

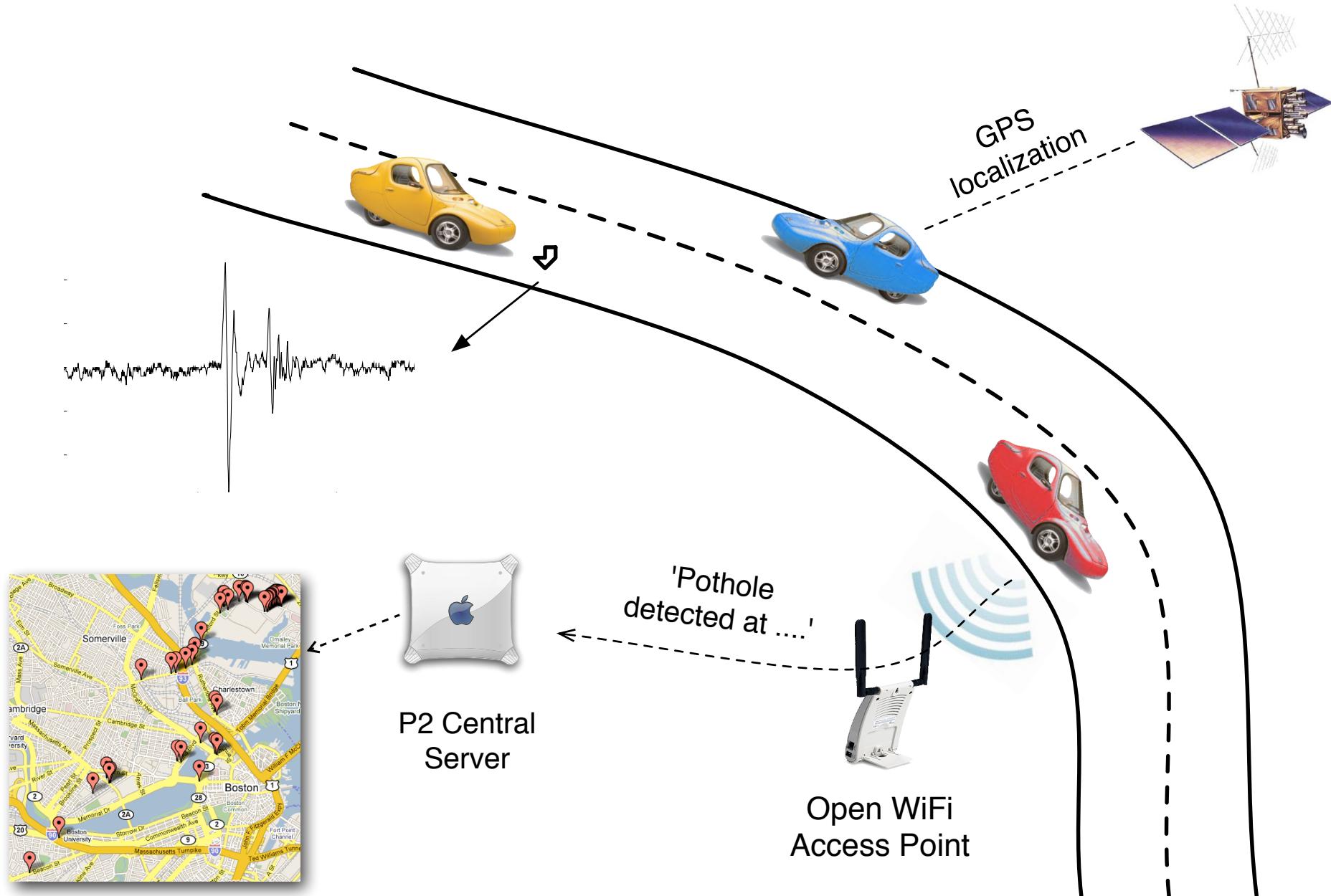
the
Pothole Patrol

6.S062
(Based on slides from Jakob Eriksson)



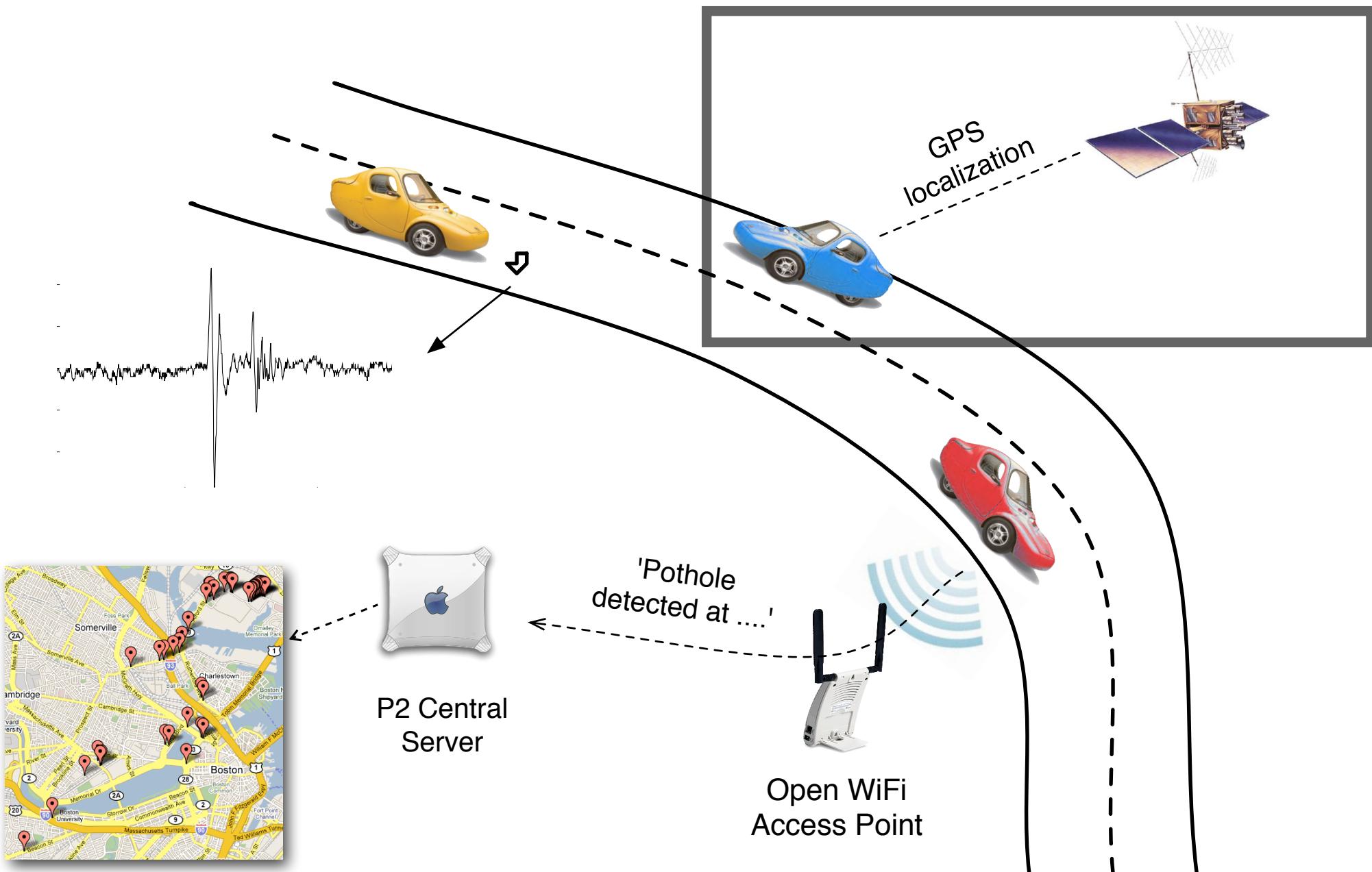
- road decay unavoidable, hard to predict
- current monitoring methods costly/ineffective

