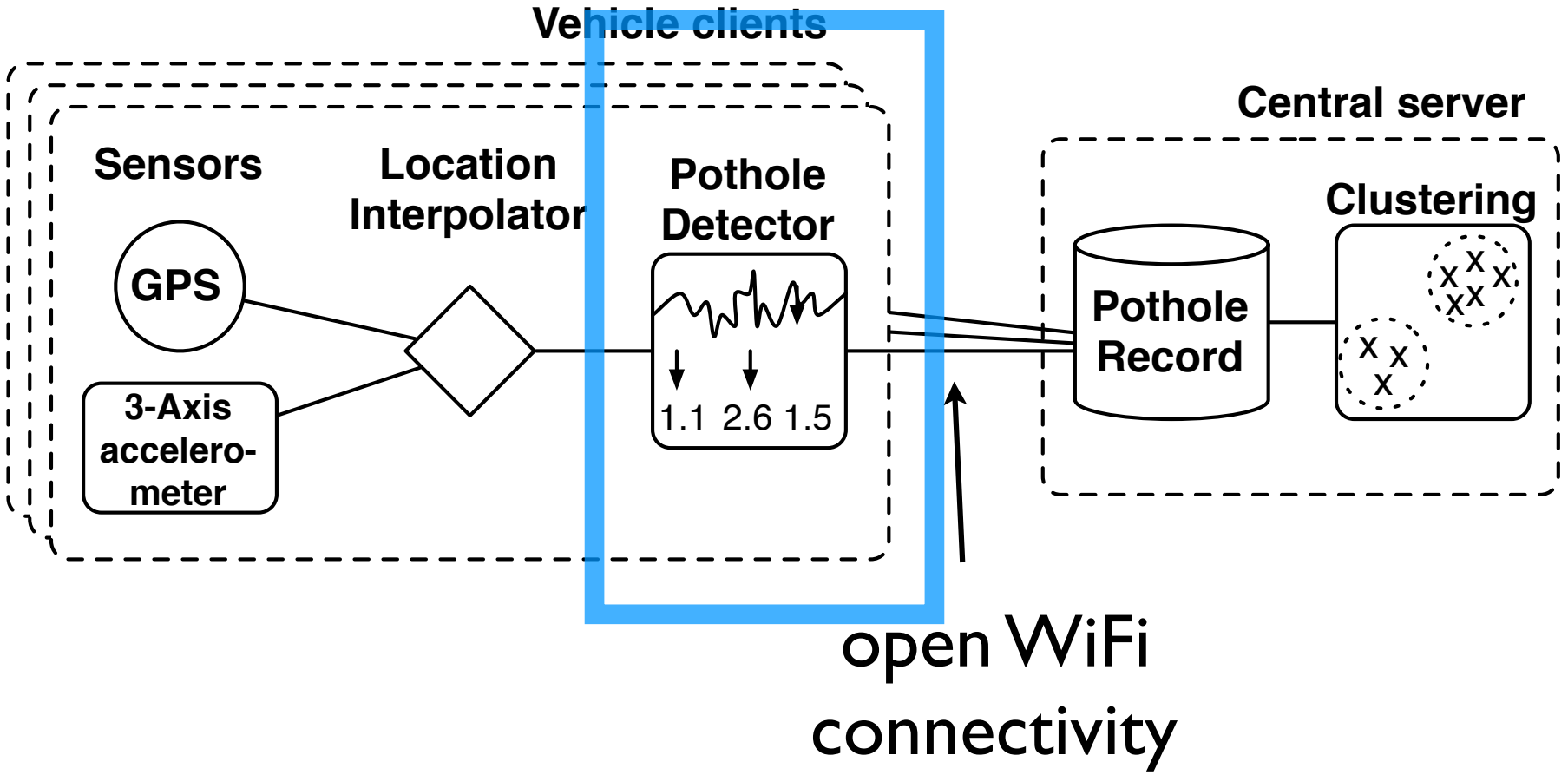


open WiFi connectivity

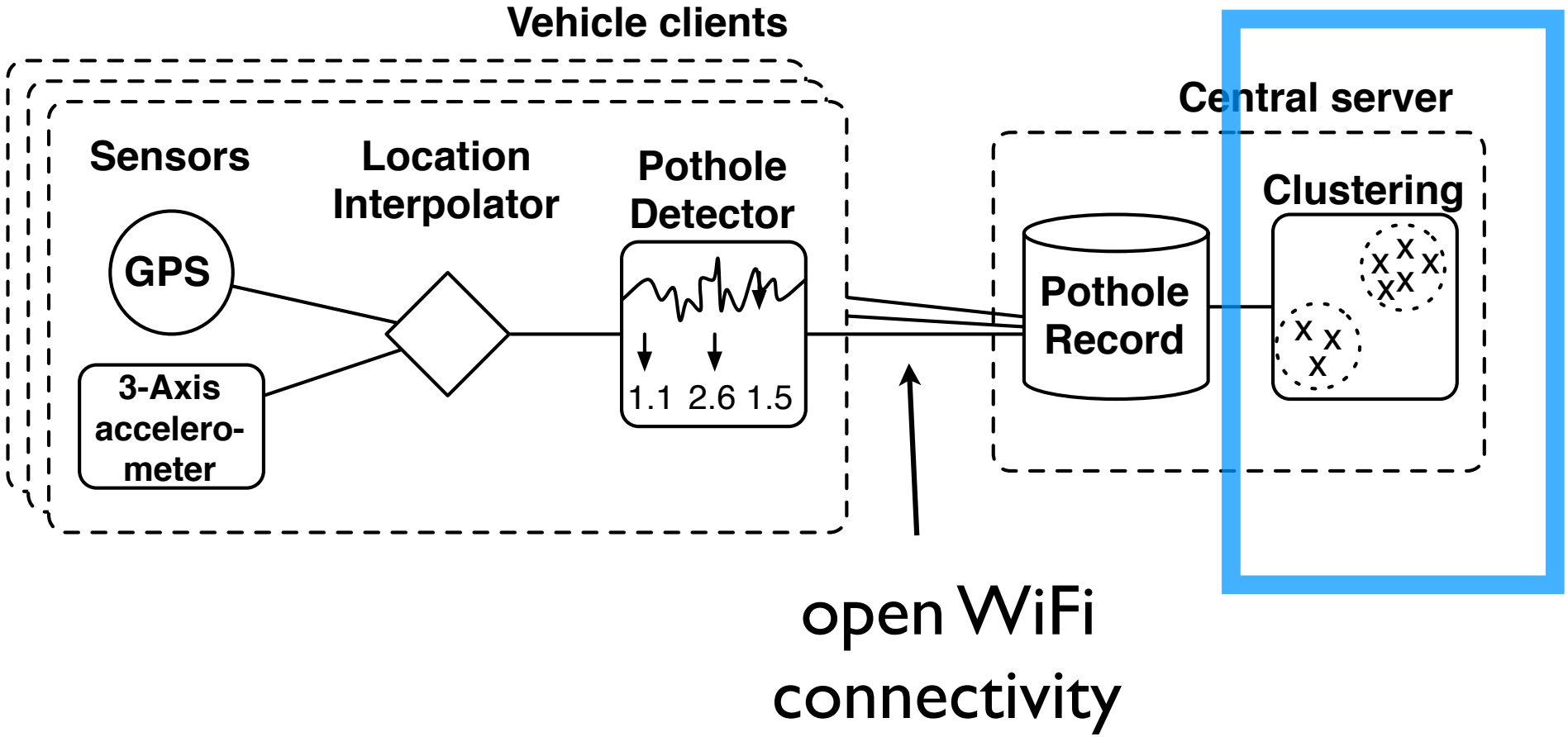
P² architecture



P² architecture



P² architecture



sensor placement



- highly accurate
- difficult mounting
- extreme exposure

sensor placement



try to stay
inside vehicle

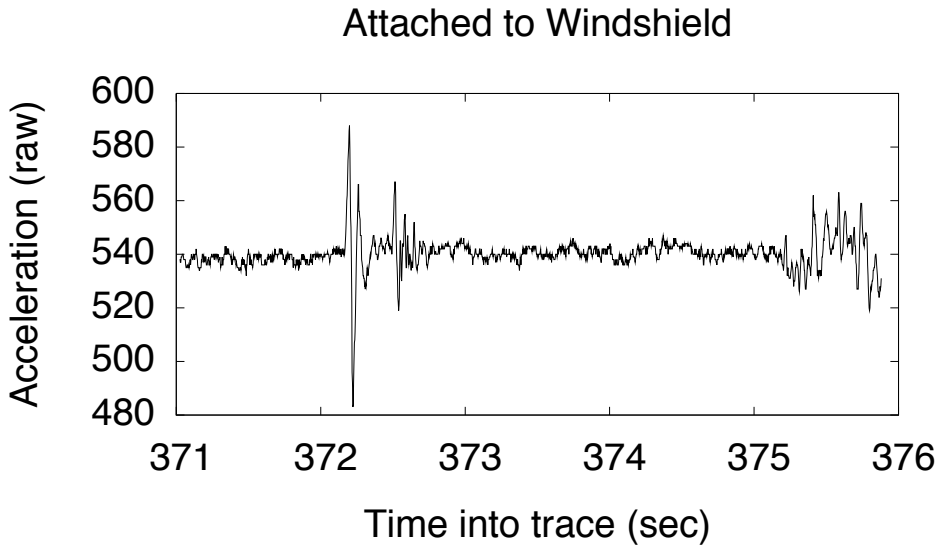
- highly accurate
- difficult mounting
- extreme exposure

WINDSHIELD?

DASHBOARD?

ATTACHED TO PC?

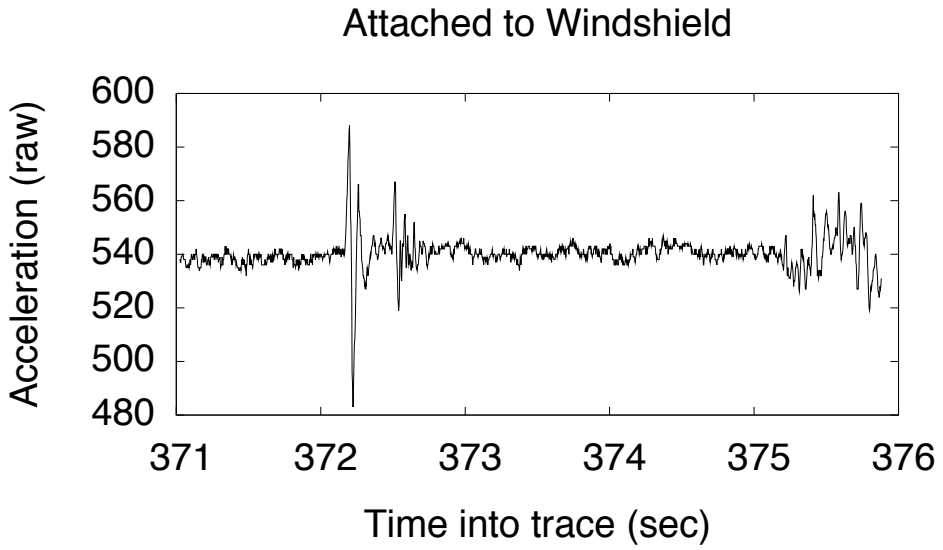
- very clean signal
- ‘gold standard’
- difficult to mount

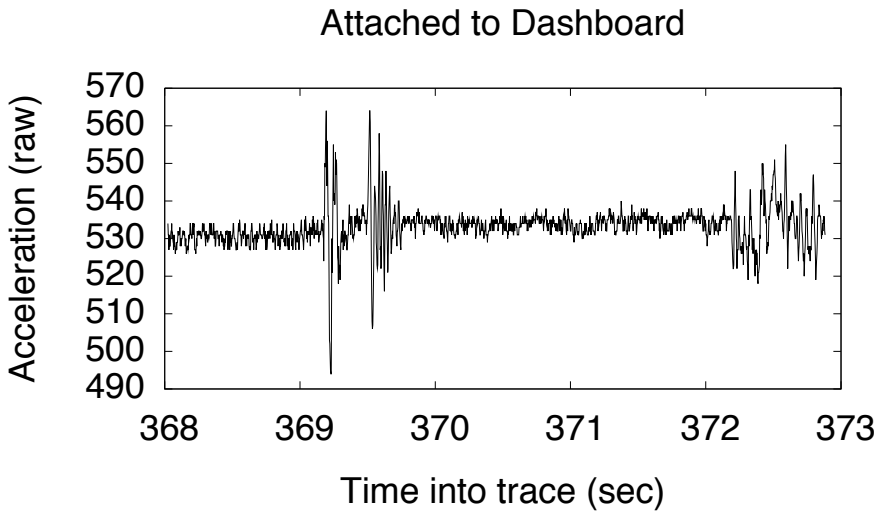


DASHBOARD?

ATTACHED TO PC?

- very clean signal
- ‘gold standard’
- difficult to mount

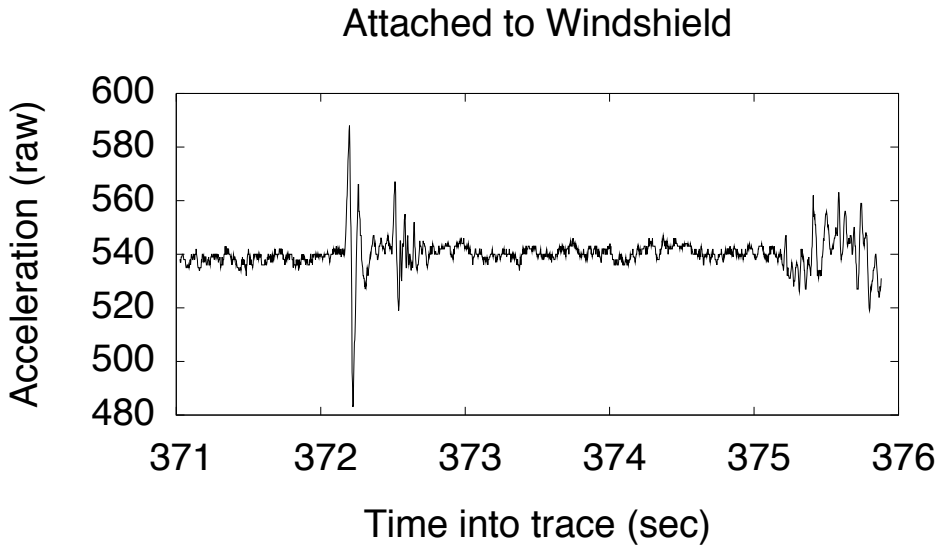


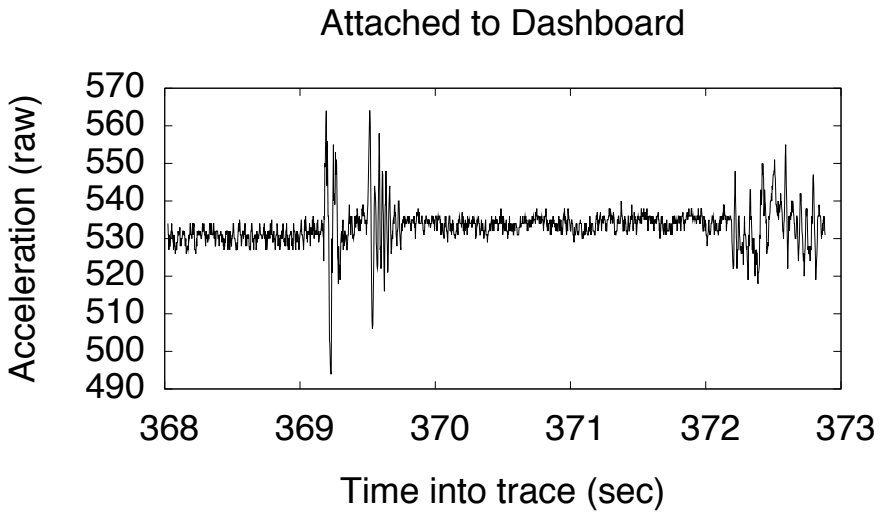


- good signal
- easy to mount
- ‘out of the way’

ATTACHED TO PC?

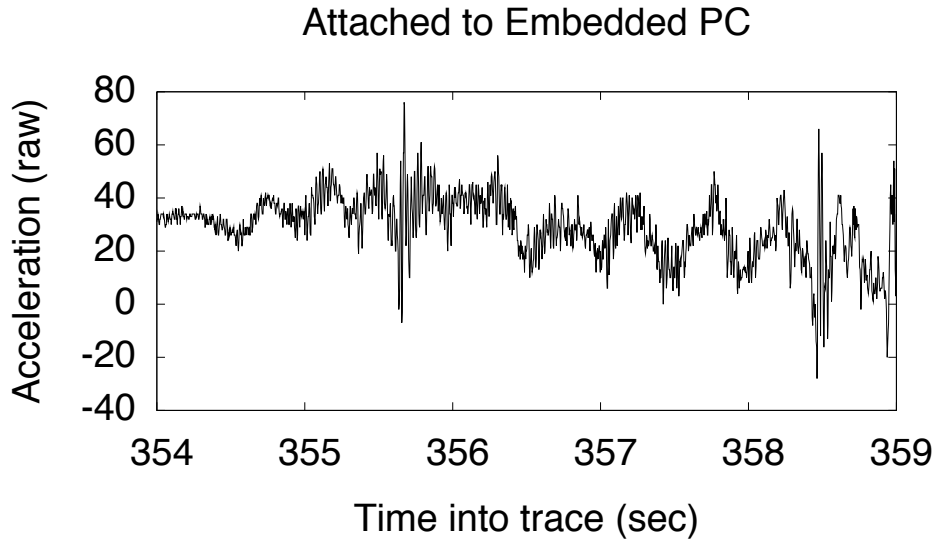
- very clean signal
- ‘gold standard’
- difficult to mount

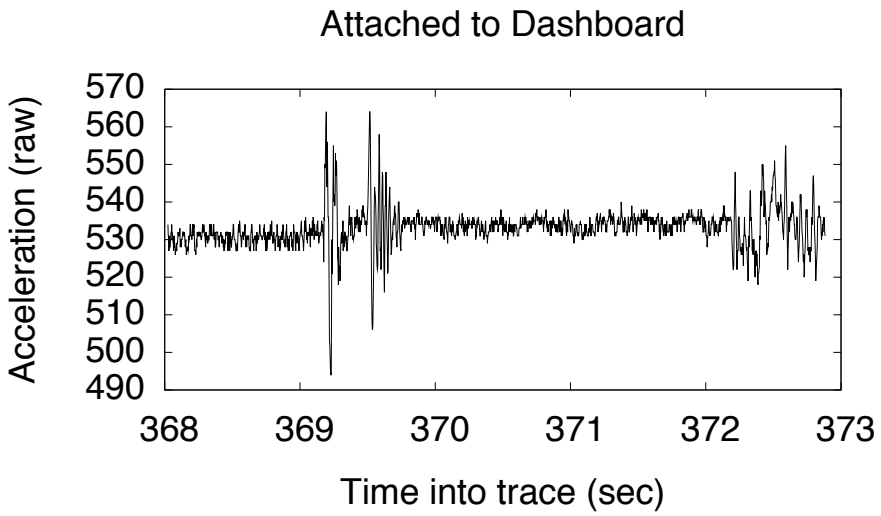




- good signal
- easy to mount
- ‘out of the way’

- very poor signal
- no mounting necessary



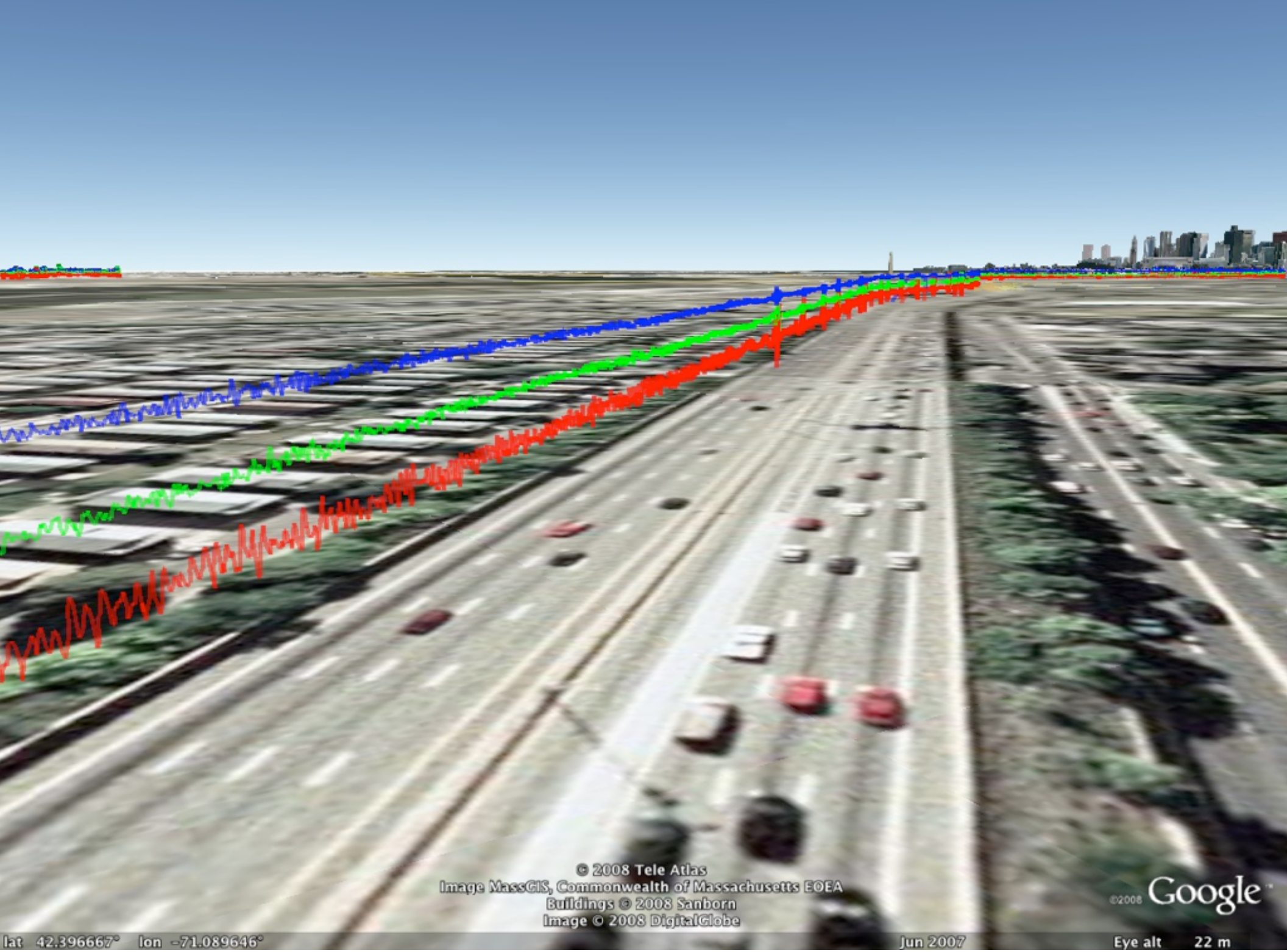


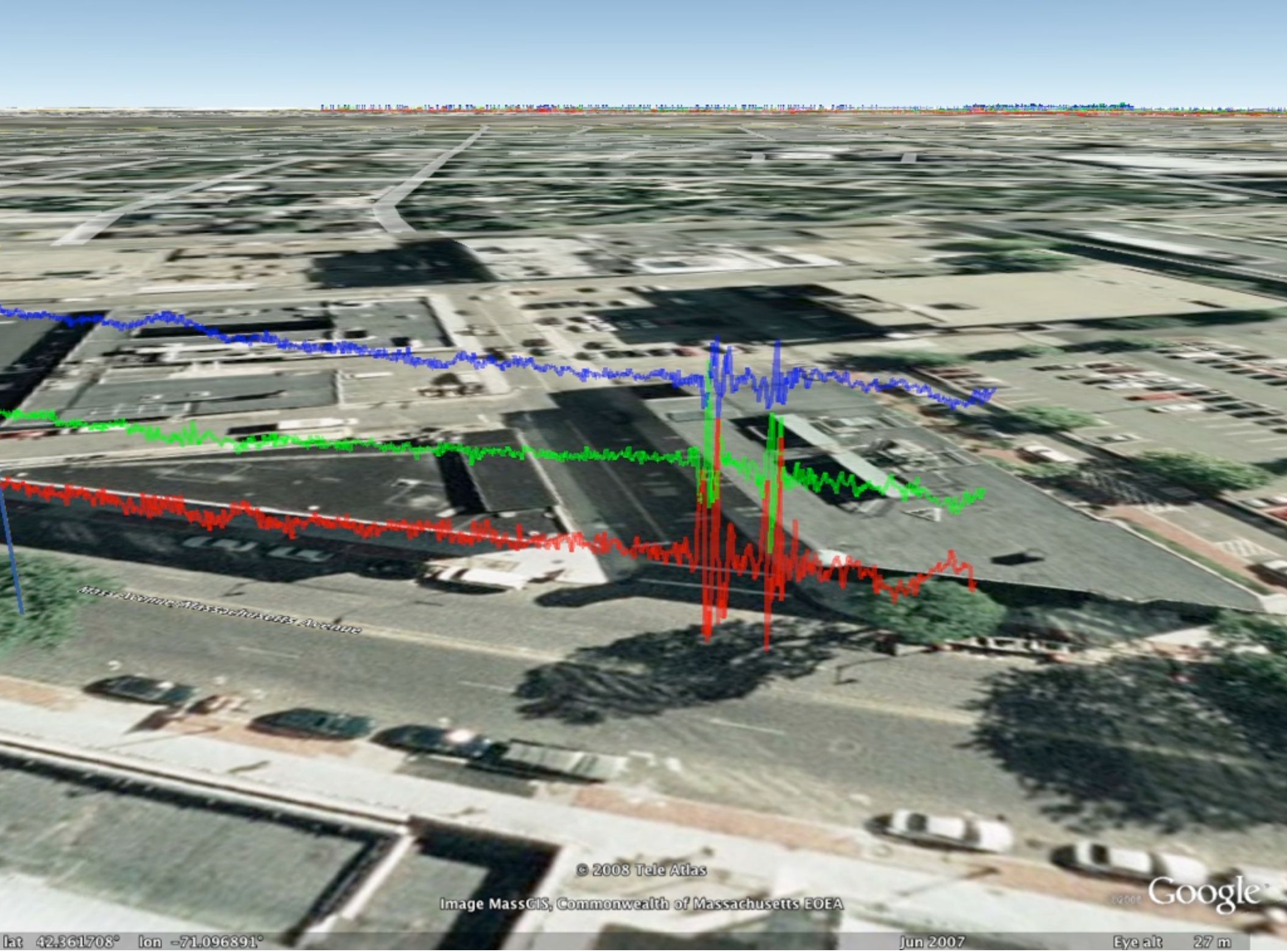
- good signal
- easy to mount
- 'out of the way'

11

crowd-pleasing graphics

CONTINUE


© 2008 Tele Atlas
Image MassGIS, Commonwealth of Massachusetts EOEA
Buildings © 2008 Sanborn
Image © 2008 DigitalGlobe
©2008 Google
lat 42.396667° lon -71.089646°
Jun 2007
Eye alt 22 m