the Pothole Patrol



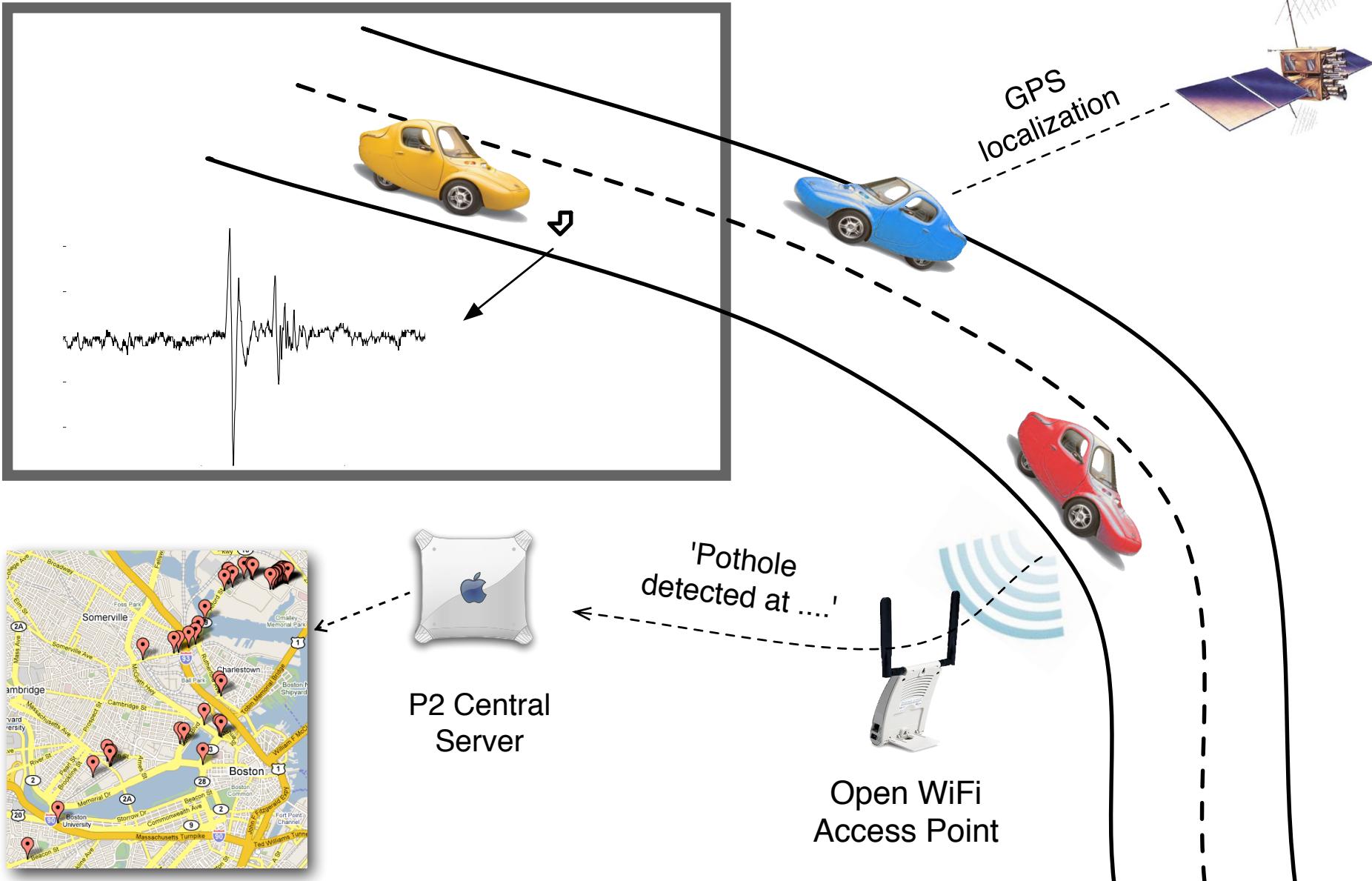
the Pothole Patrol

GPS localization

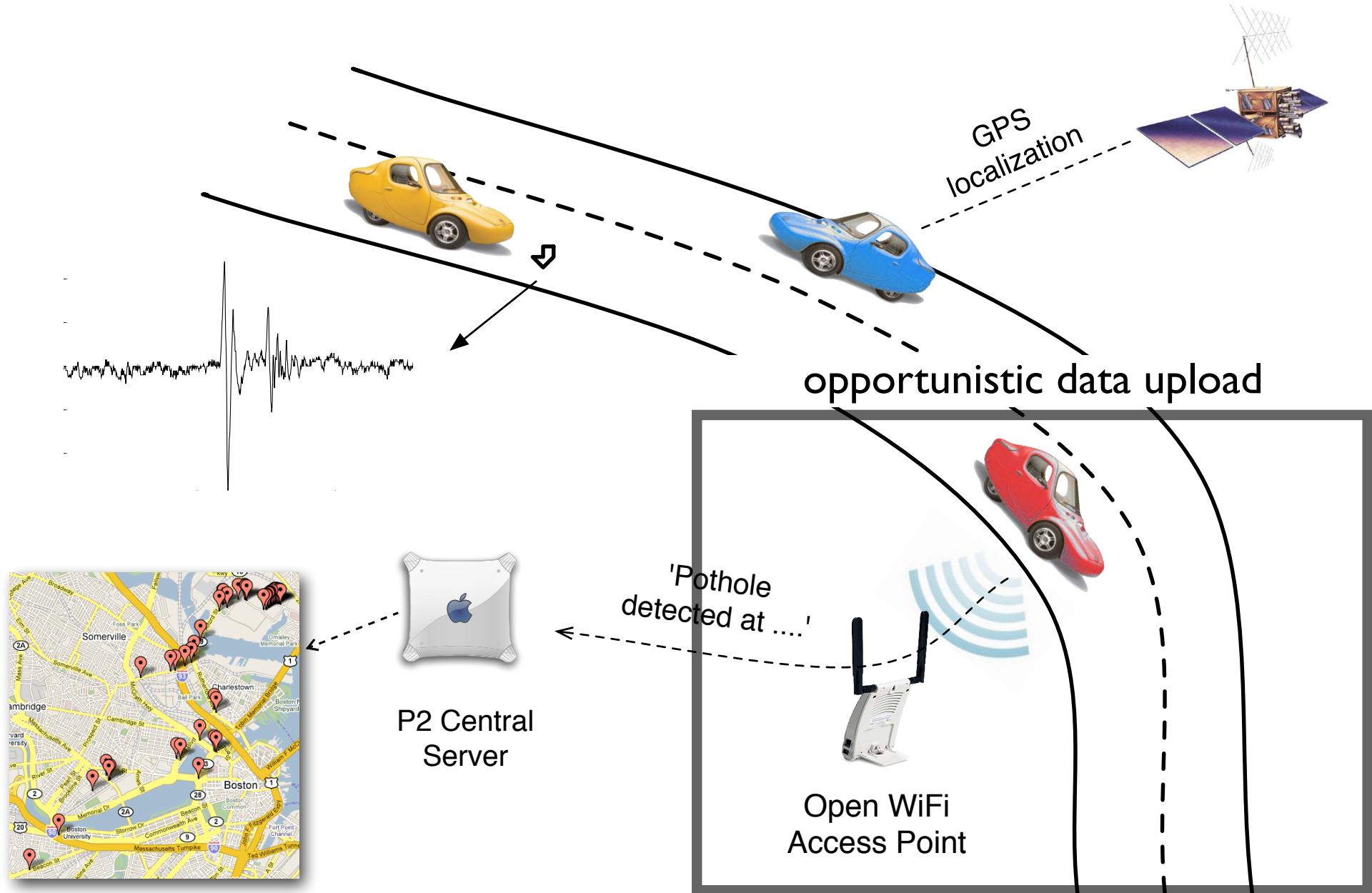


the Pothole Patrol

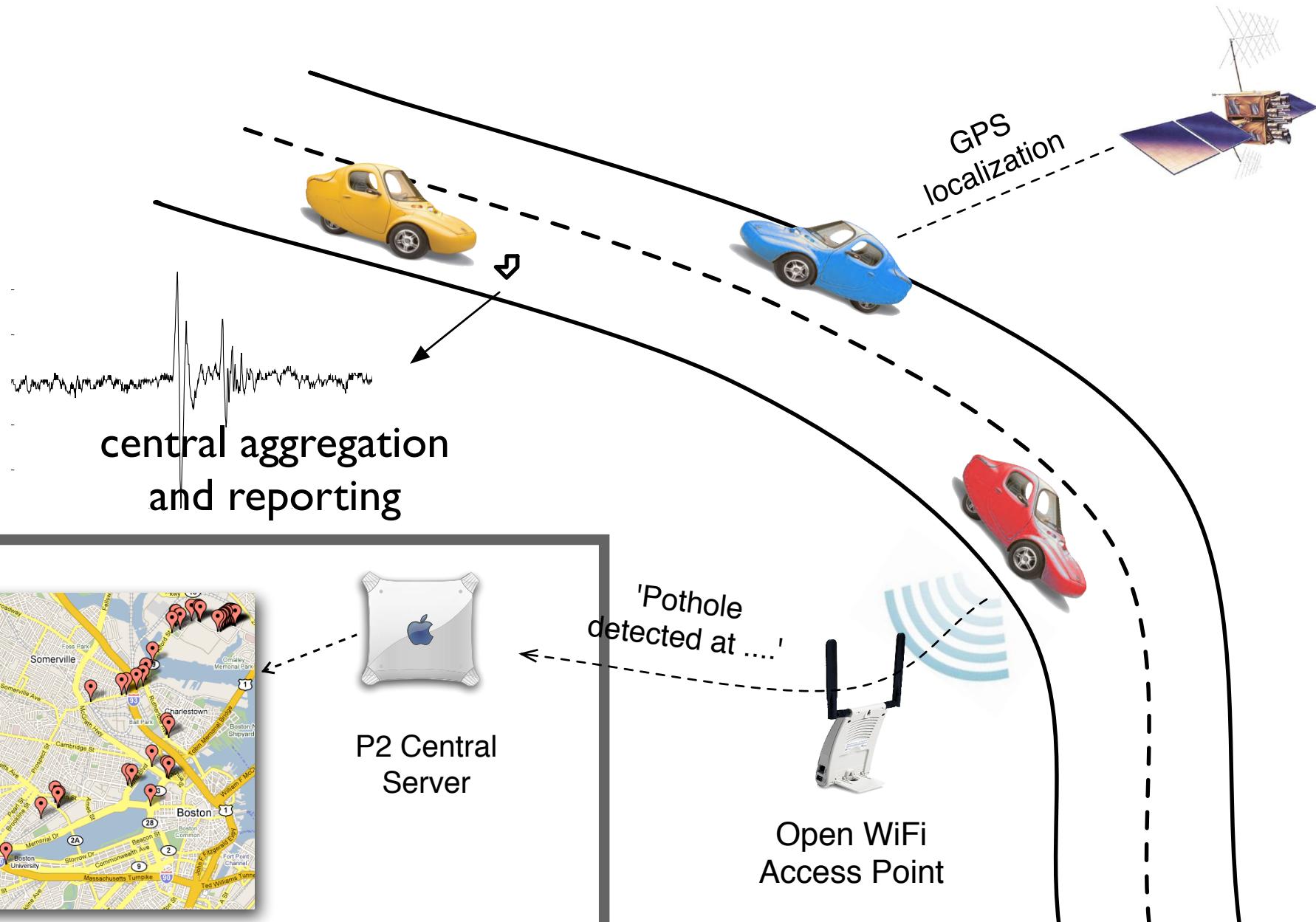
opportunistic accelerometer sensing



the Pothole Patrol



the Pothole Patrol

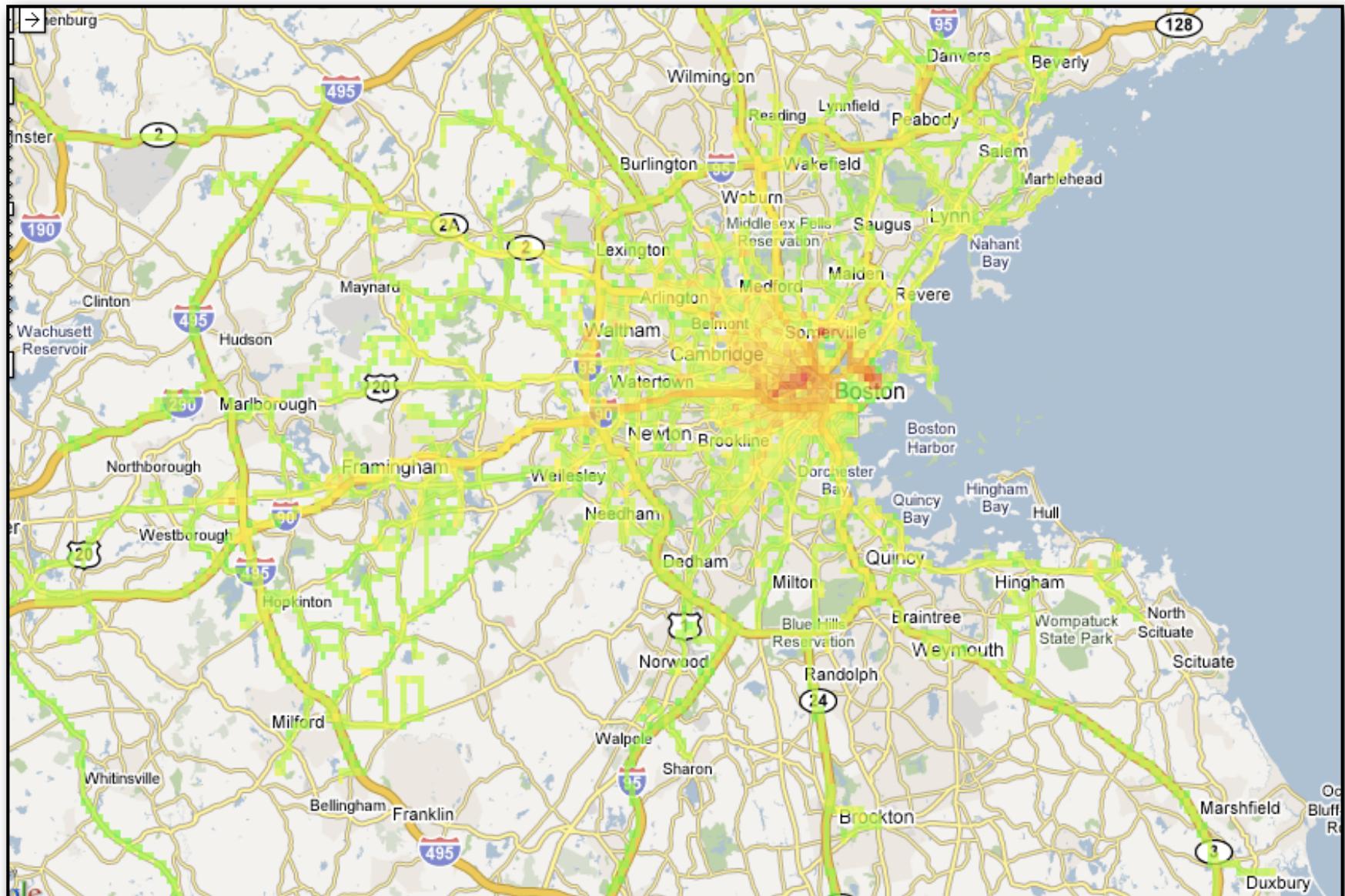


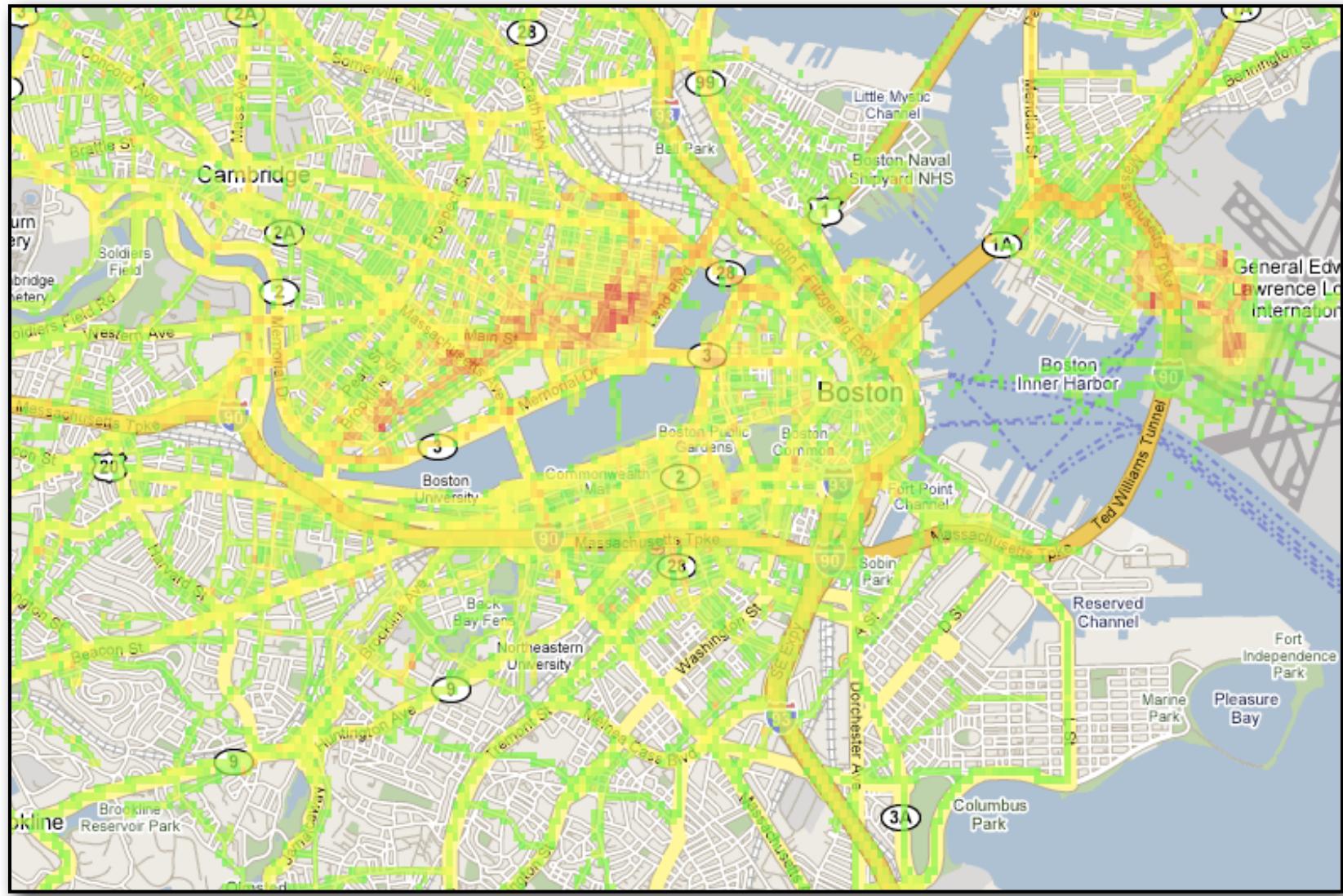
experimental platform

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



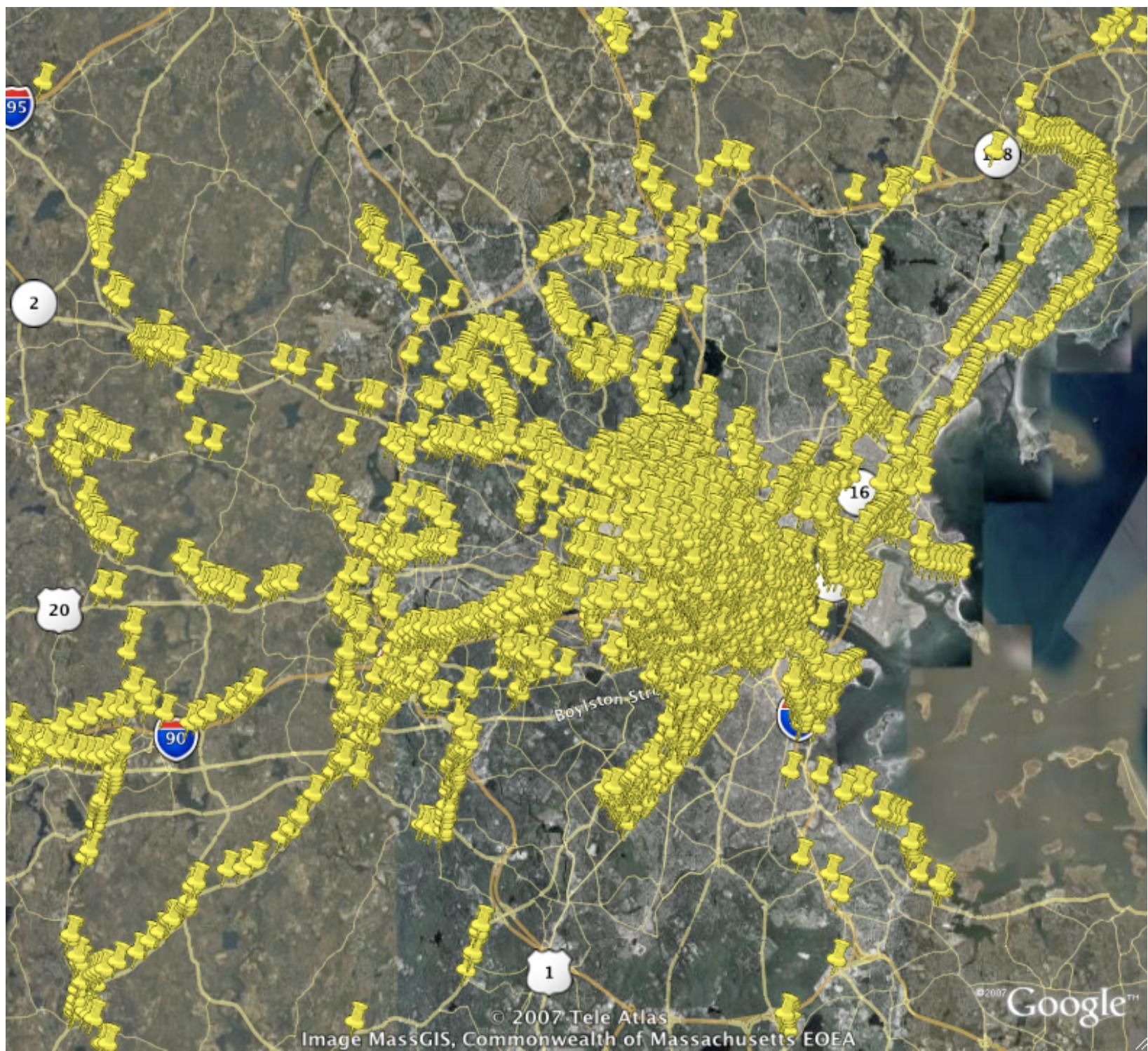
wide-area sensing



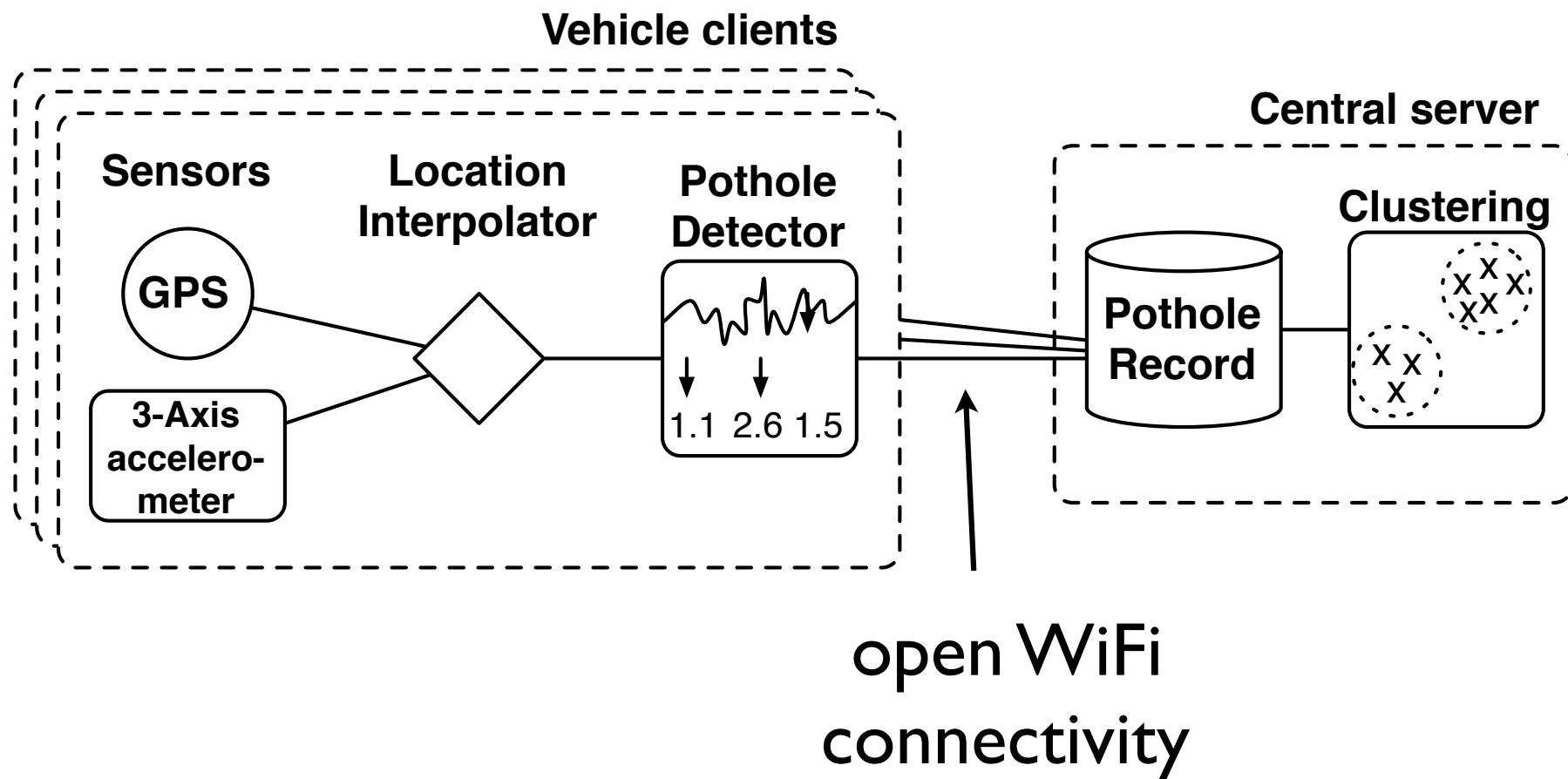


open WiFi connectivity

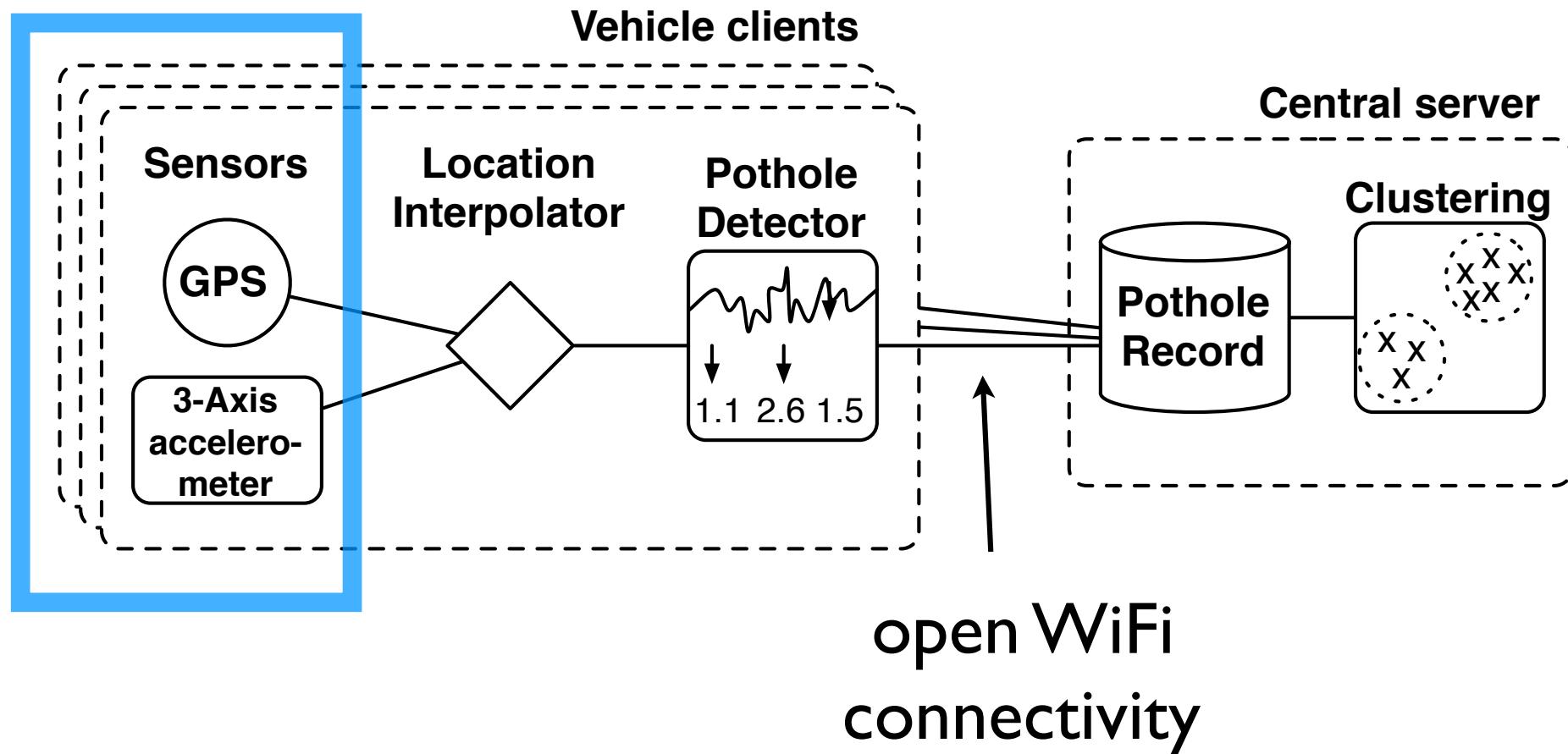




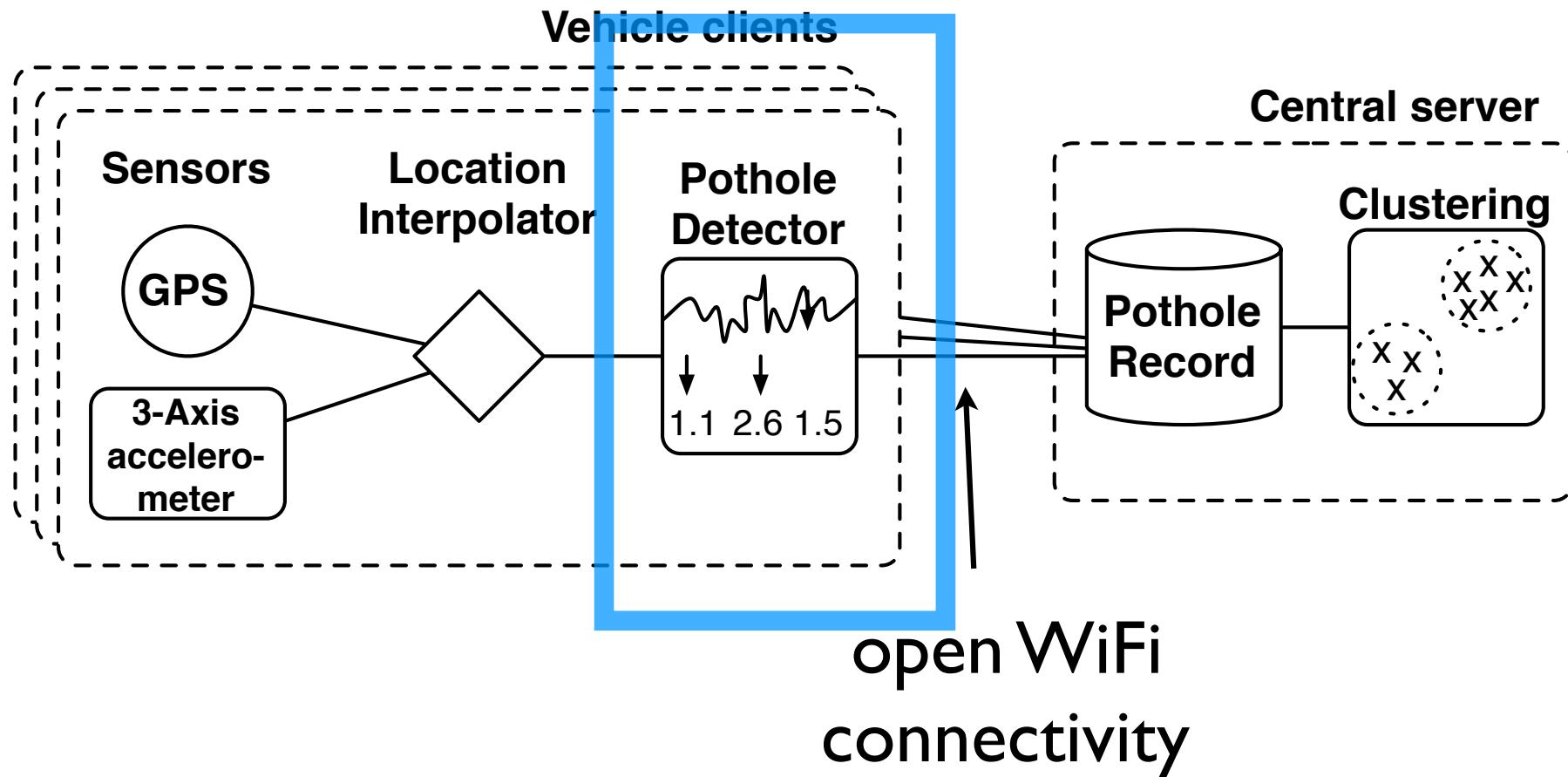
P² architecture



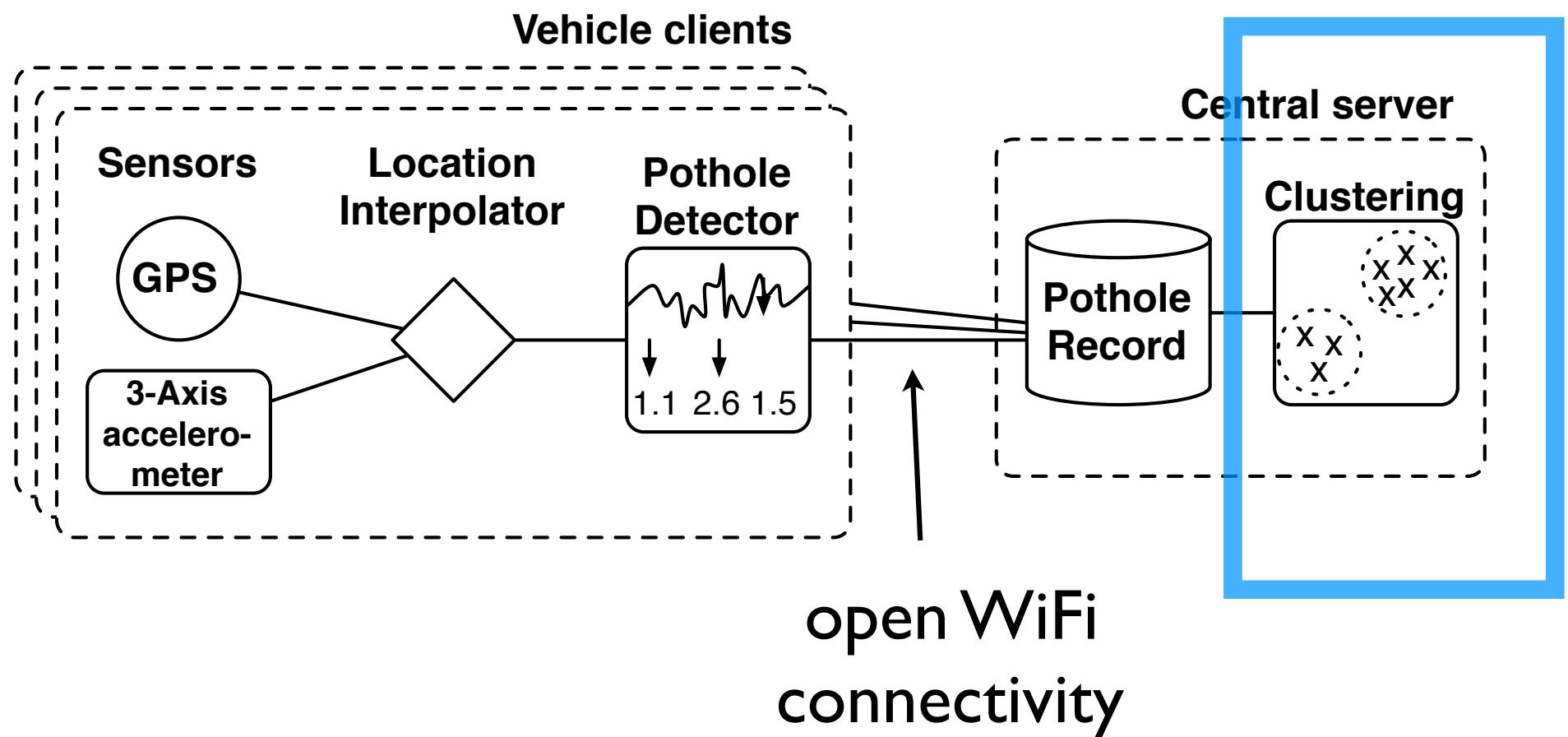
P² architecture



P² architecture



P² architecture



sensor placement



- highly accurate
- difficult mounting
- extreme exposure

sensor placement



try to stay
inside vehicle

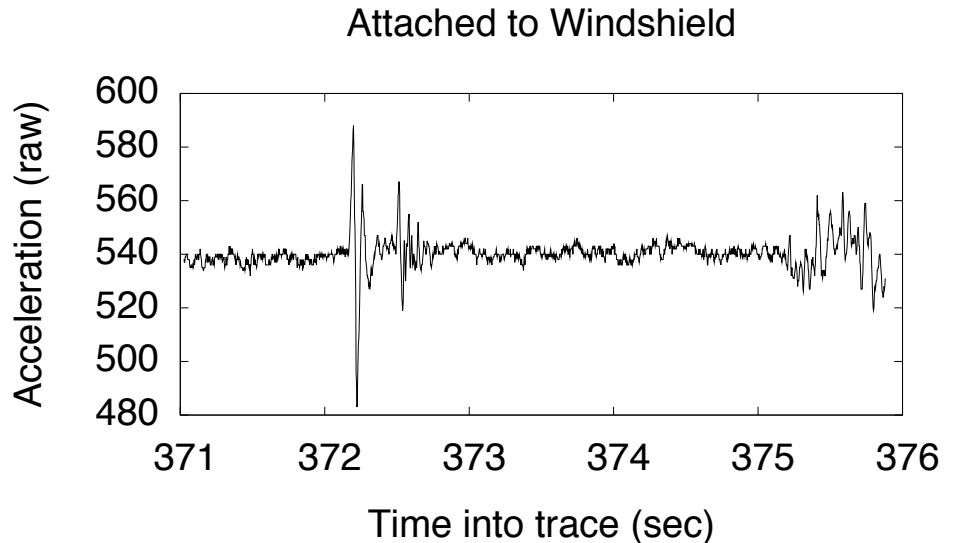
- highly accurate
- difficult mounting
- extreme exposure

WINDSHIELD?