Massachusetts Avenue
© 2008 Tele Atlas
Image MassGIS, Commonwealth of Massachusetts EOEA
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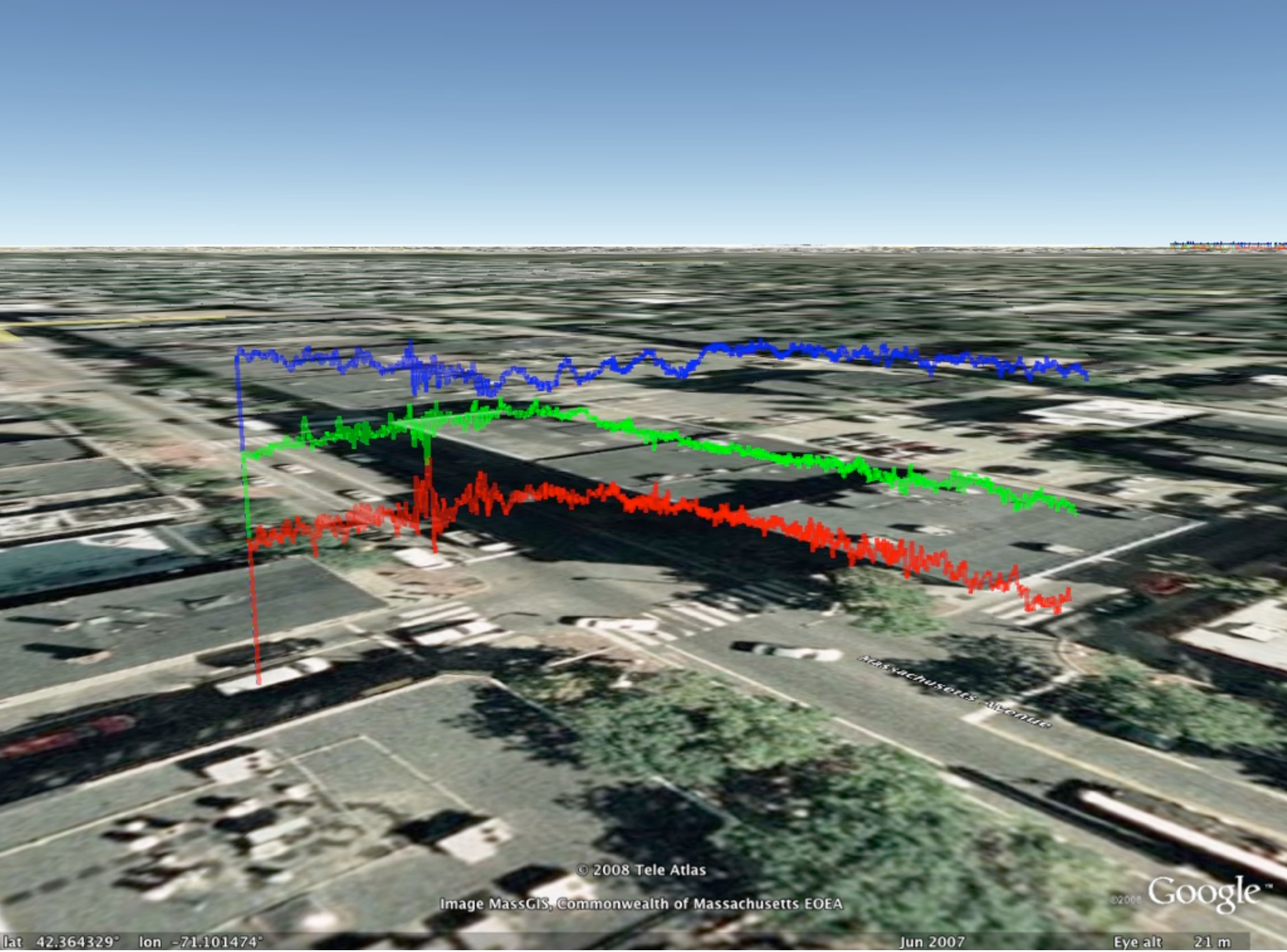
Massachusetts Avenue
© 2008 Tele Atlas
Image MassGIS, Commonwealth of Massachusetts EOEA
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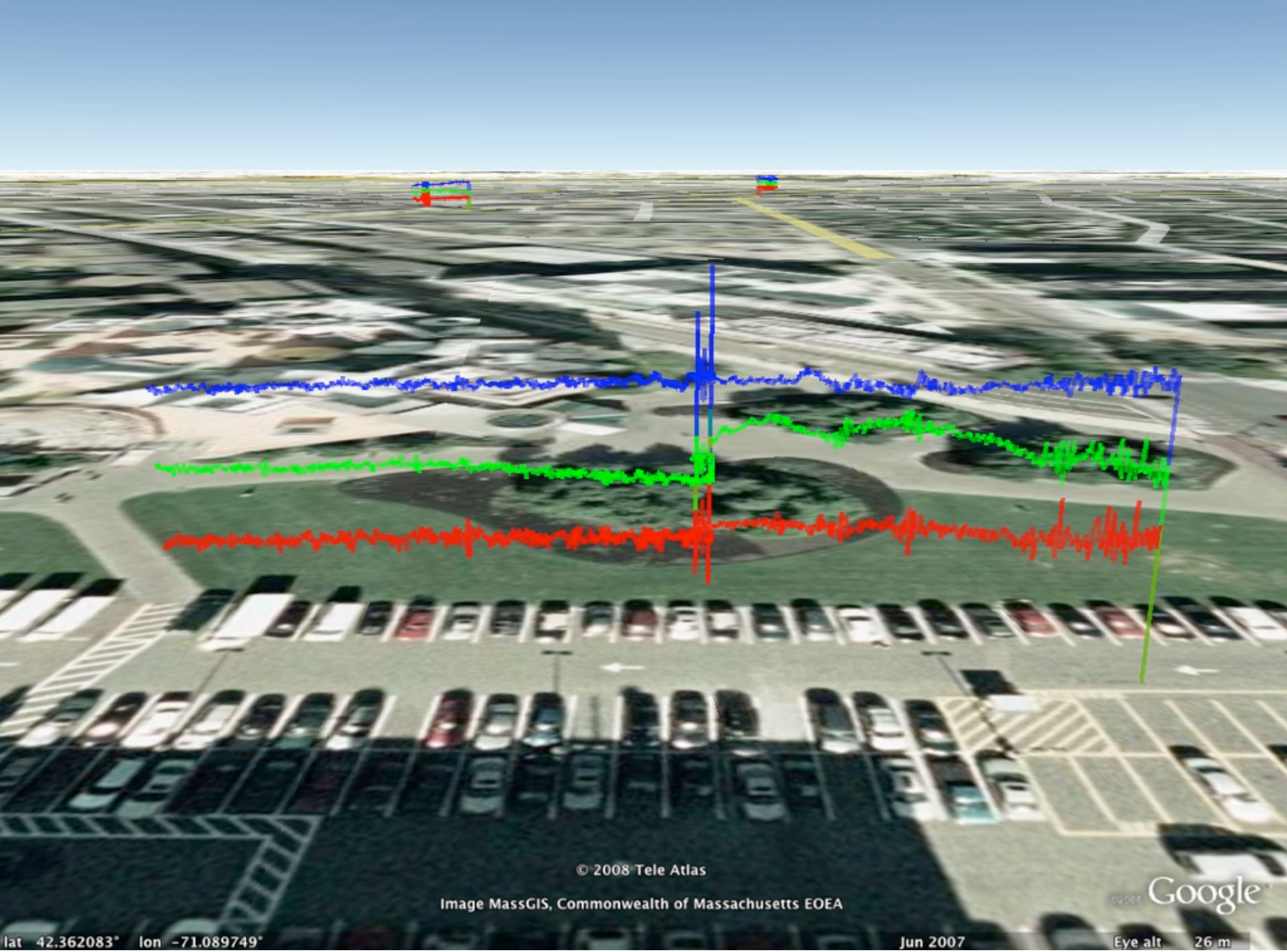
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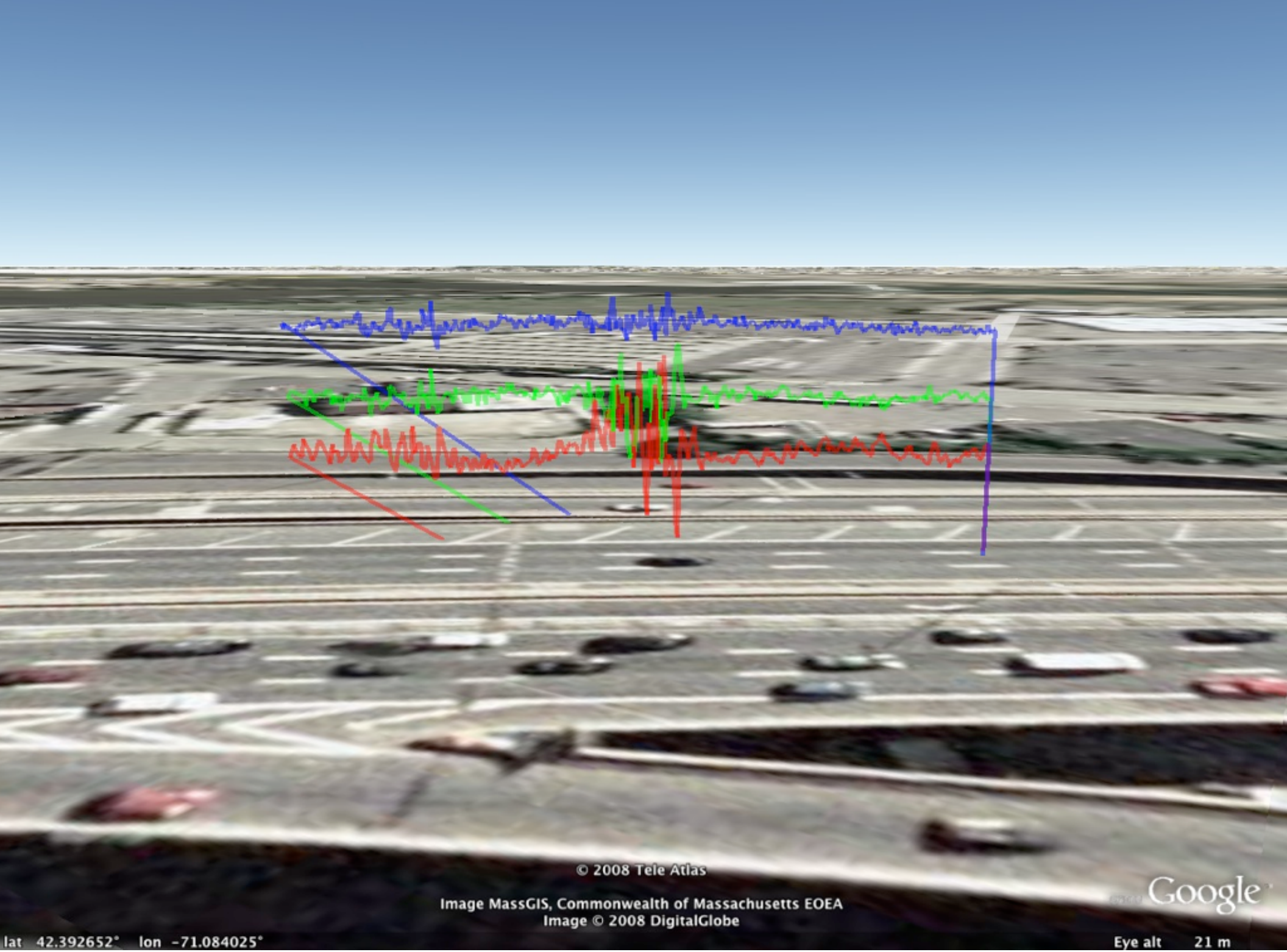
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Image MassGIS, Commonwealth of Massachusetts EOEA
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Google
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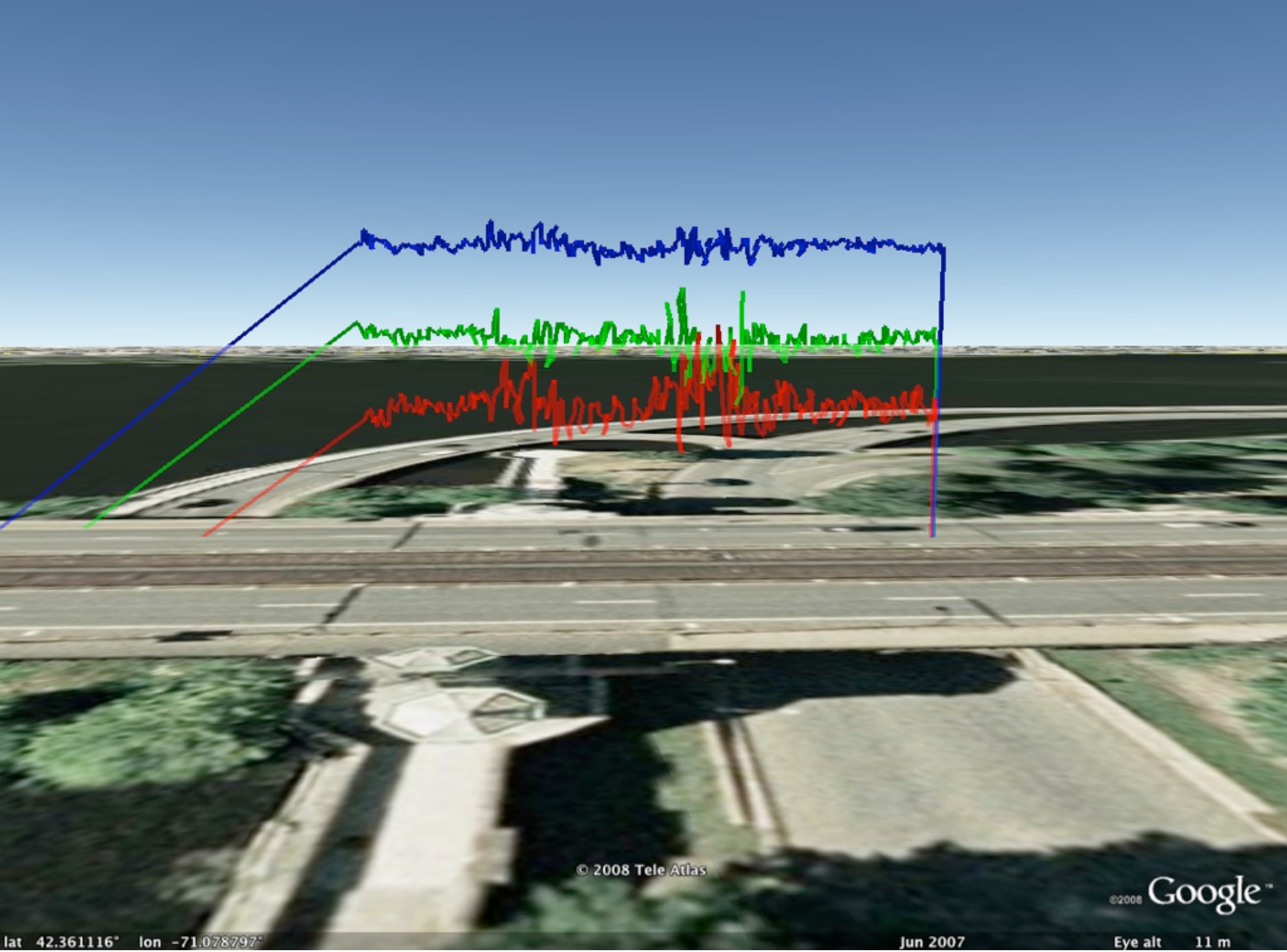
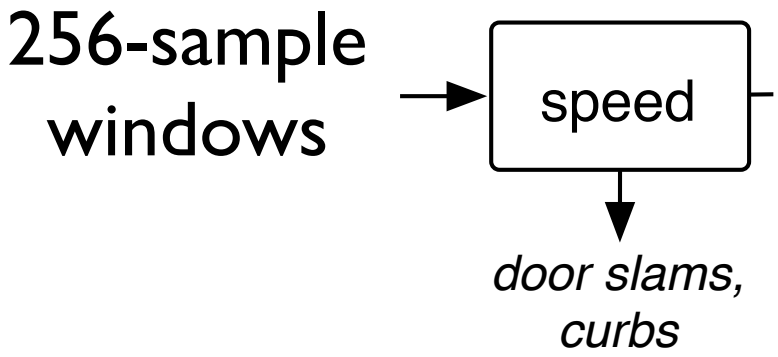
Eye alt 21 m