DASHBOARD?

ATTACHED TO PC?

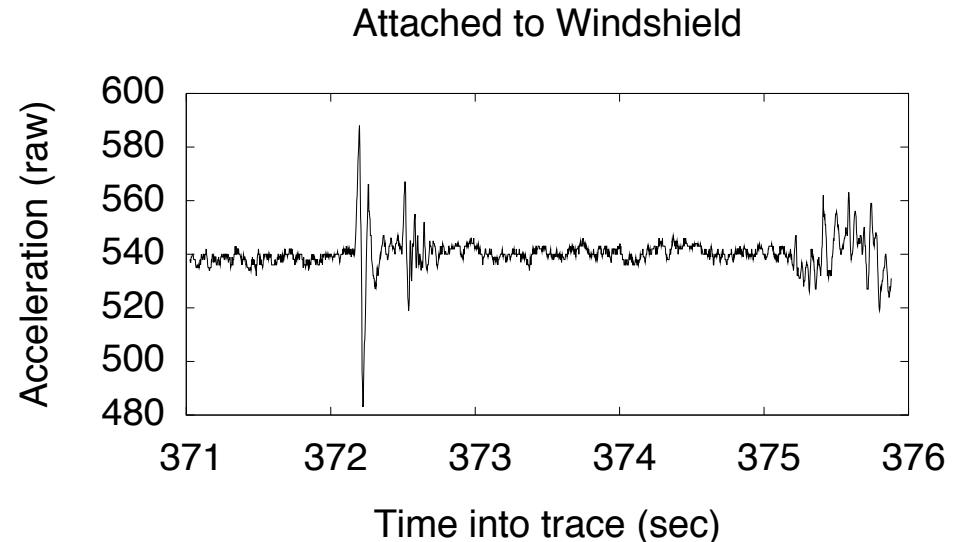
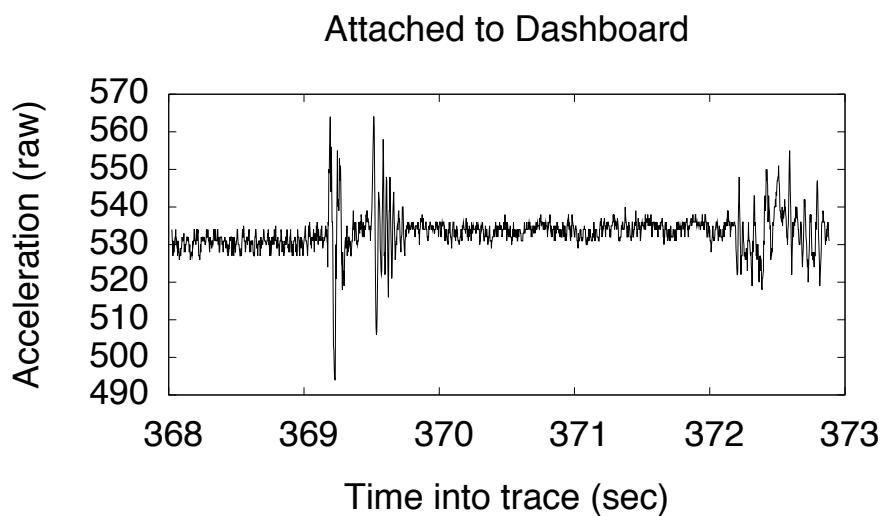
- very clean signal
- ‘gold standard’
- difficult to mount



DASHBOARD?

ATTACHED TO PC?

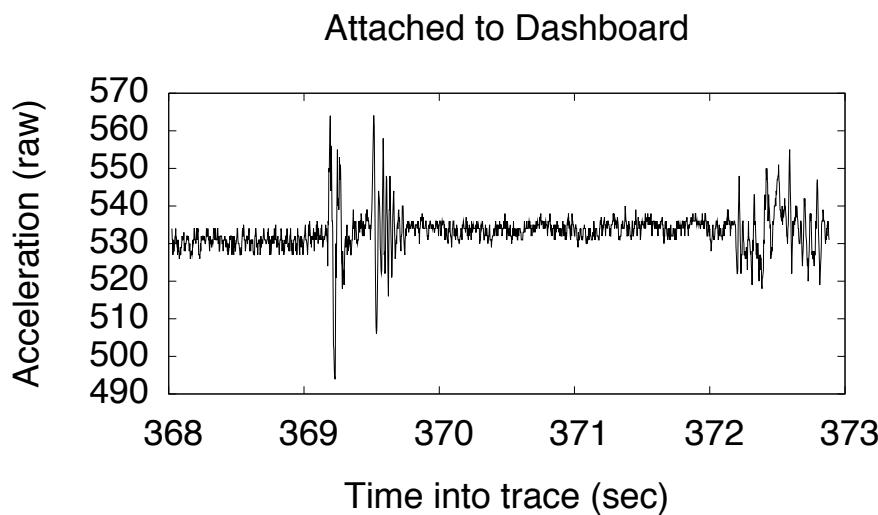
- very clean signal
- ‘gold standard’
- difficult to mount



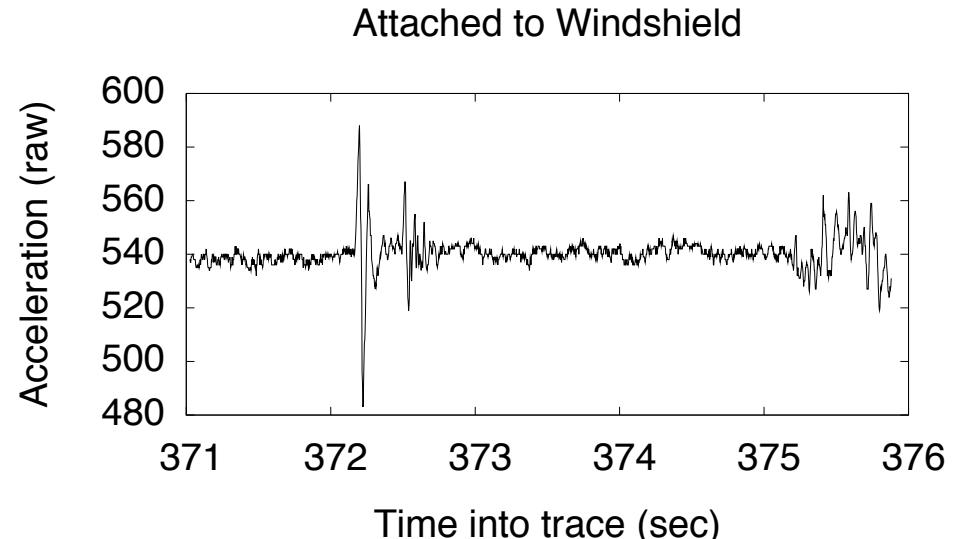
- good signal
- easy to mount
- ‘out of the way’

ATTACHED TO PC?

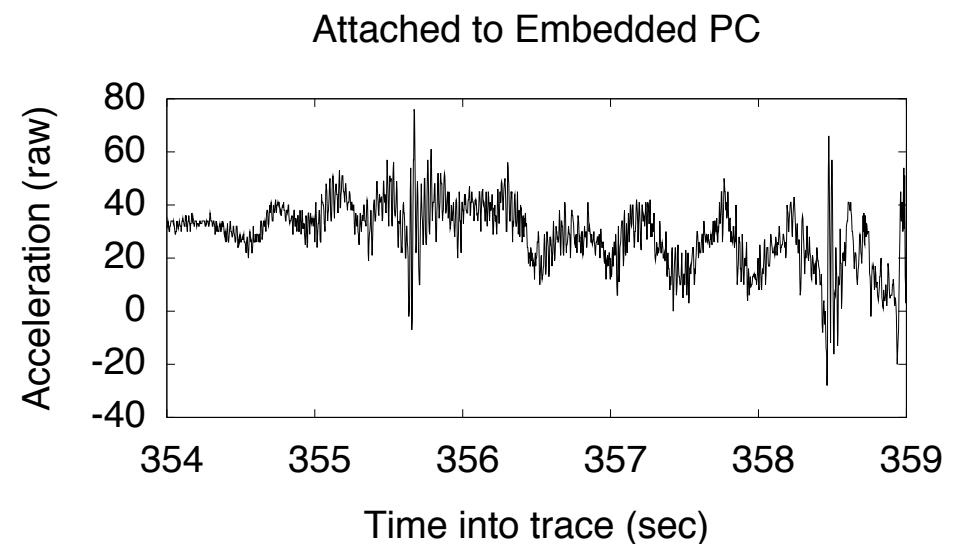
- very clean signal
- ‘gold standard’
- difficult to mount

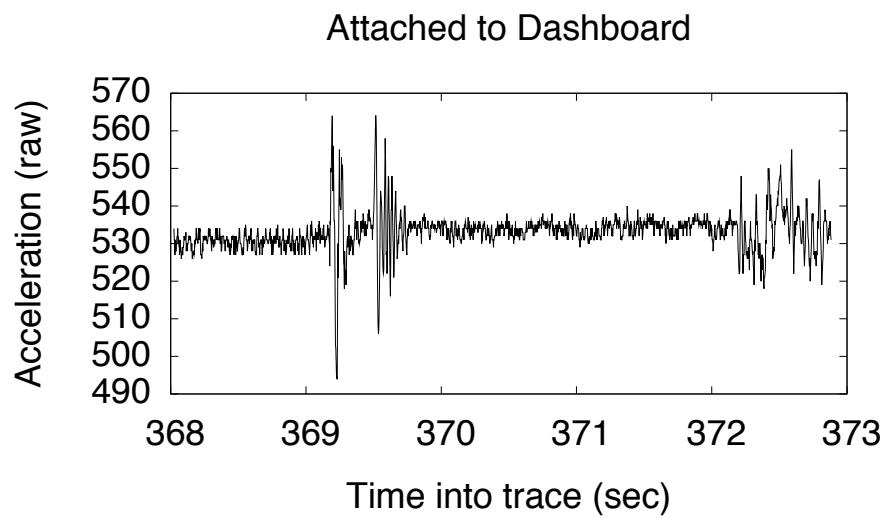


- very poor signal
- no mounting necessary



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

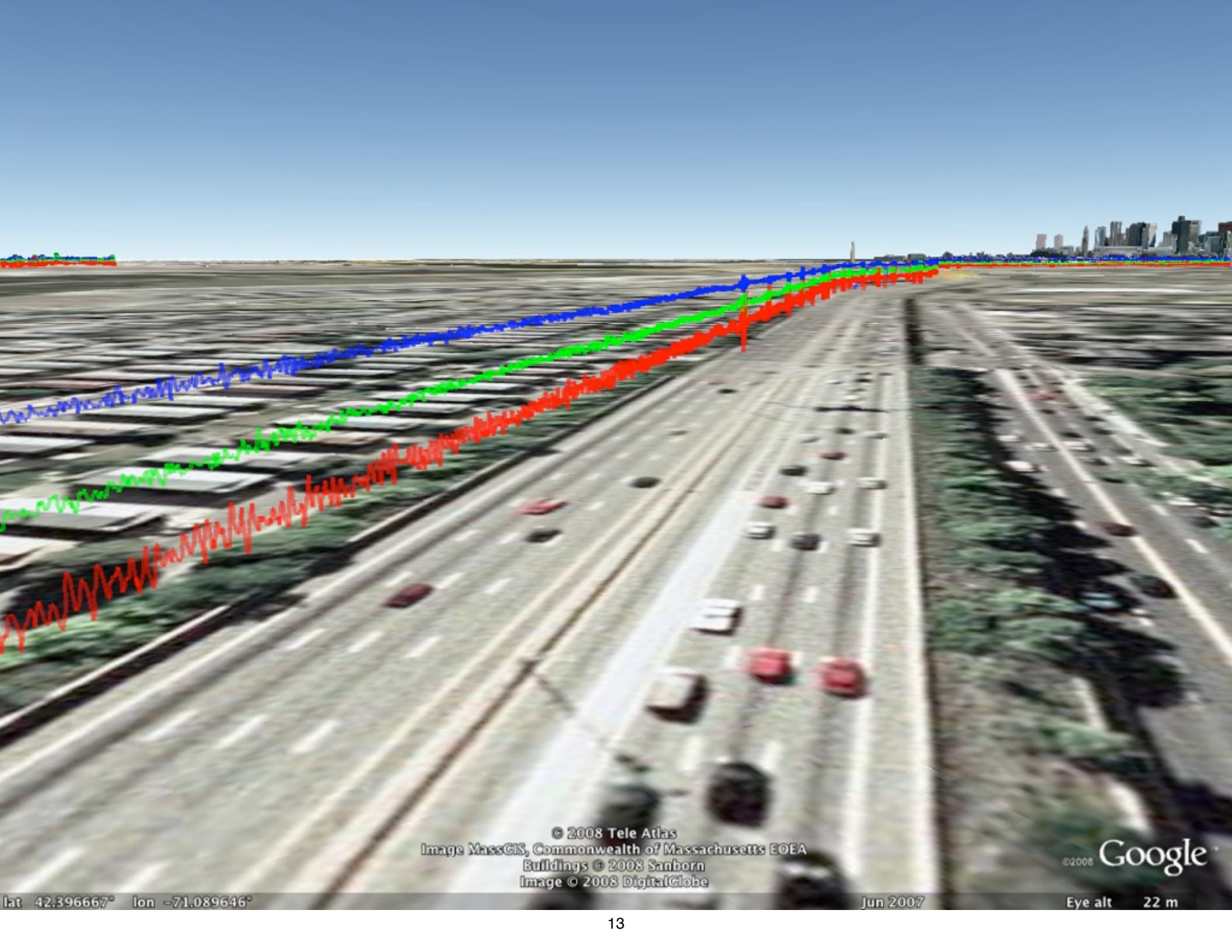




- good signal
- easy to mount
- ‘out of the way’