© 2008 Tele Atlas
©2008 Google
lat 42.361116° lon -71.078797°
Jun 2007
Eye alt 11 m

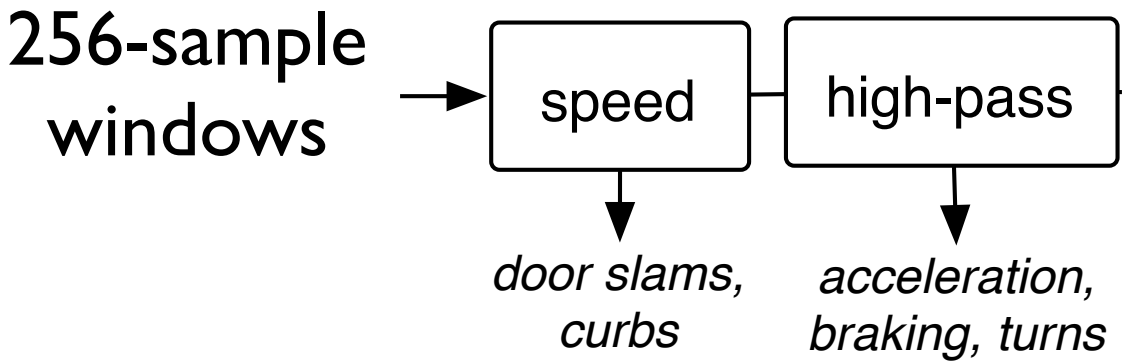
P^2 detector

256-sample windows →

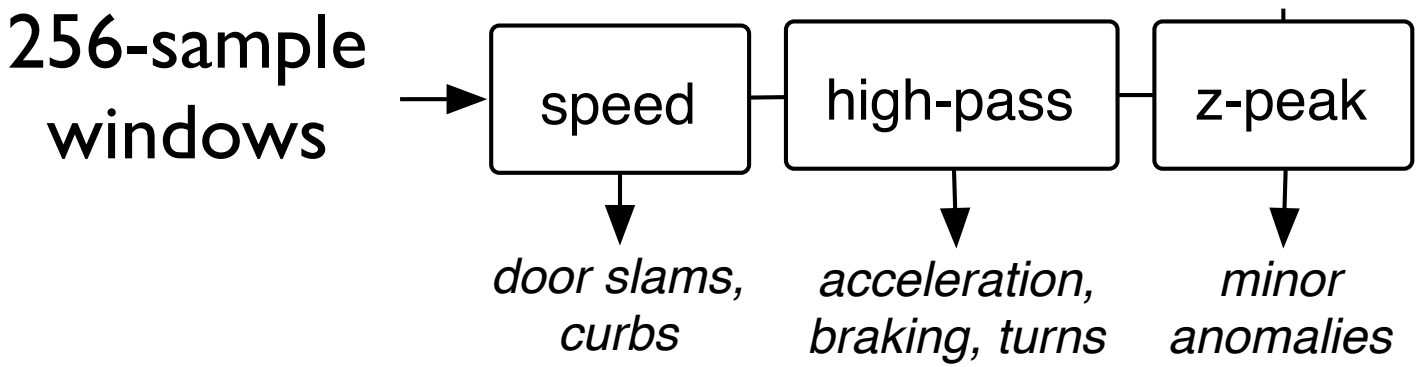
P^2 detector



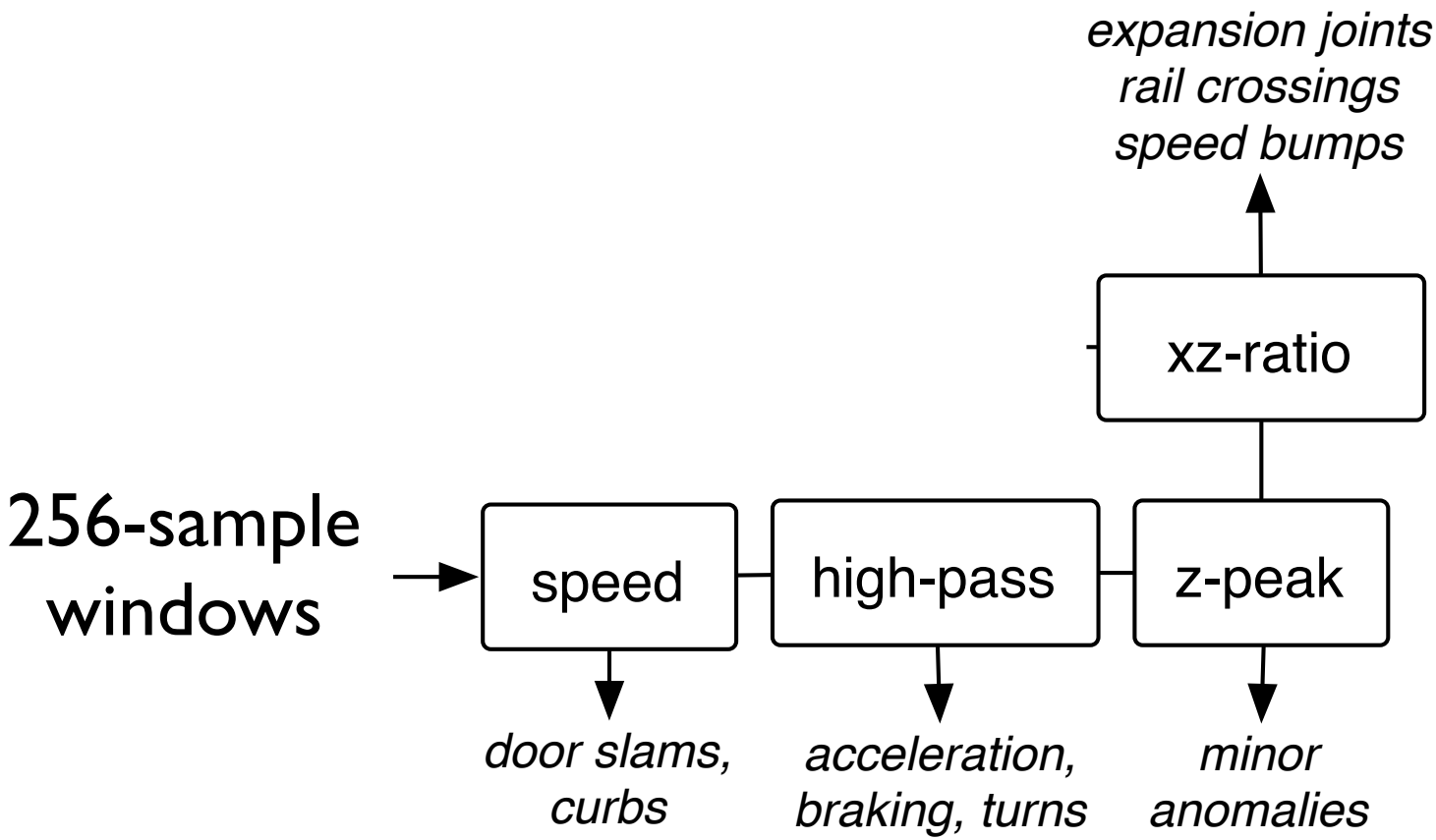
P^2 detector


256-sample windows
speed
high-pass
door slams, curbs
acceleration, braking, turns

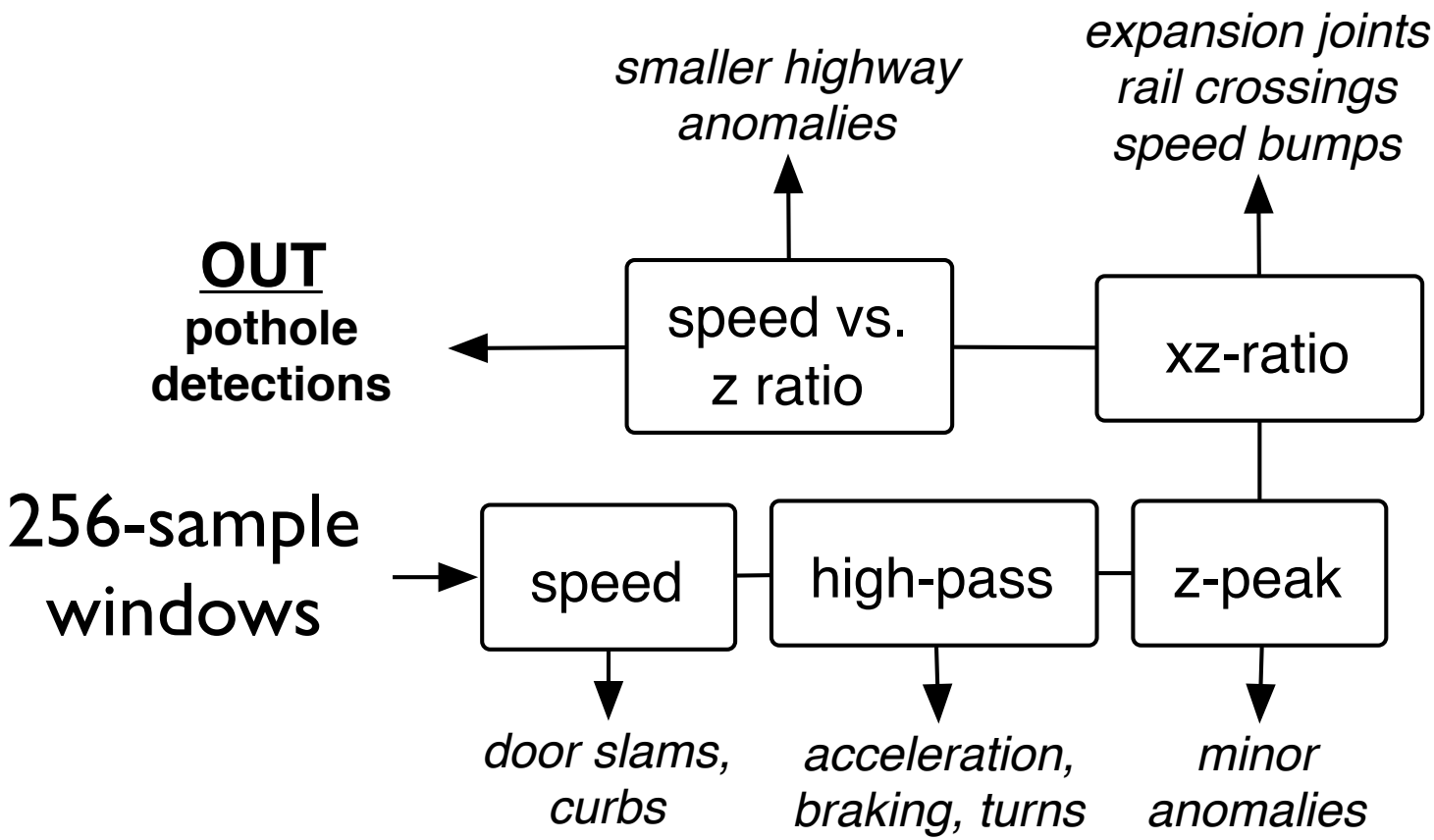
P² detector


256-sample windows
speed
high-pass
z-peak
door slams, curbs
acceleration, braking, turns
minor anomalies

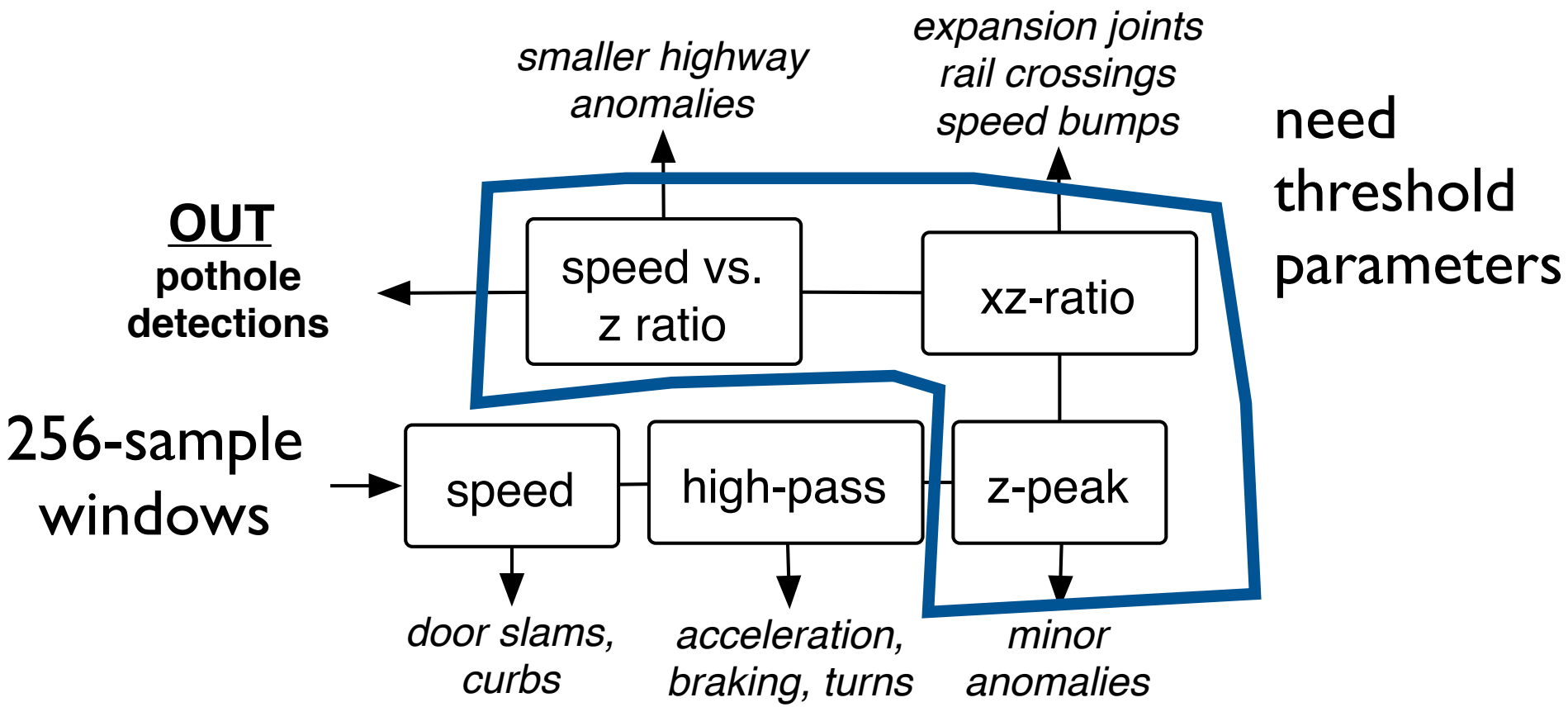
P² detector


expansion joints
rail crossings
speed bumps
xz-ratio
256-sample windows
speed
high-pass
z-peak
door slams, curbs
acceleration, braking, turns
minor anomalies