crowd-pleasing graphics

CONTINUE



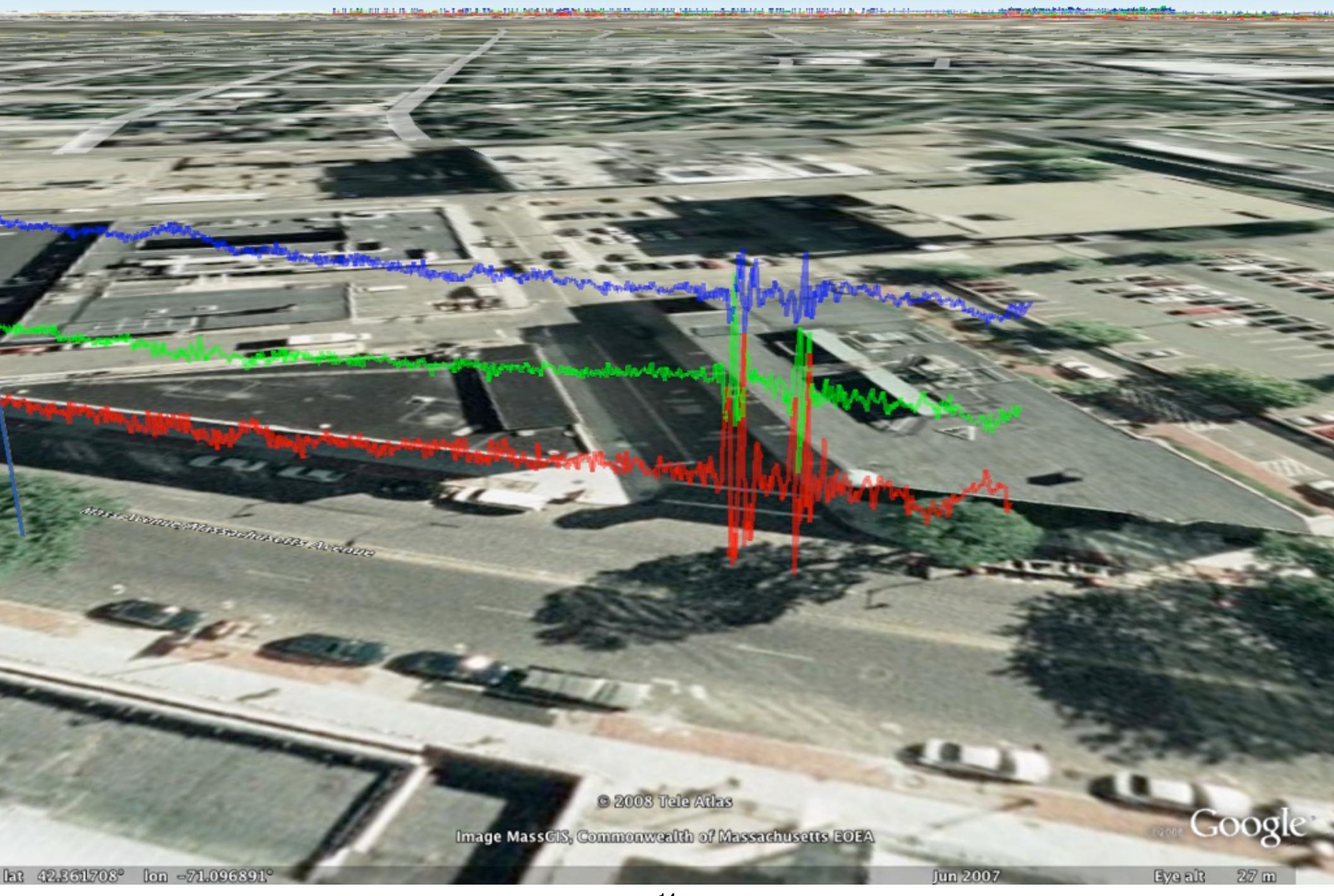
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Image MassGIS, Commonwealth of Massachusetts EOEA
Buildings © 2008 Sanborn
Image © 2008 DigitalGlobe

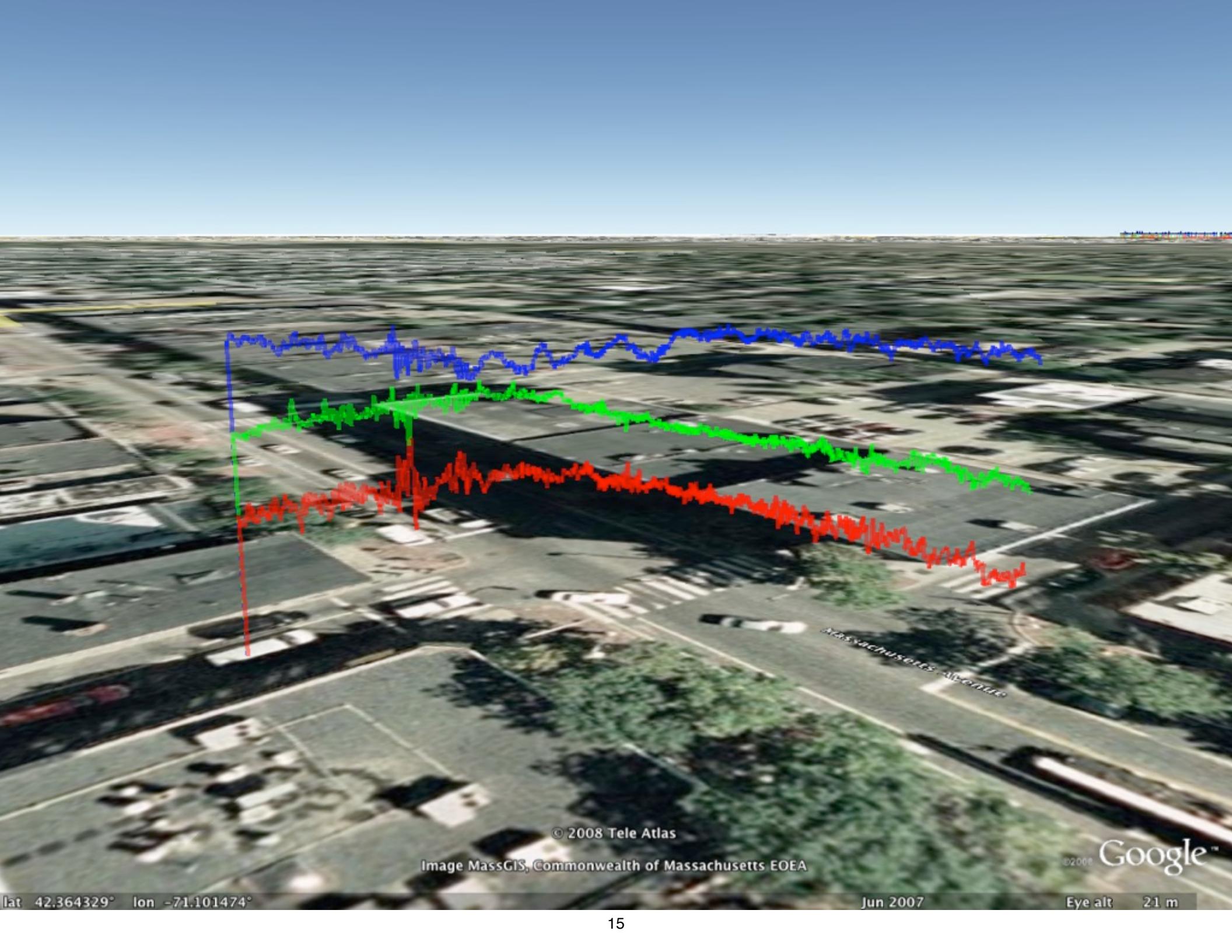
©2008 Google™

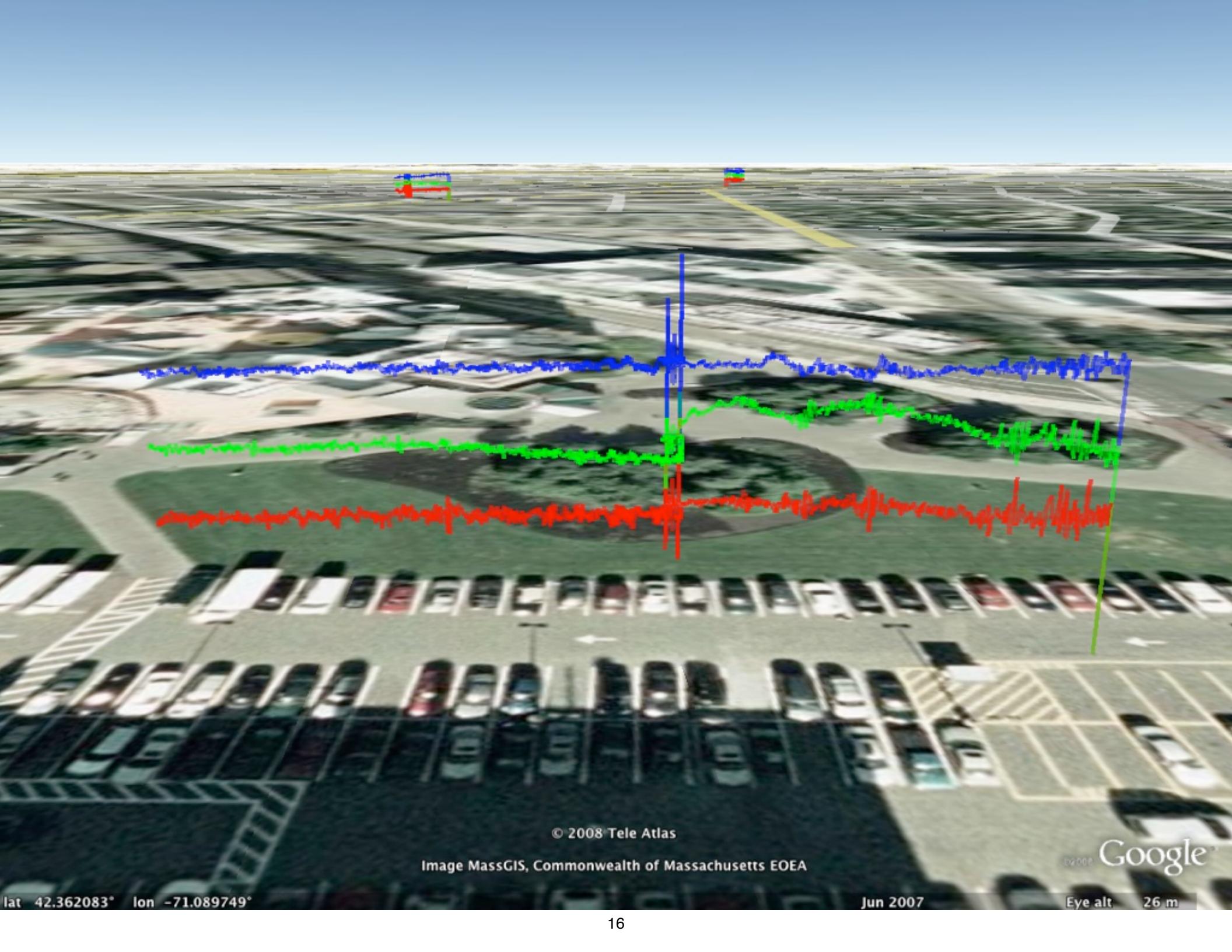
lat 42.396667° lon -71.089646°

Jun 2007

Eye alt 22 m







© 2008 Tele Atlas

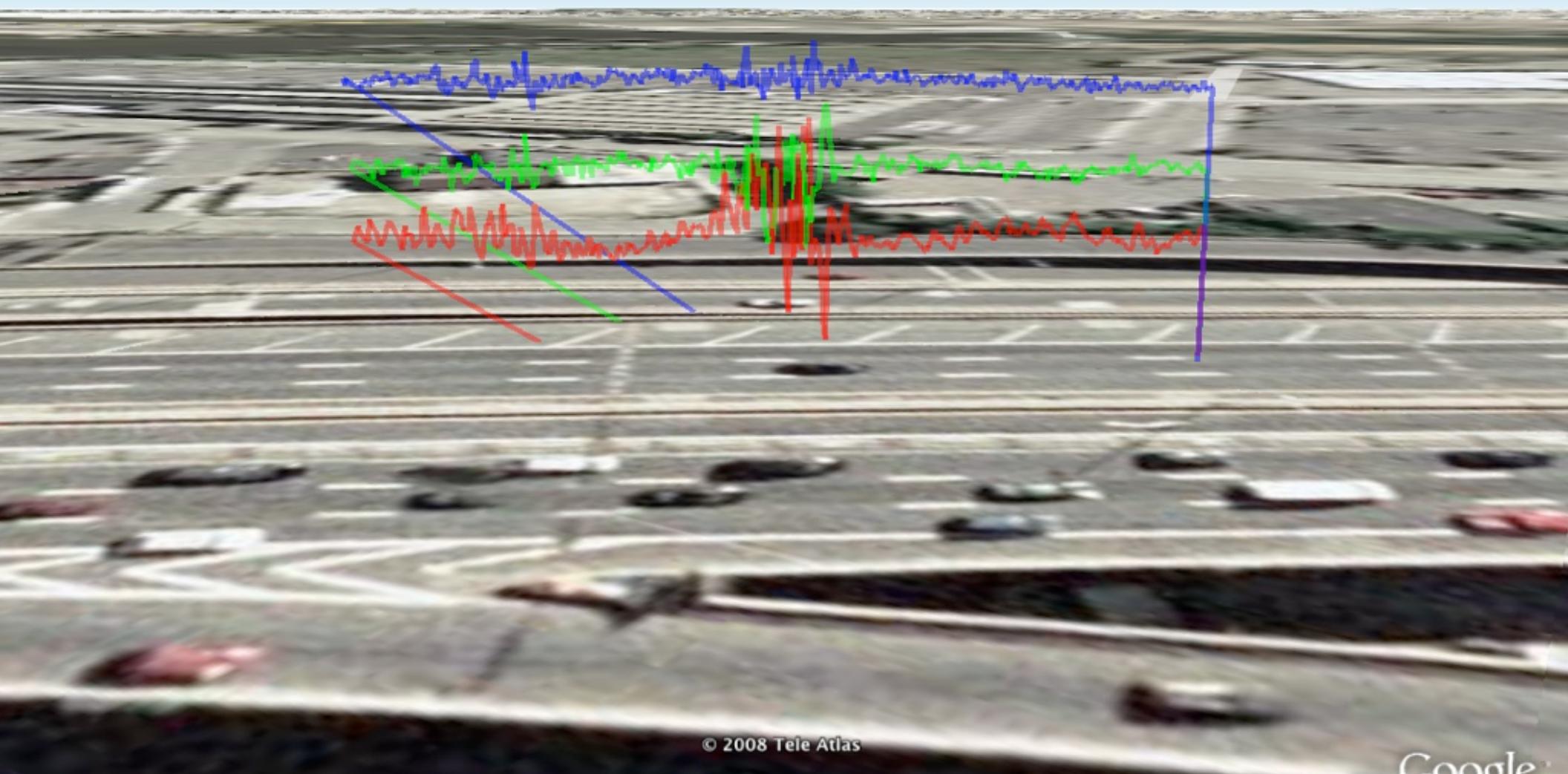
Image MassGIS, Commonwealth of Massachusetts EOEA