P² detector


smaller highway anomalies
expansion joints rail crossings speed bumps
OUT
pothole detections
speed vs. z ratio
xz-ratio
256-sample windows
speed
high-pass
z-peak
door slams, curbs
acceleration, braking, turns
minor anomalies

P² detector


smaller highway anomalies
expansion joints rail crossings speed bumps
need threshold parameters
OUT
pothole detections
speed vs. z ratio
xz-ratio
256-sample windows
speed
high-pass
z-peak
door slams, curbs
acceleration, braking, turns
minor anomalies

training the detector

- manually label training samples

Type	Count	Percentage
Smooth road (SM)	64	23%
Potholes (PH)	63	23%
Manholes (MH)	59	21%
Railroad Crossing (RC)	18	6%
Crosswalk/Exp. Joint (CWEJ)	76	27%

20

training the detector

- pick an objective function

training the detector

- pick an objective function

$$s(\mathbf{t}) = corr - incorr^2$$

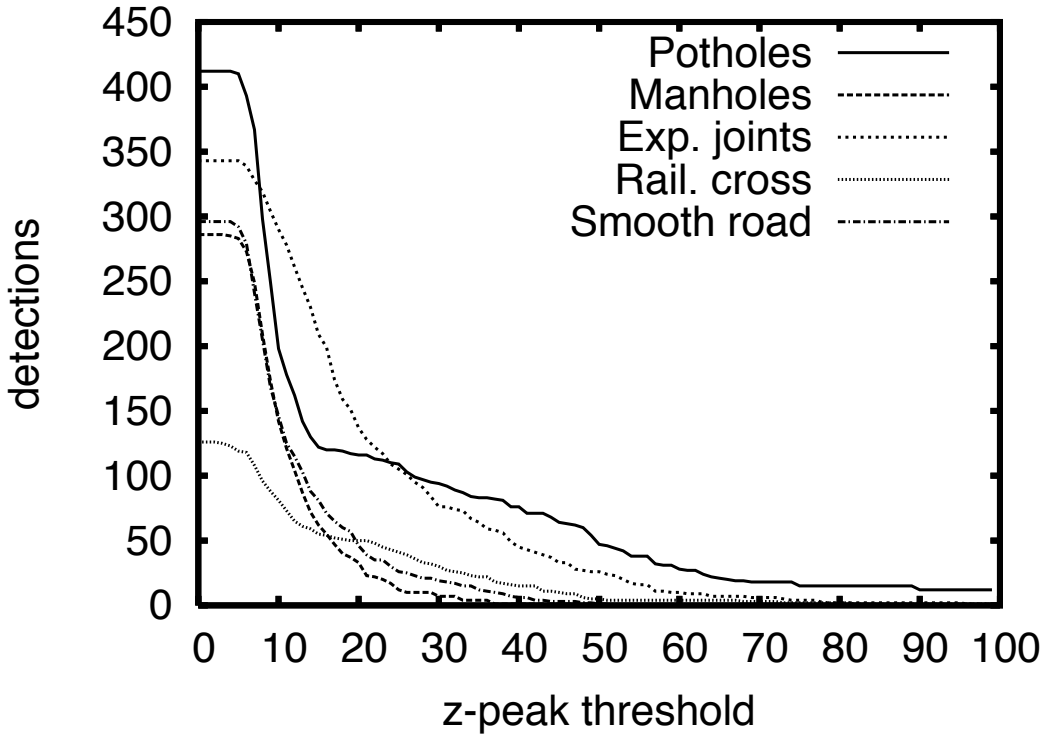
training the detector

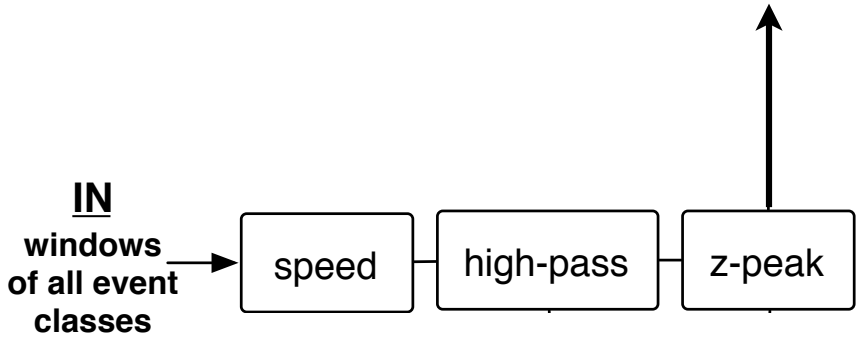
- pick an objective function

$$s(\mathbf{t}) = corr - incorr^2$$

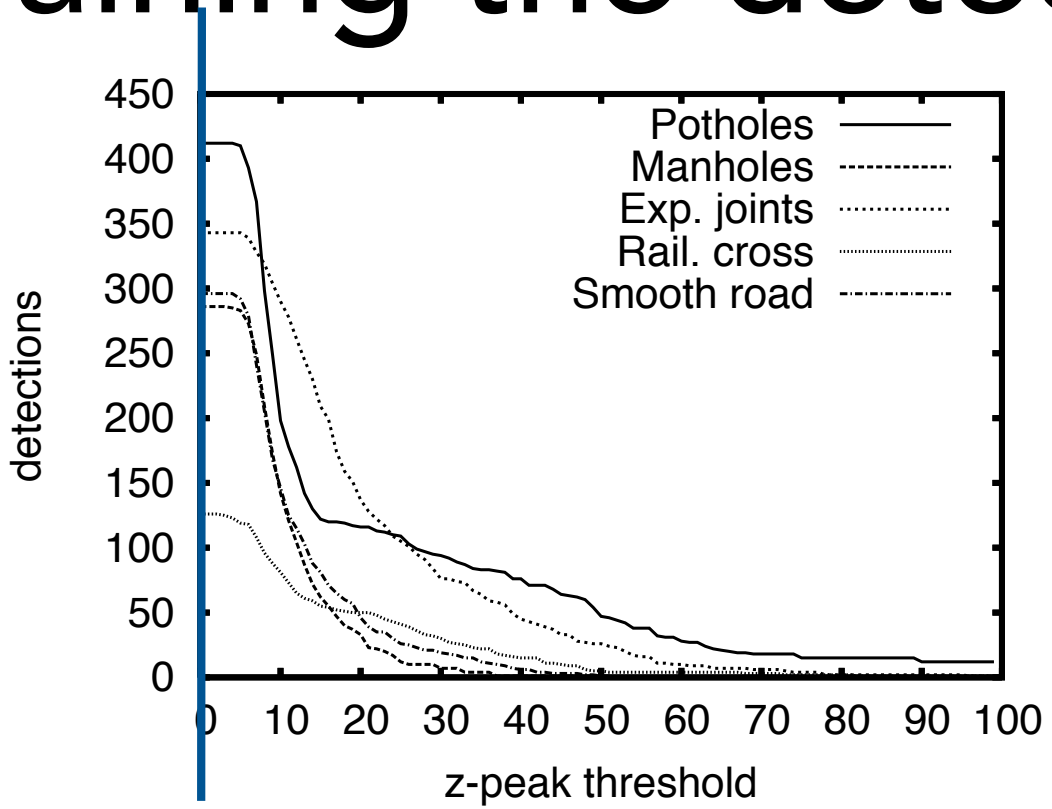
- optimize over 3 threshold parameters
  - z-peak
  - xy-ratio
  - speed vs. z-ratio