Google

lat 42.362083° lon -71.089749°

Jun 2007

Eye alt 26 m



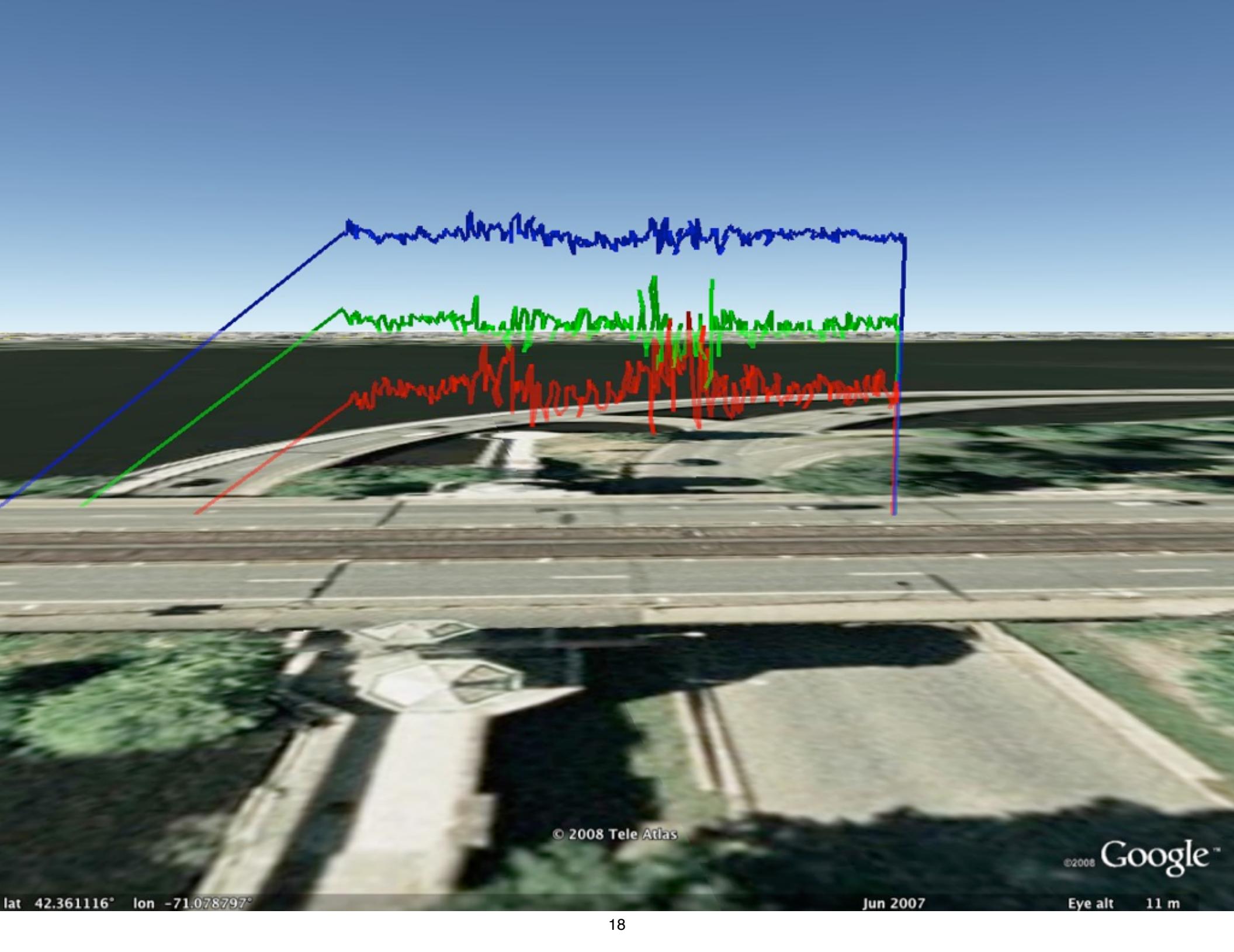
© 2008 Tele Atlas

Image MassGIS, Commonwealth of Massachusetts EOEA
Image © 2008 DigitalGlobe

Google

lat 42.392652° lon -71.084025°

Eye alt 21 m



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lat 42.361116° lon -71.078797°