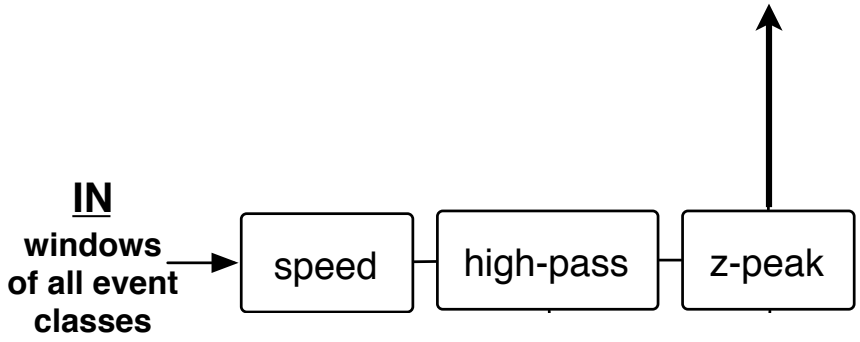
training the detector



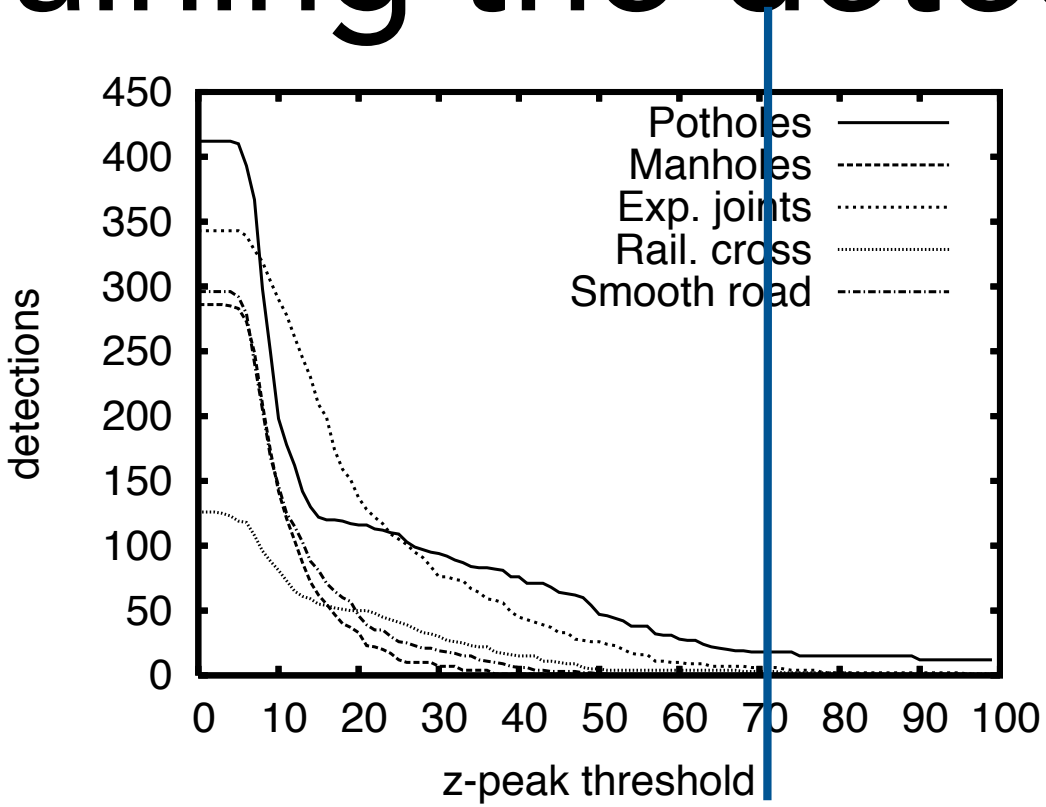


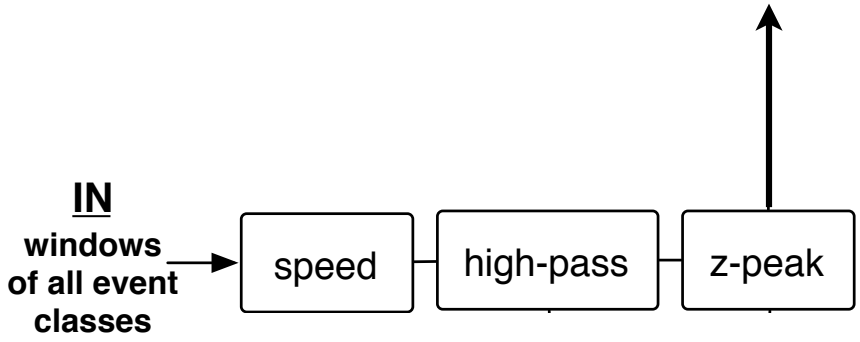
training the detector



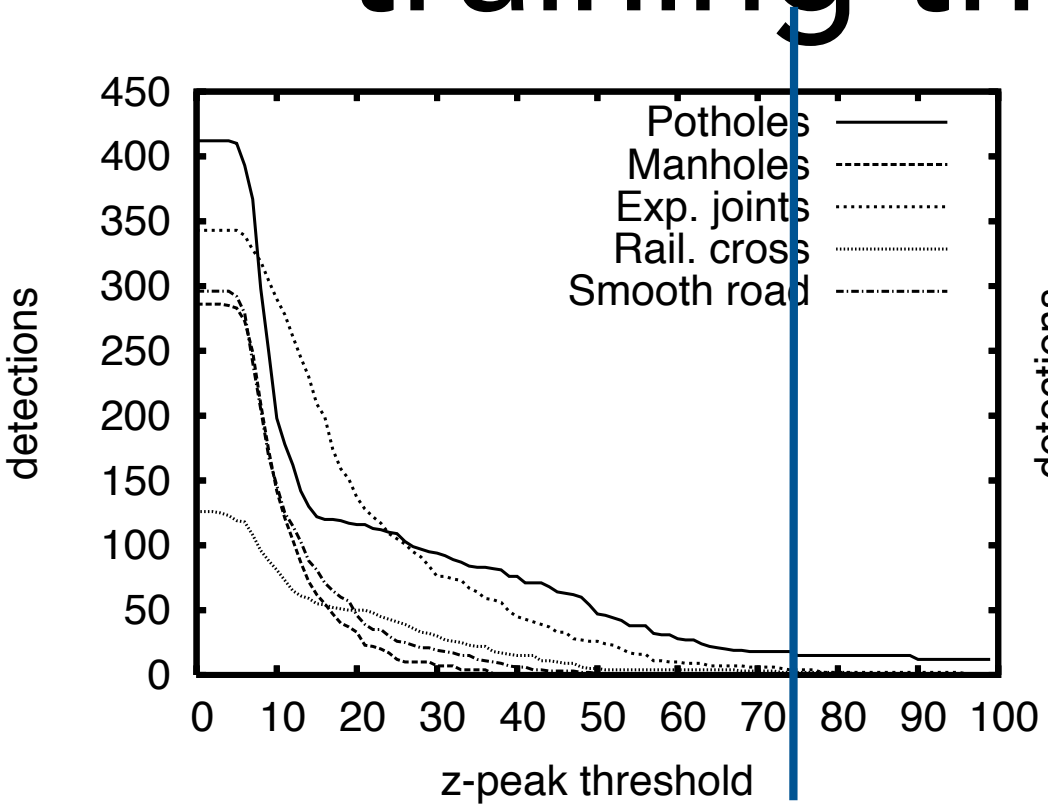


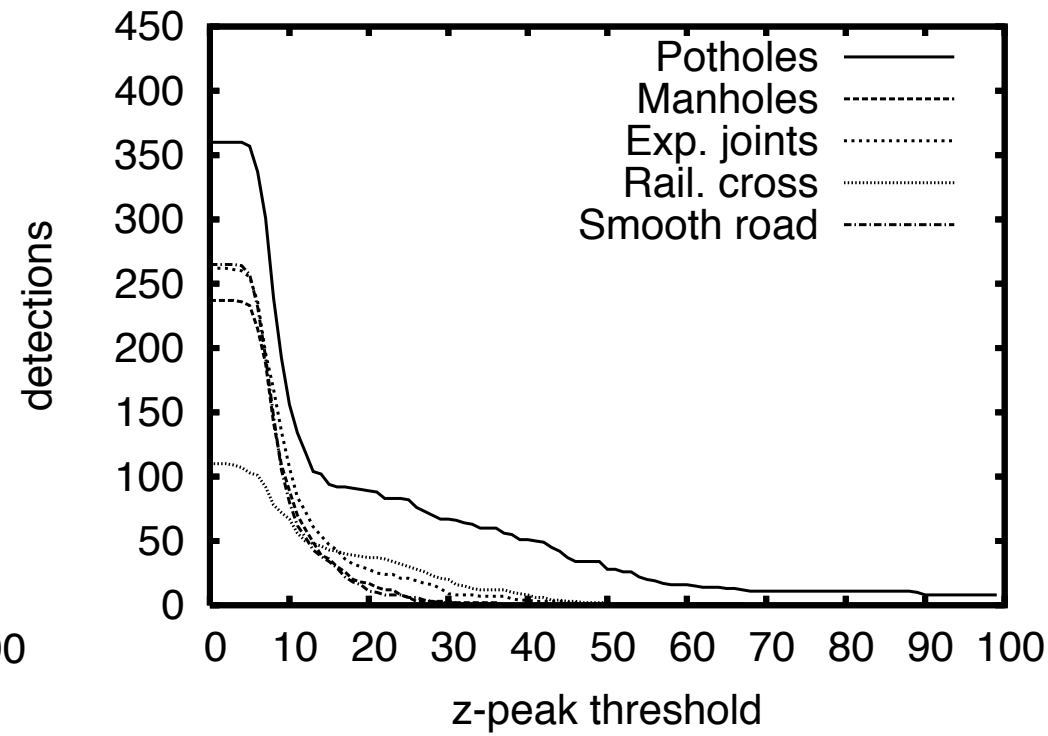
training the detector

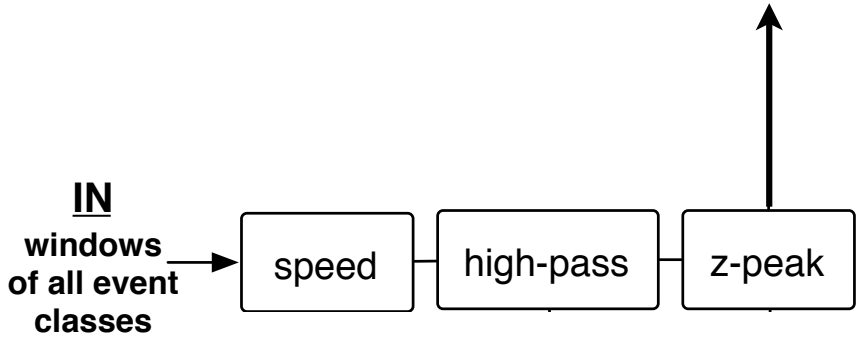


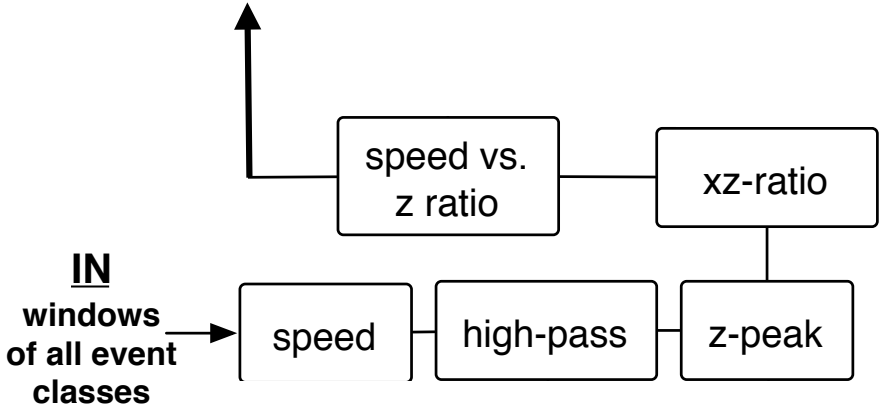


training the detector



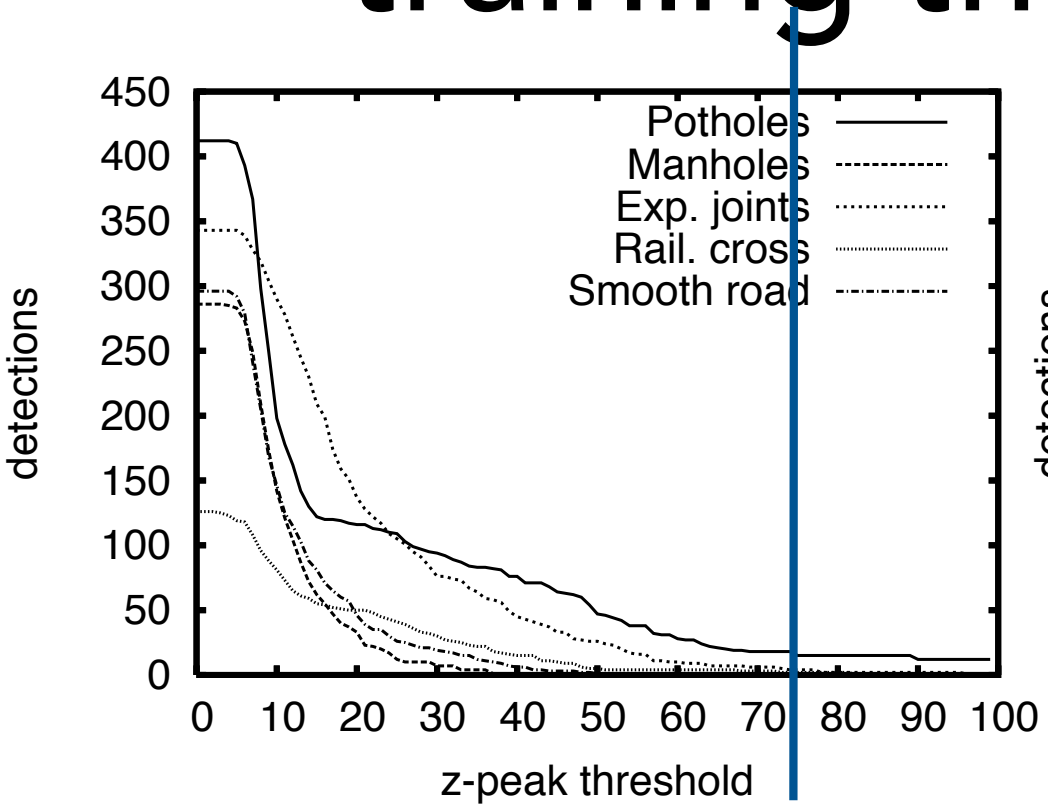


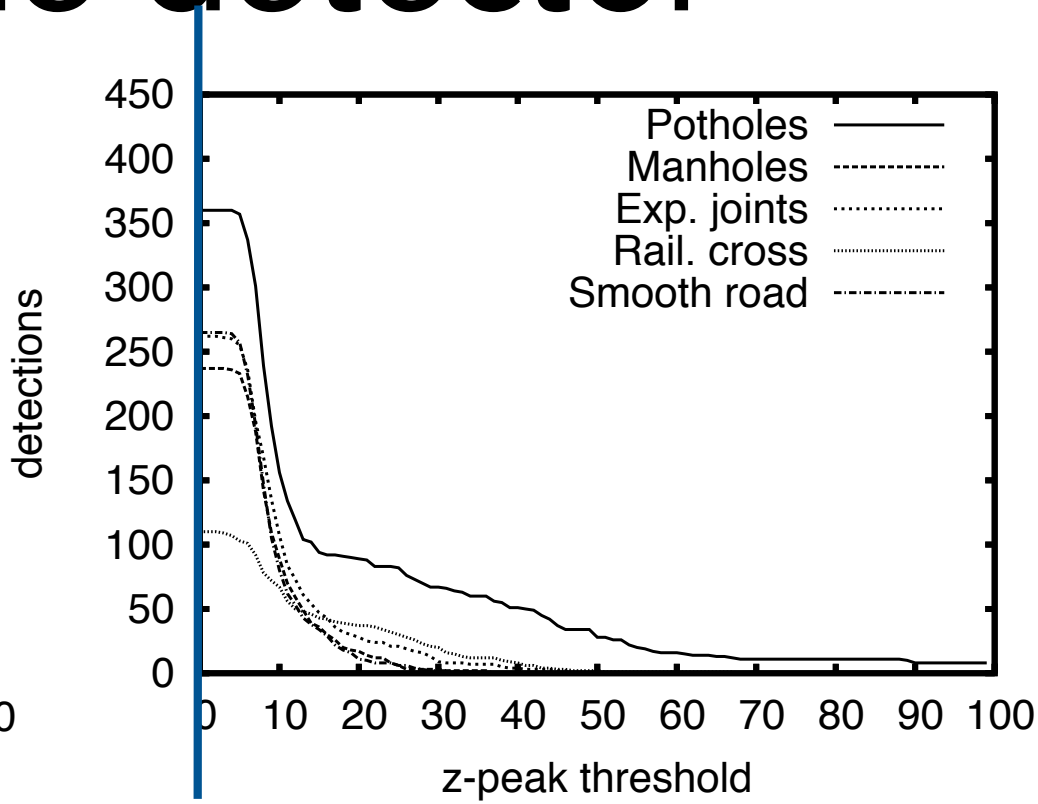


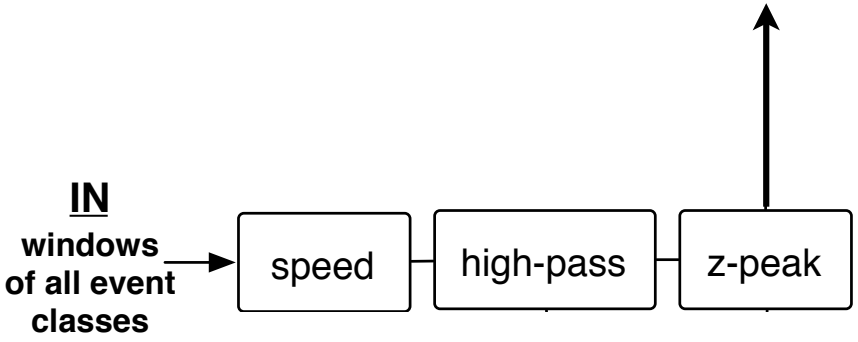


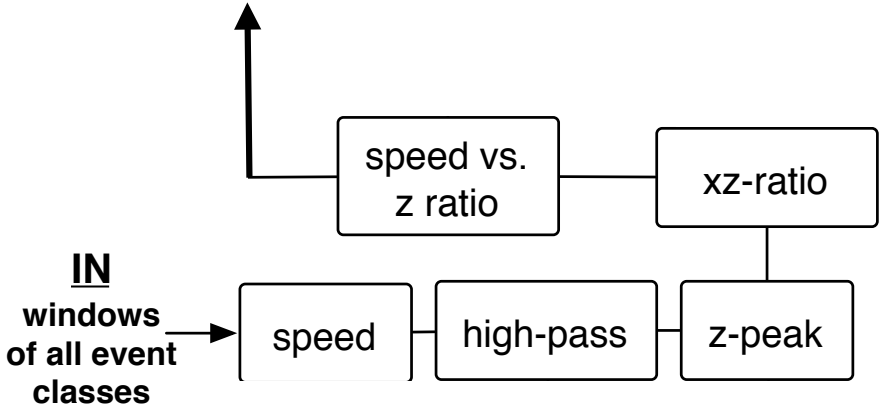