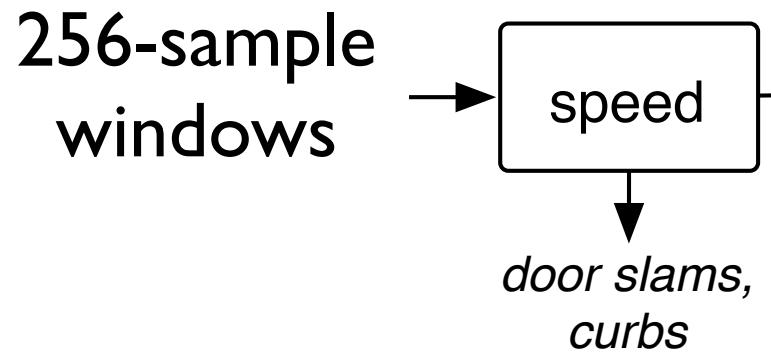
Jun 2007

Eye alt 11 m

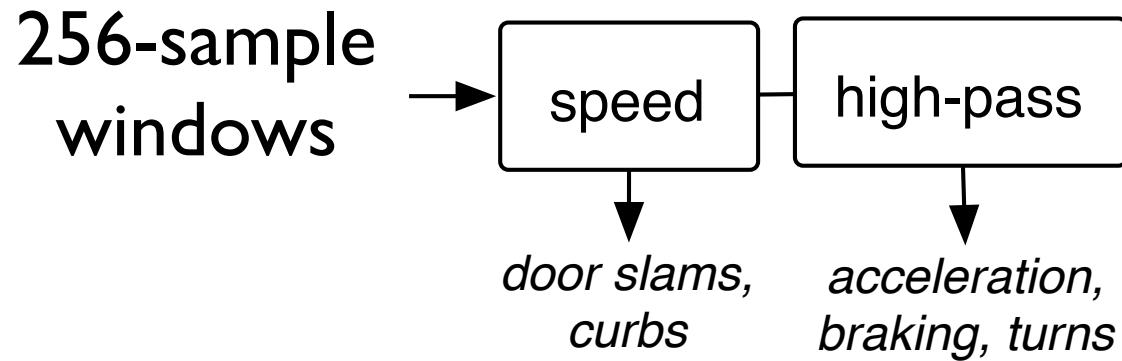
P² detector

256-sample
windows →

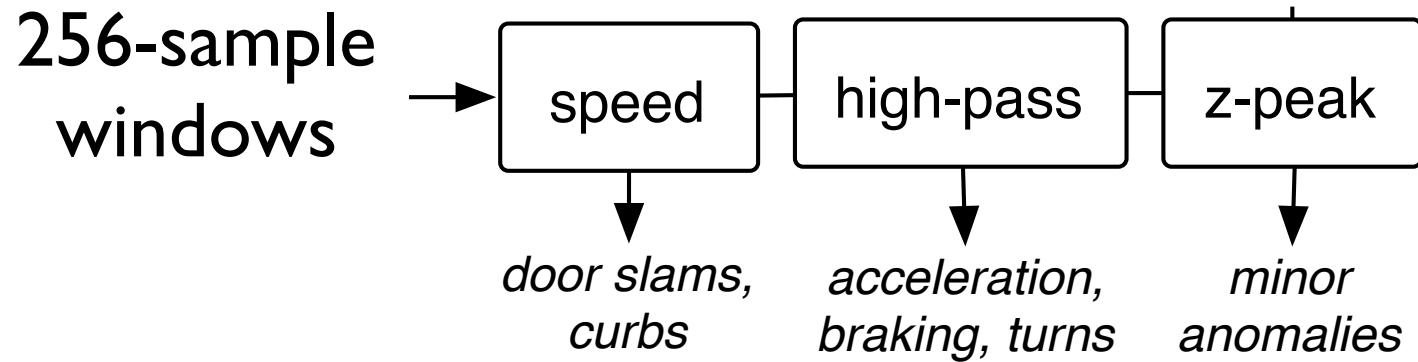
P² detector



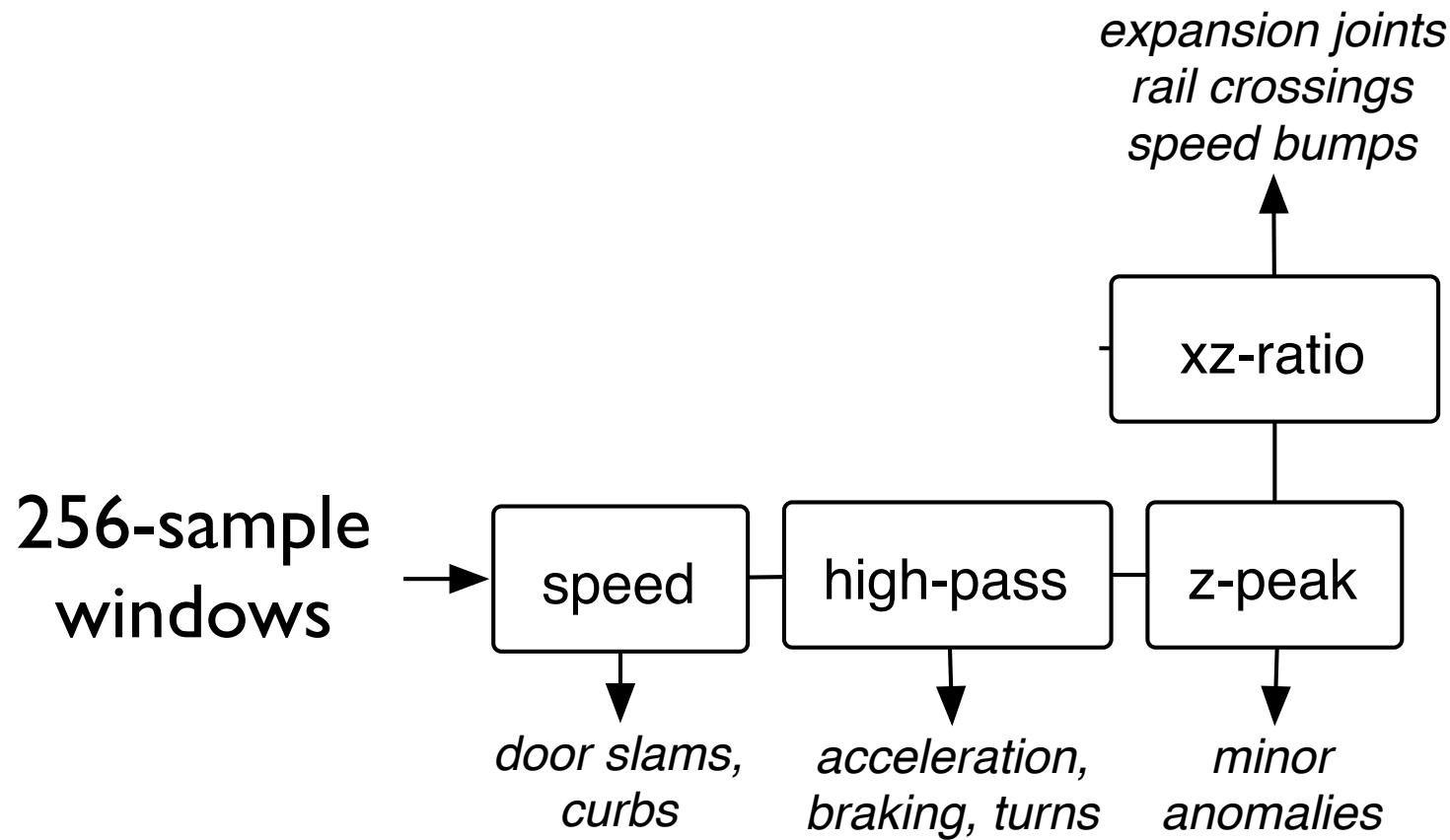
P² detector



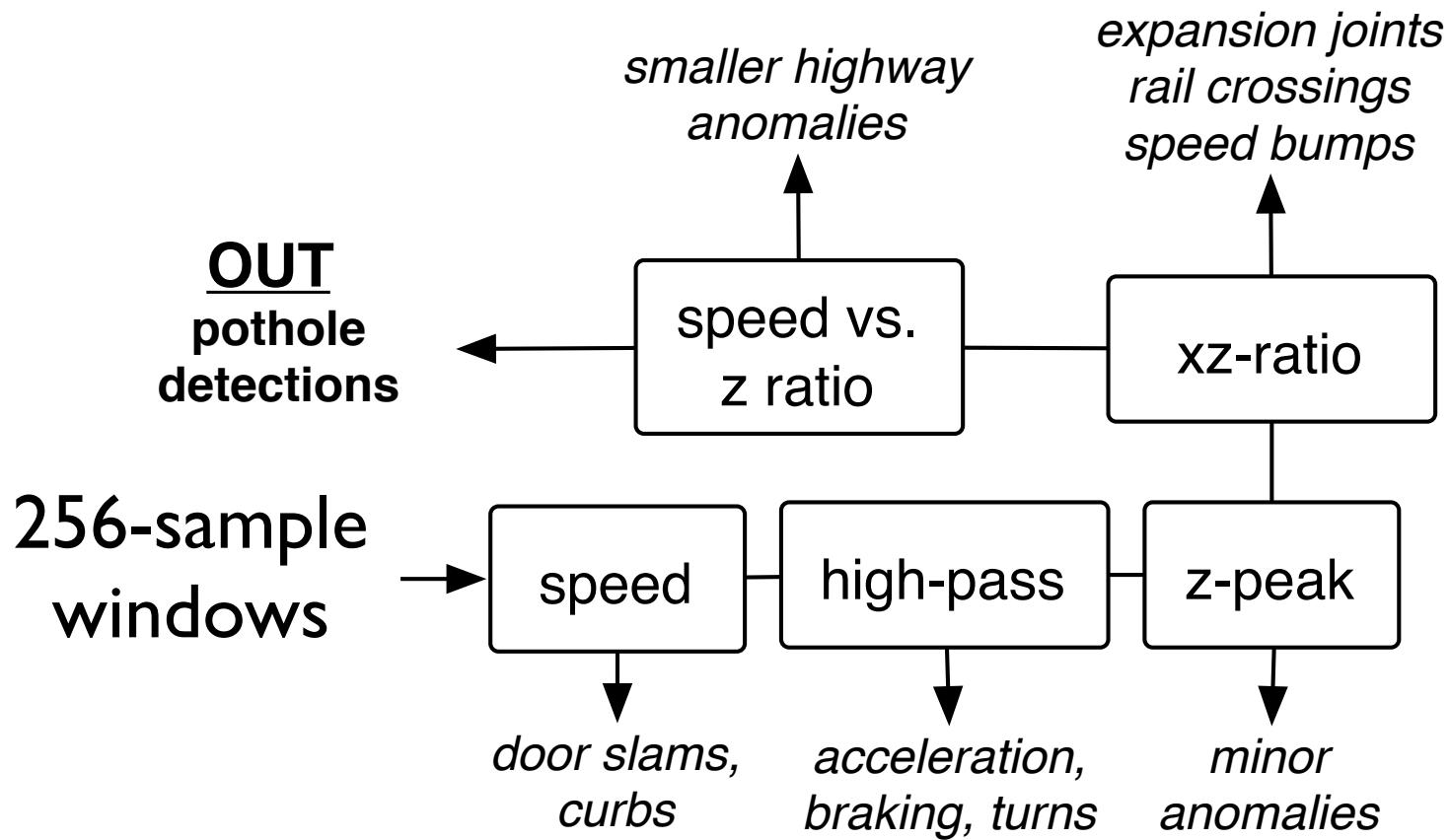
P² detector



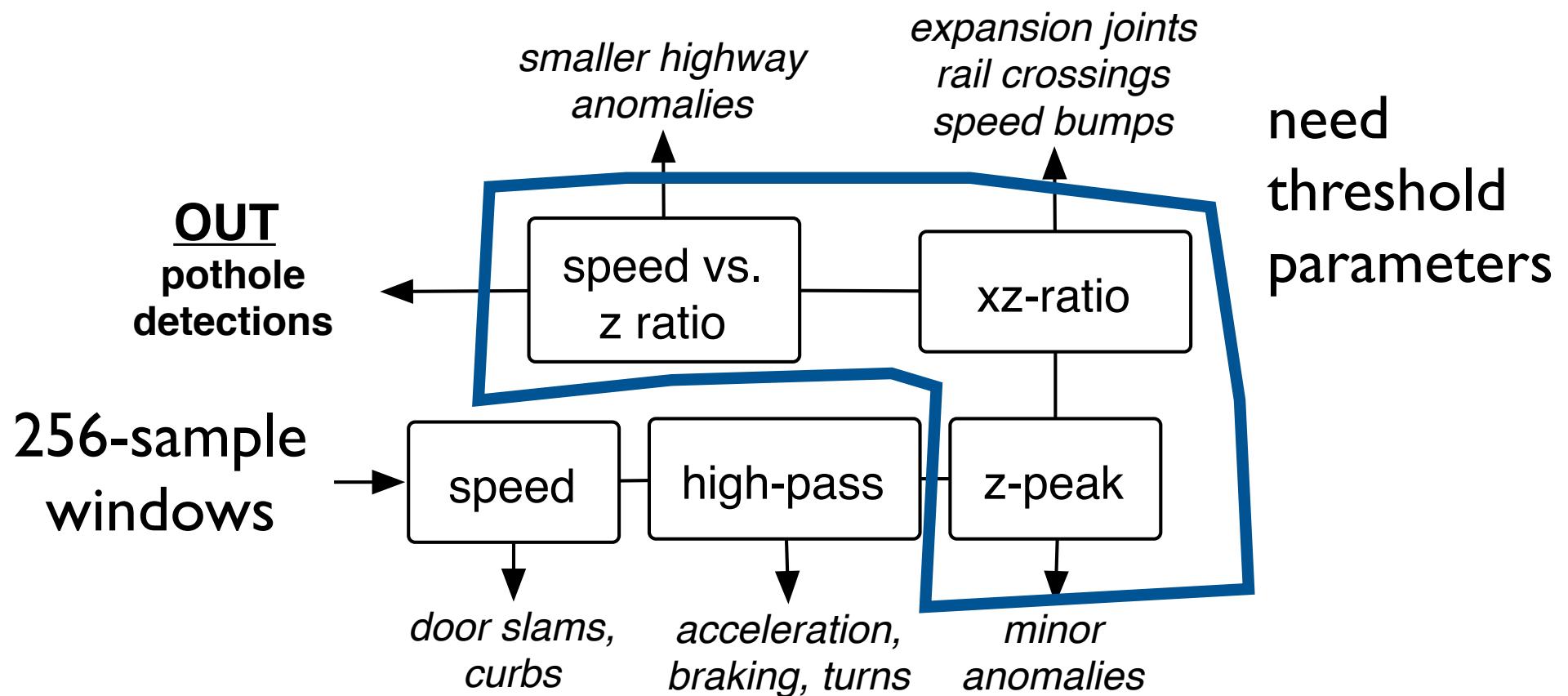
P² detector



P² detector



P² detector



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%

training the detector

- pick an objective function

training the detector

- pick an objective function

$$s(t) = corr - incorr^2$$

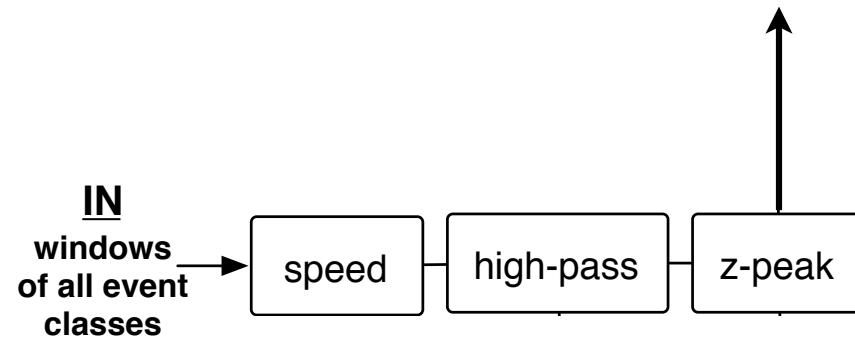
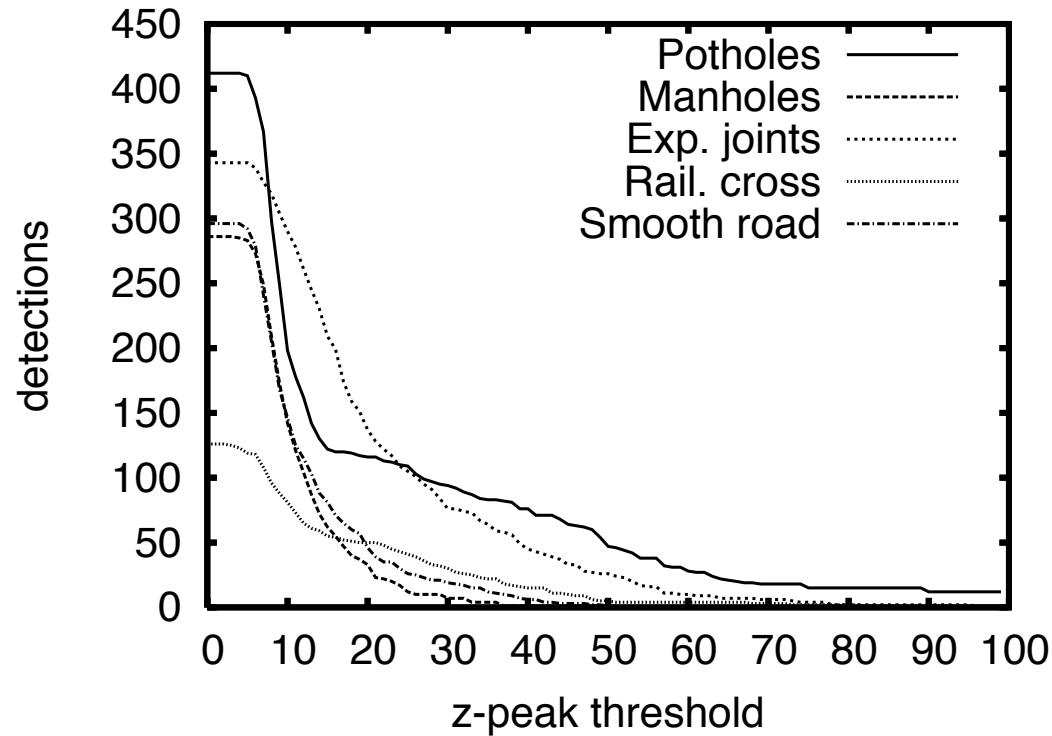
training the detector

- pick an objective function

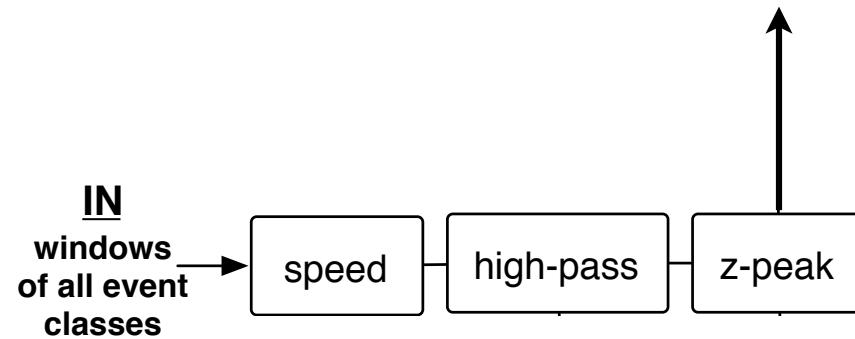
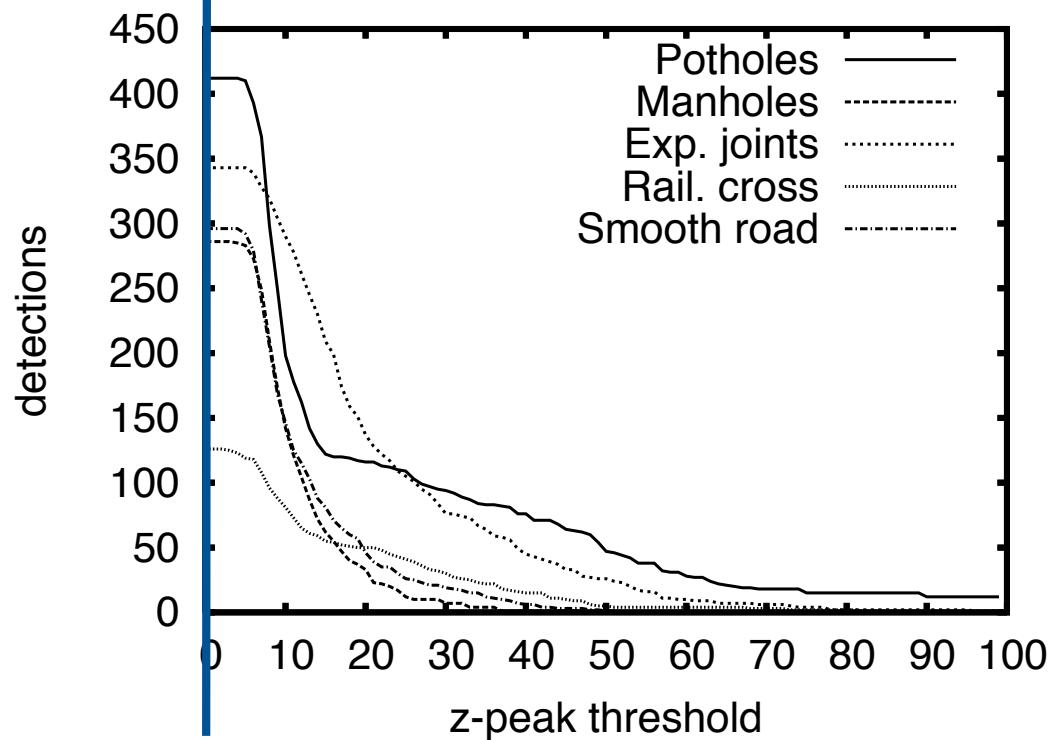
$$s(t) = corr - incorr^2$$

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

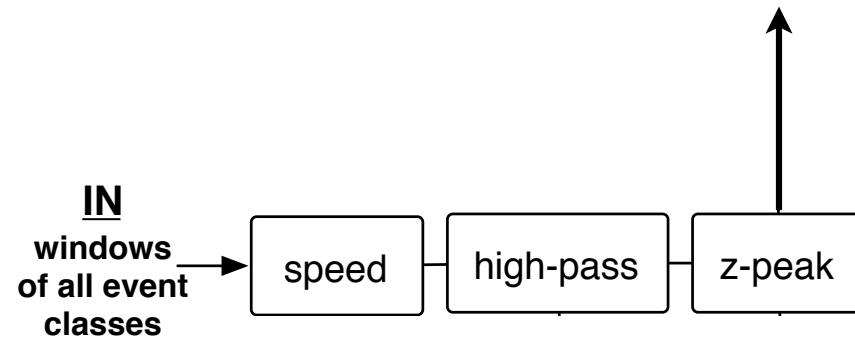
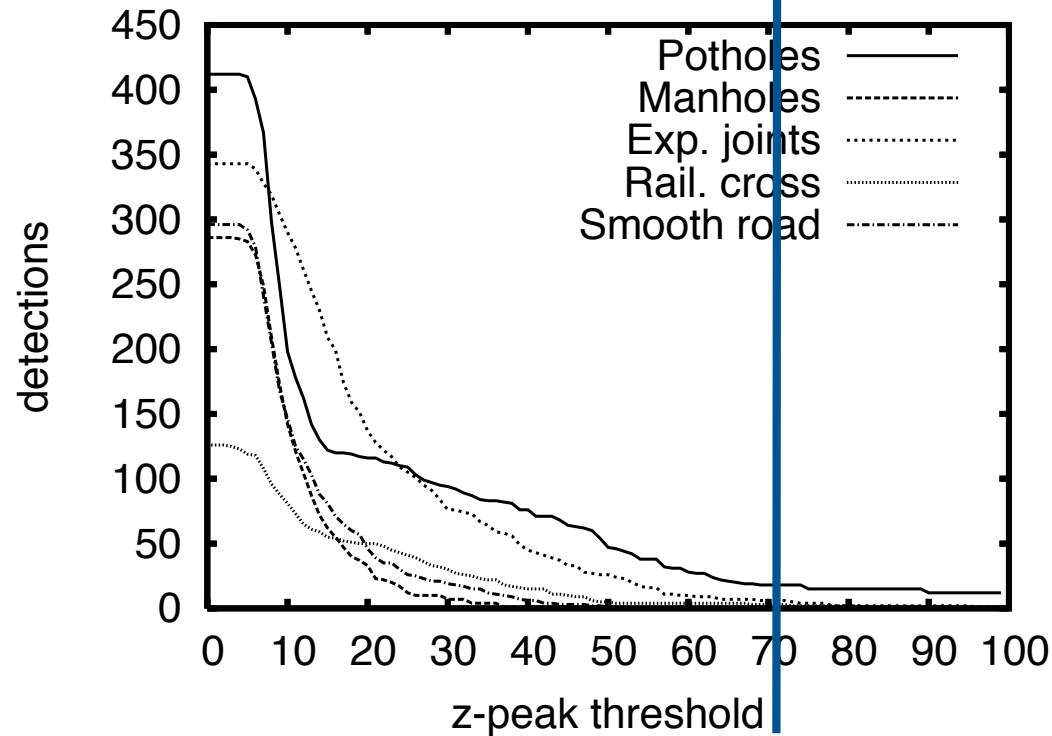
training the detector



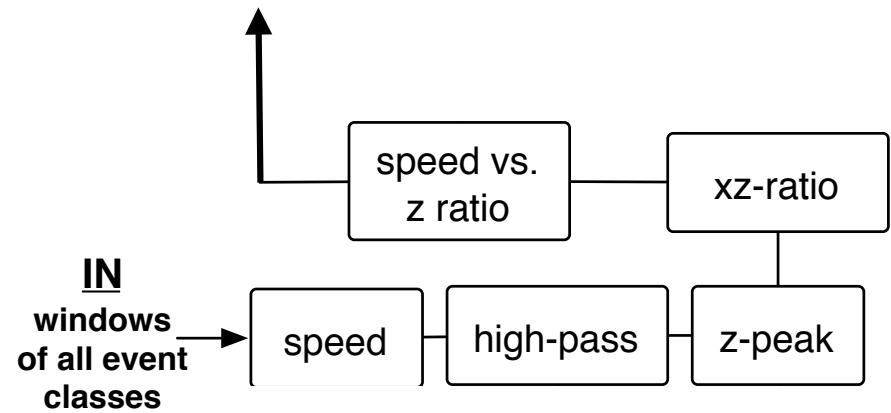
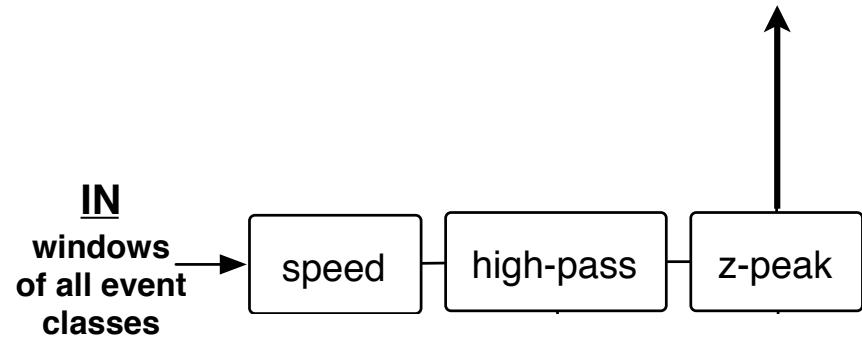
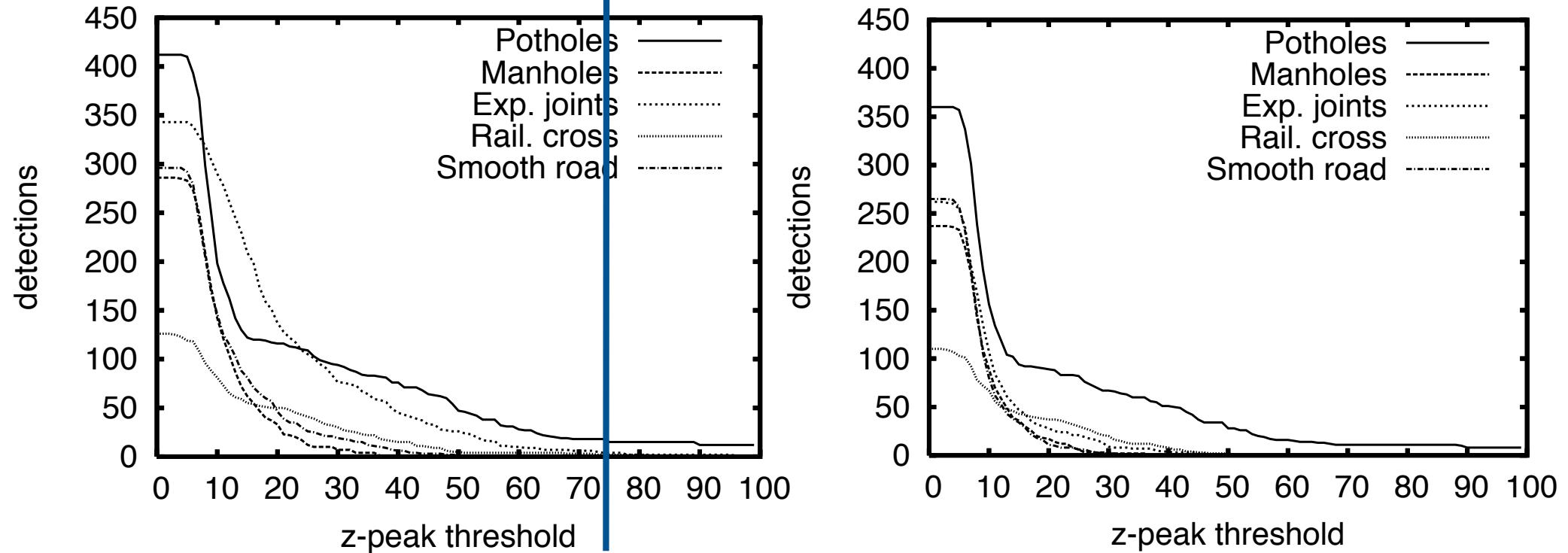
training the detector