22

training the detector

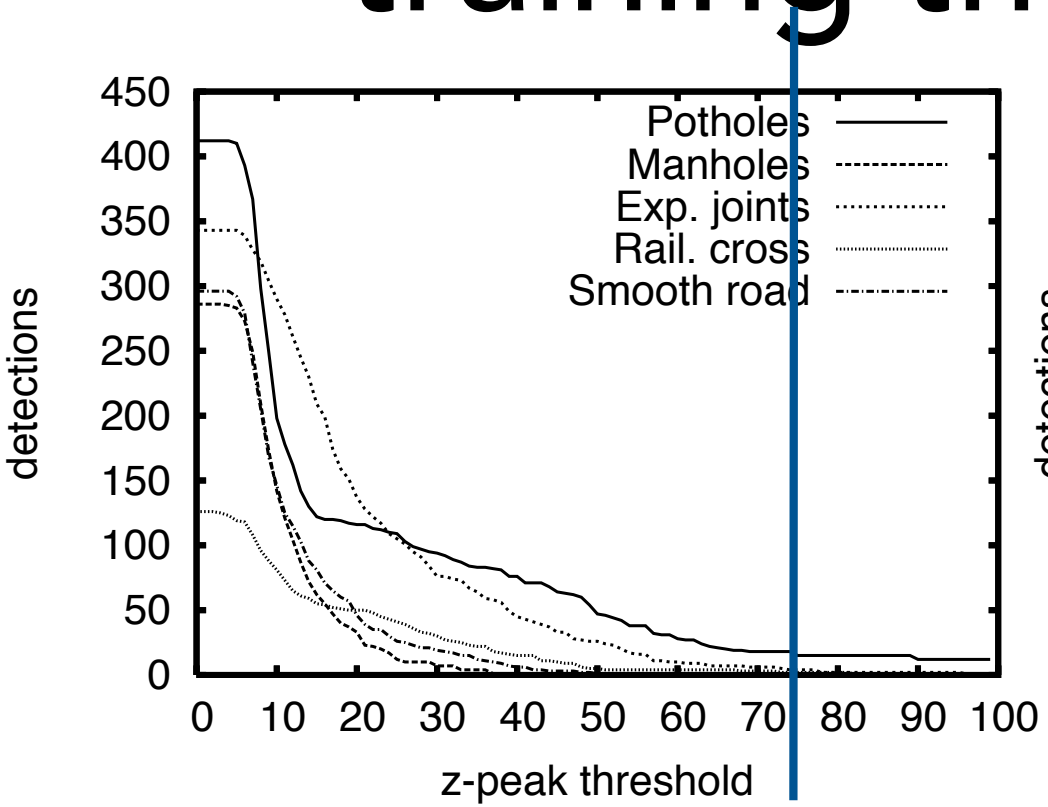


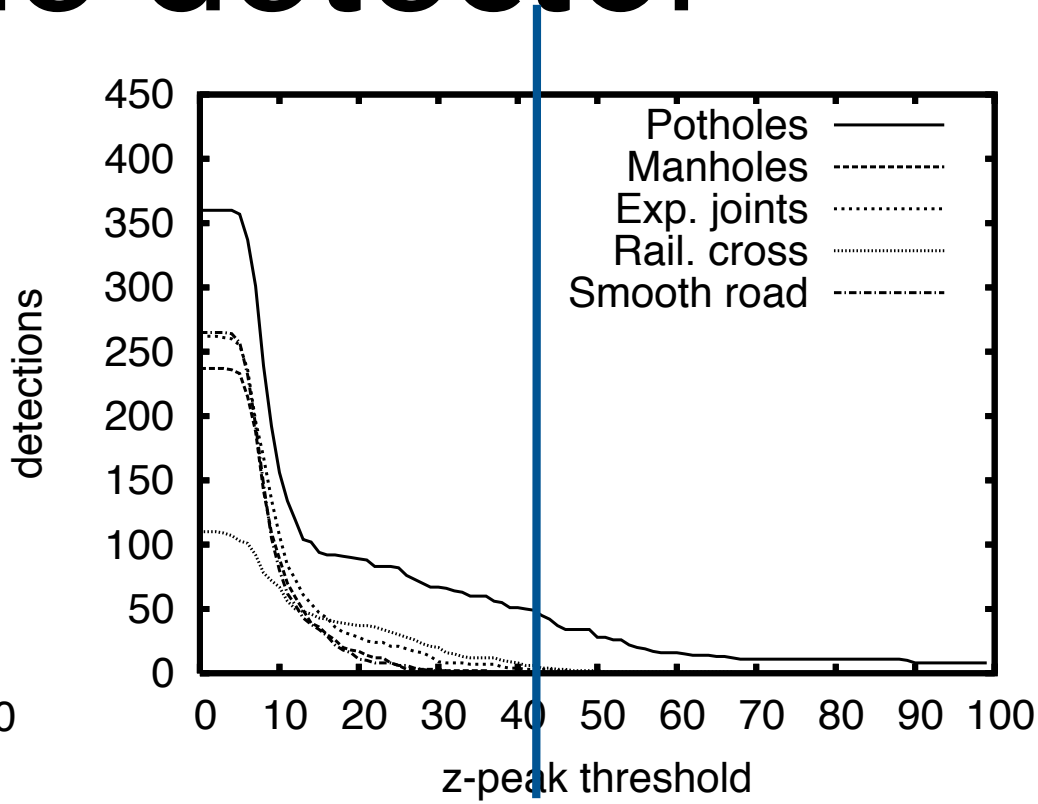


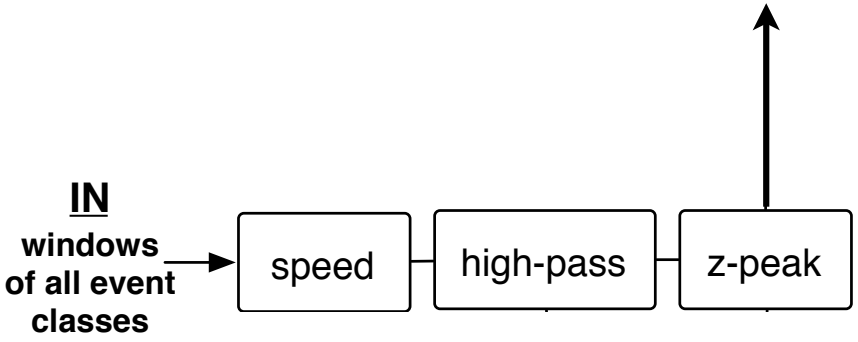


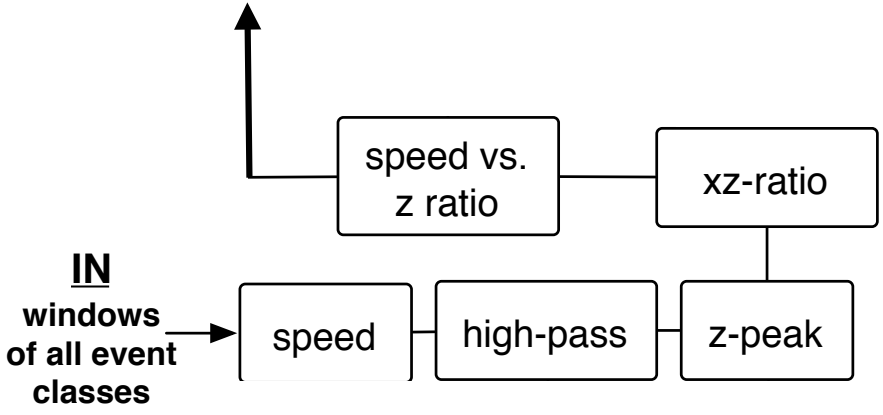


training the detector









22

detector performance

Road	# potholes	#win	#det.	rate
Storrow Dr.	few	1865	3	0.16%
Memorial Dr.	few	1781	2	0.12%
Hwy I-93	few	2877	5	0.17%

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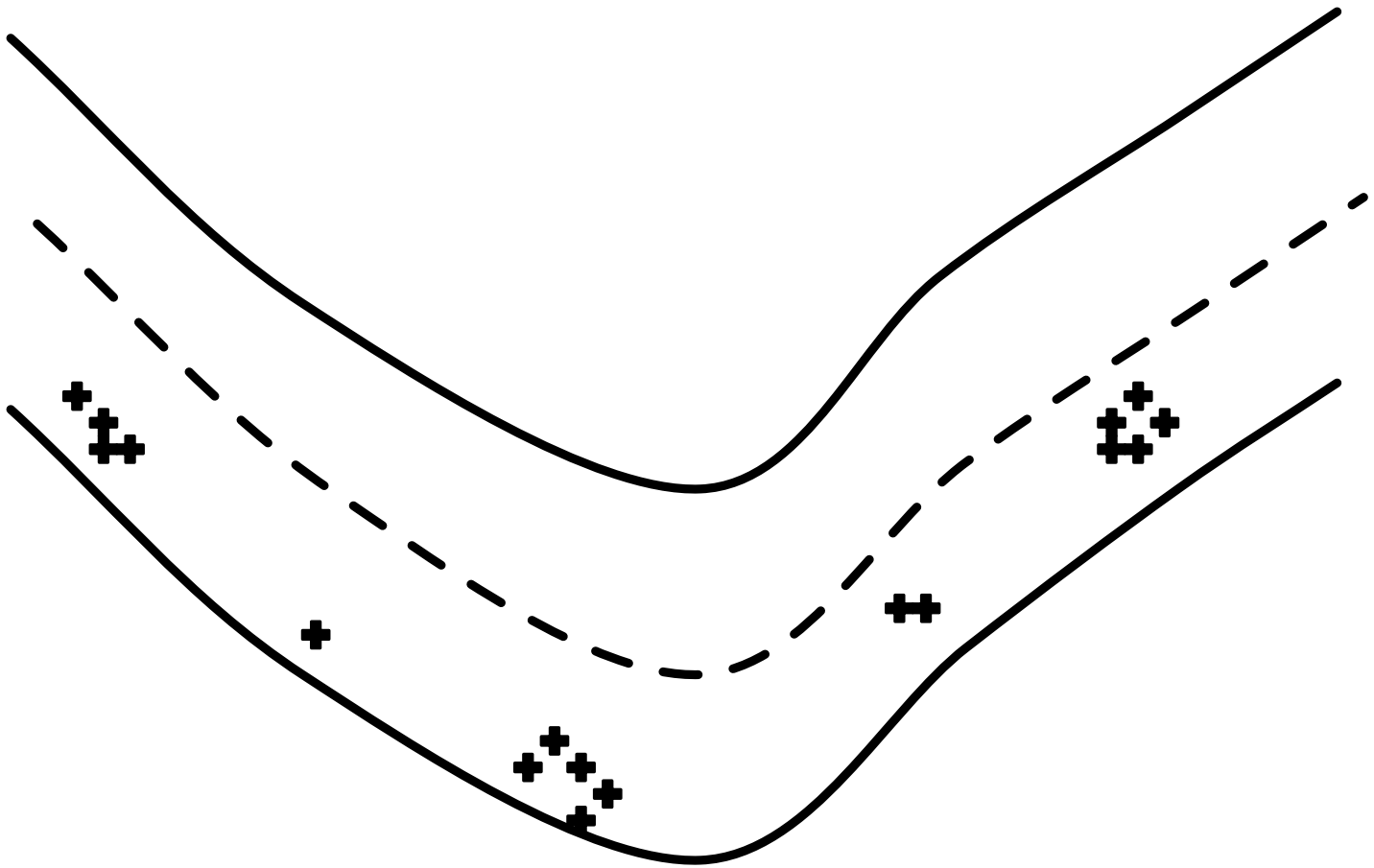
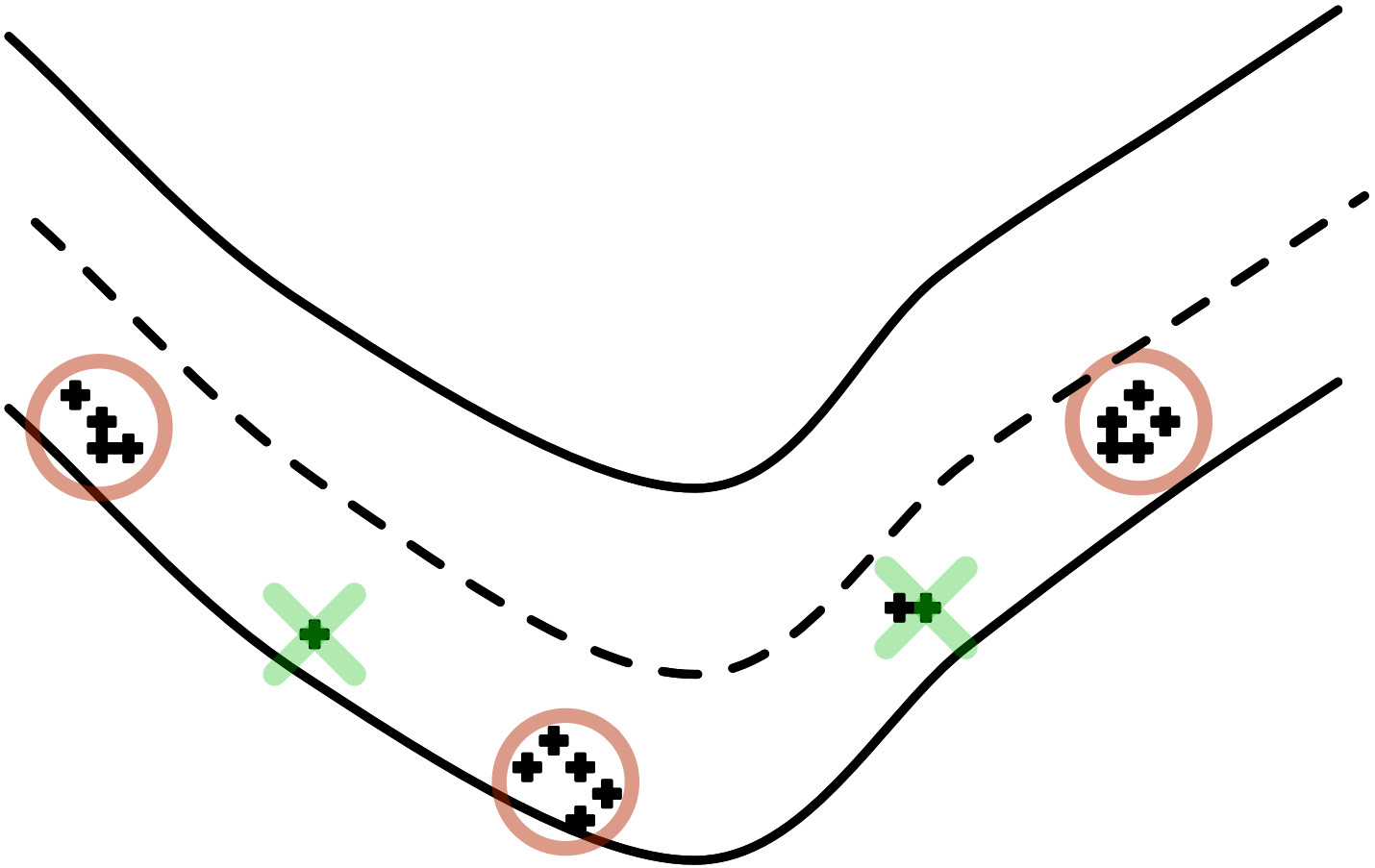
clustering



clustering



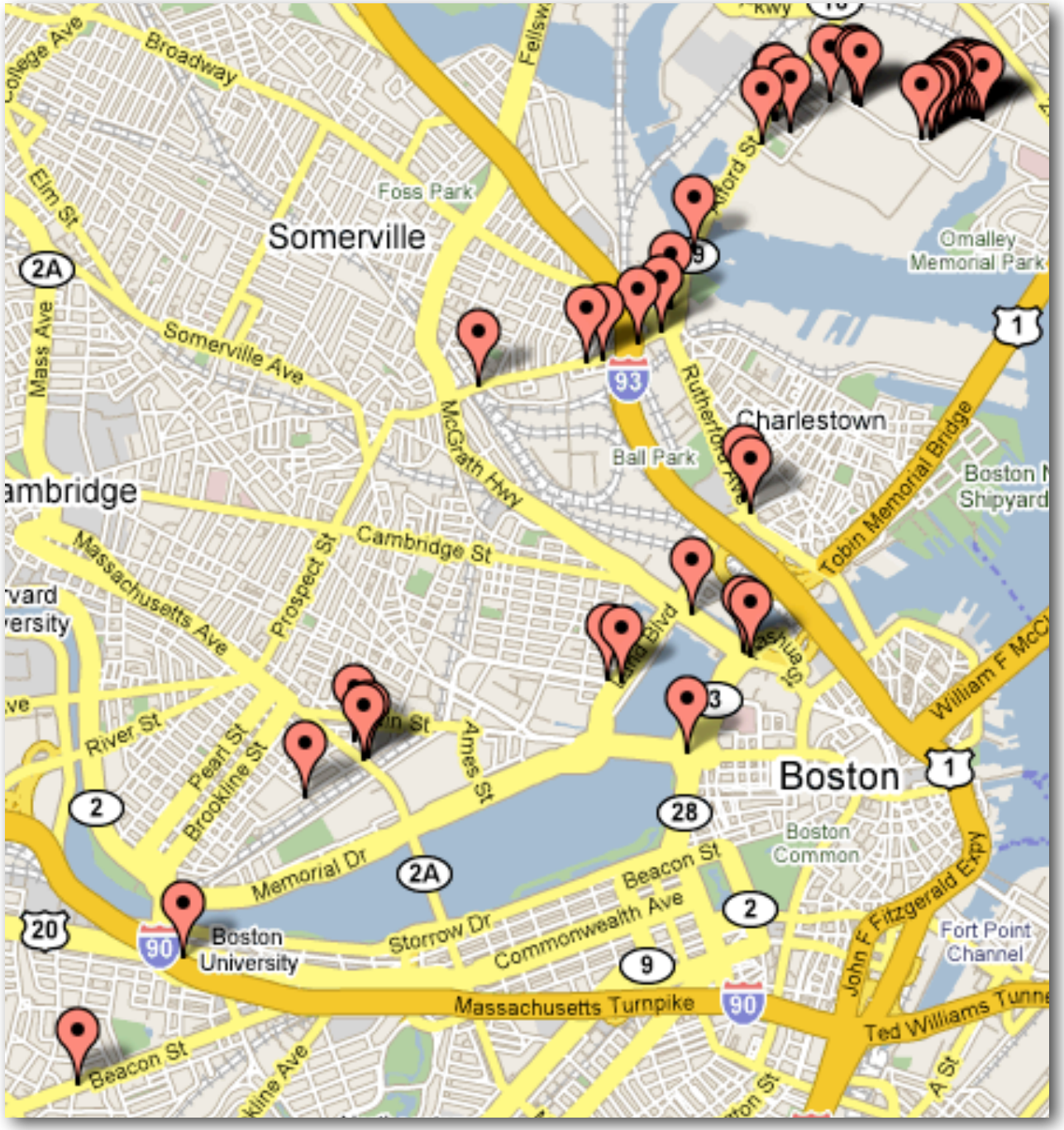
- 1.4 million sample windows
- 2500 unique km of road covered
- 4131 detections in 2709 locations

25

impact of cluster size



26


Somerville
Foss Park
Broadway
College Ave
Elm St
2A
Mass Ave
Somerville Ave
McGrath Hwy
93
Rutherford Ave
Charlestown
Ball Park
Omalley Memorial Park
Tobin Memorial Bridge
Boston N Shipyard
1
Cambridge
Massachusetts Ave
Prospect St
Cambridge St
River St
Pearl St
Brookline St
Ames St
Boston
28
Boston Common
Memorial Dr
2A
Beacon St
Commonwealth Ave
2
20
90
Boston University
Storrow Dr
9
Massachusetts Turnpike
John F Fitzgerald Expy
Fort Point Channel
Ted Williams Tunnel
Beacon St
A St
William F McC

27

48 spot-checks

potholes	39
sunk-in manholes	3
railways and exp. joints	4
undetermined	2

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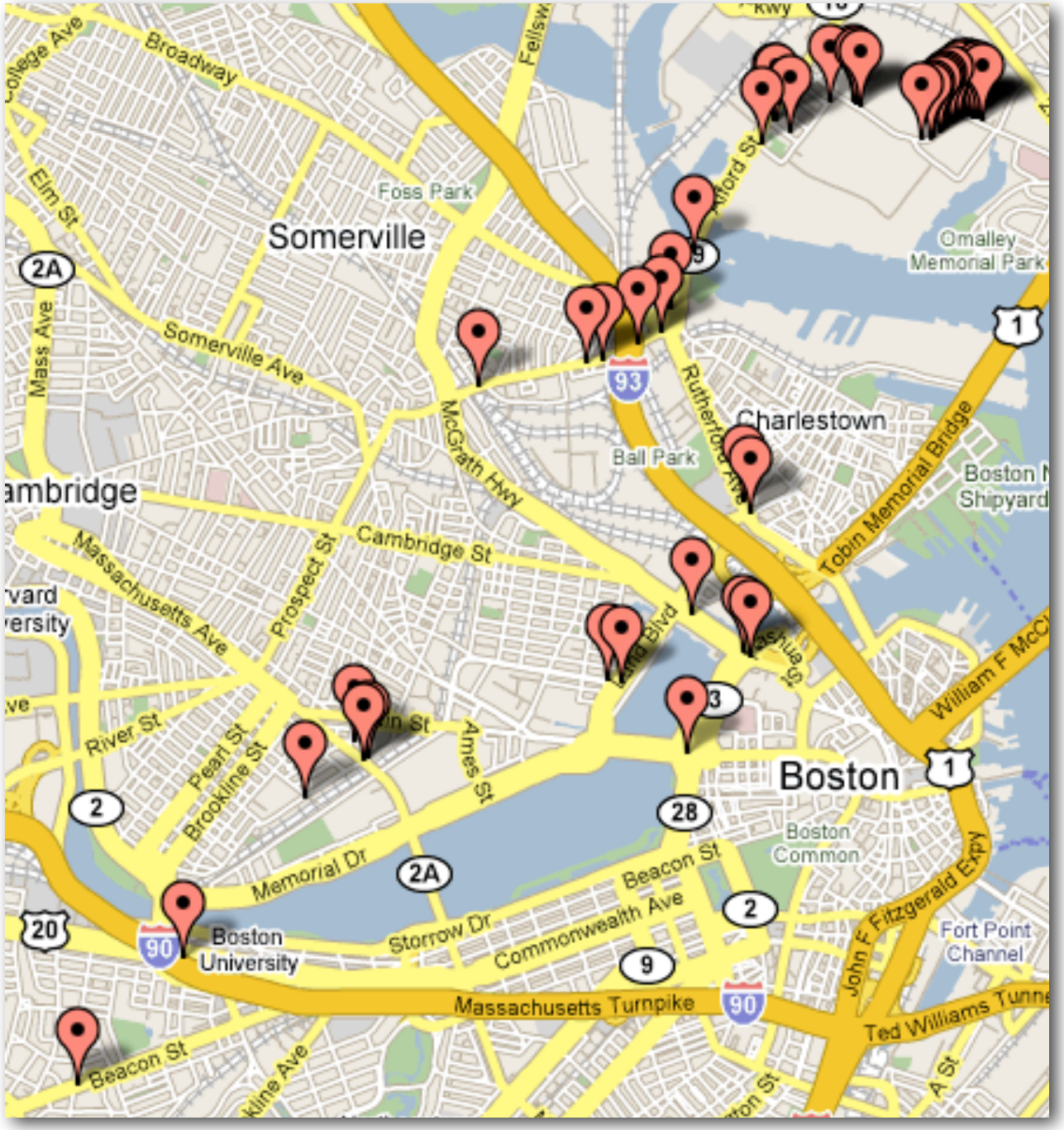
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29

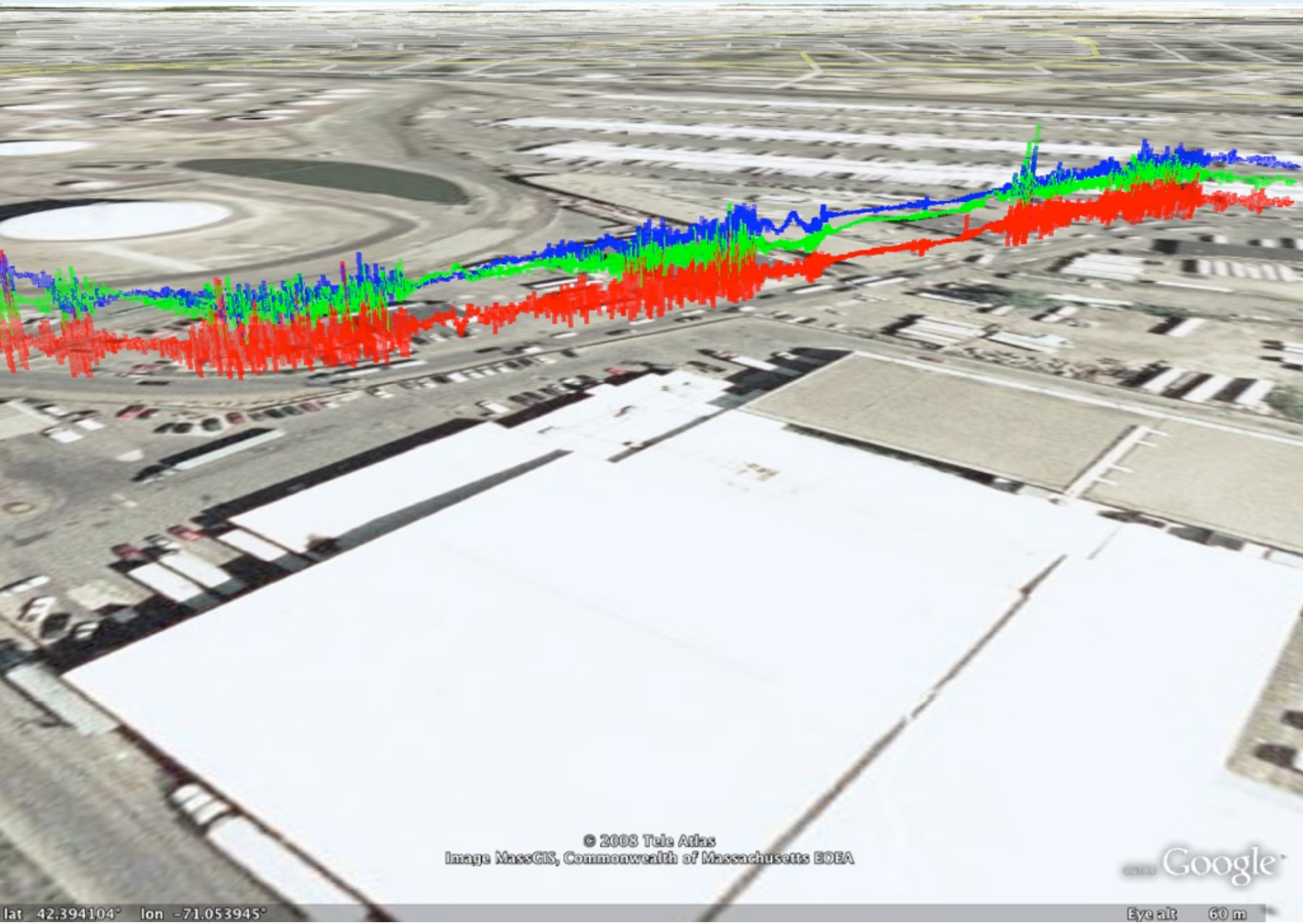
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Image MassGIS, Commonwealth of Massachusetts EOEA
Google
lat 42.394104° lon -71.053945°
Eye alt 60 m



P^2: the Pothole Patrol

- automatic wide-area road quality monitoring
- use of opportunistic mobility
  - mobile sensing
  - delay-tolerant communication
- low-cost approach to help solve a costly problem

</talk>