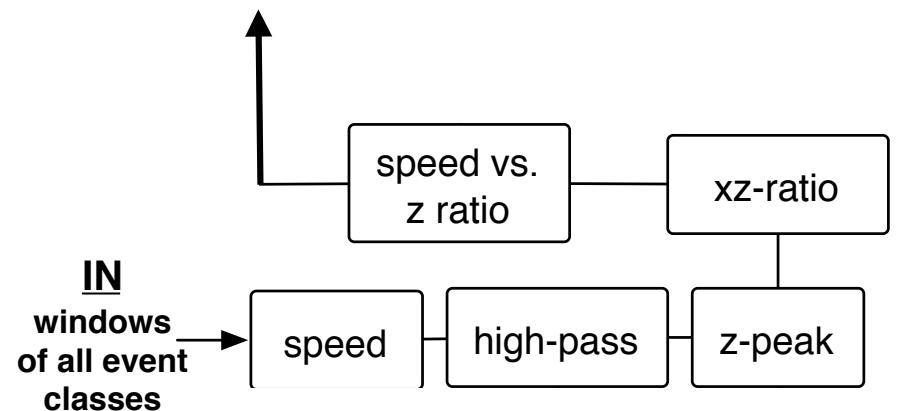
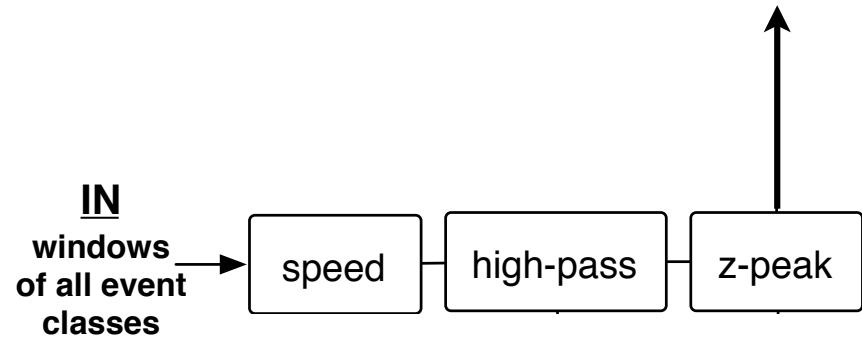
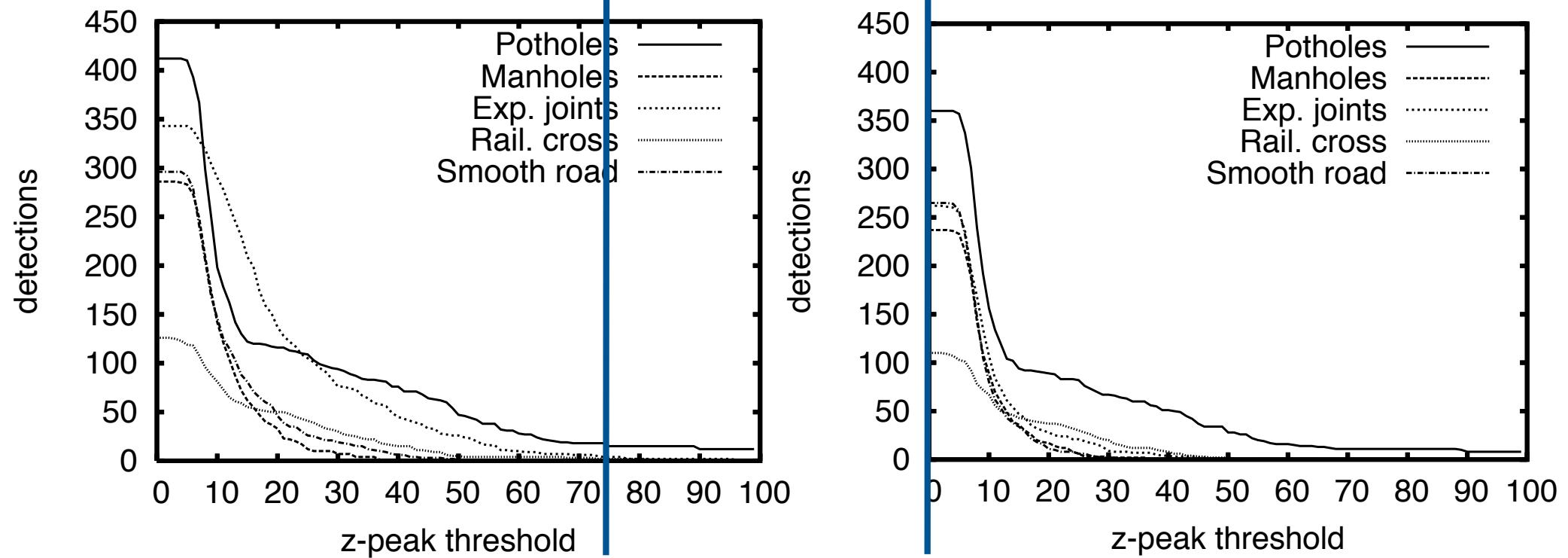
training the detector



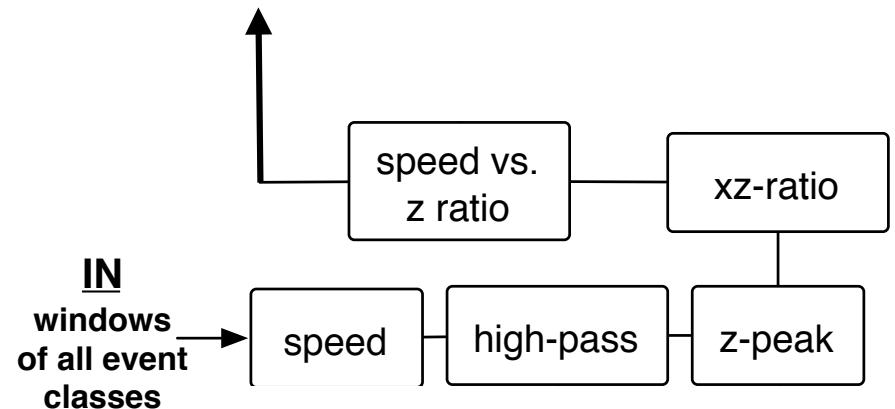
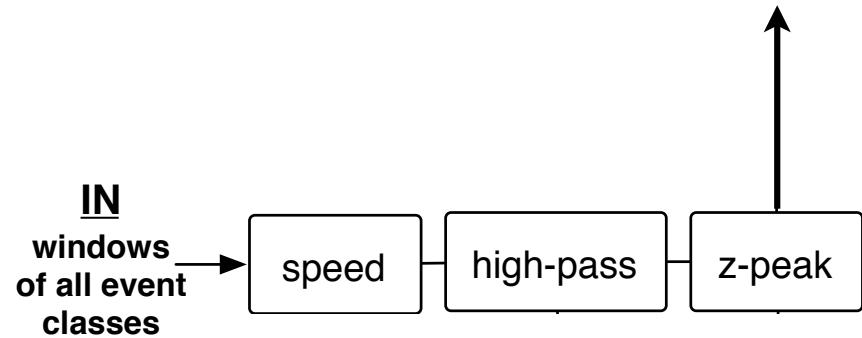
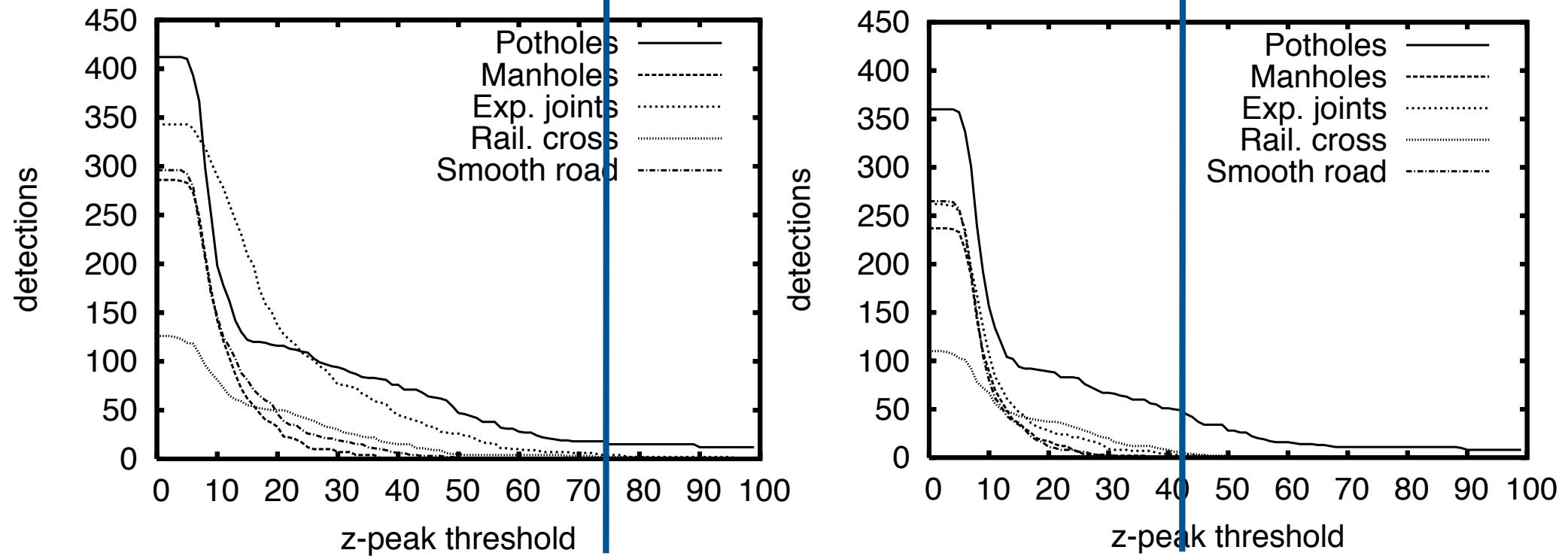
training the detector



training the detector



training the detector



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%

detector performance

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Binney St	some	6887	25	0.63%

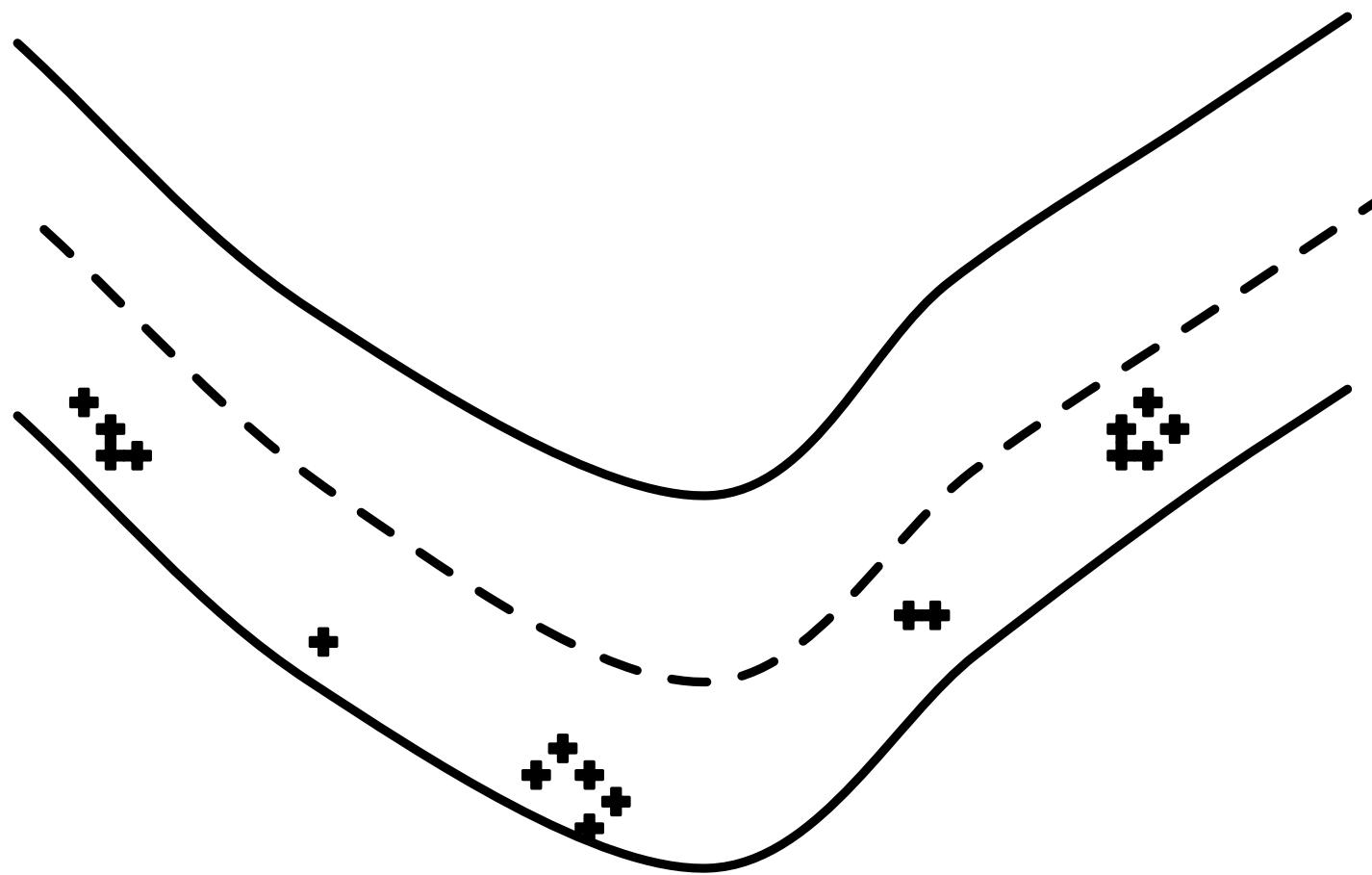
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Binney St	some	6887	25	0.63%
Beacham St	many	1643	231	14%

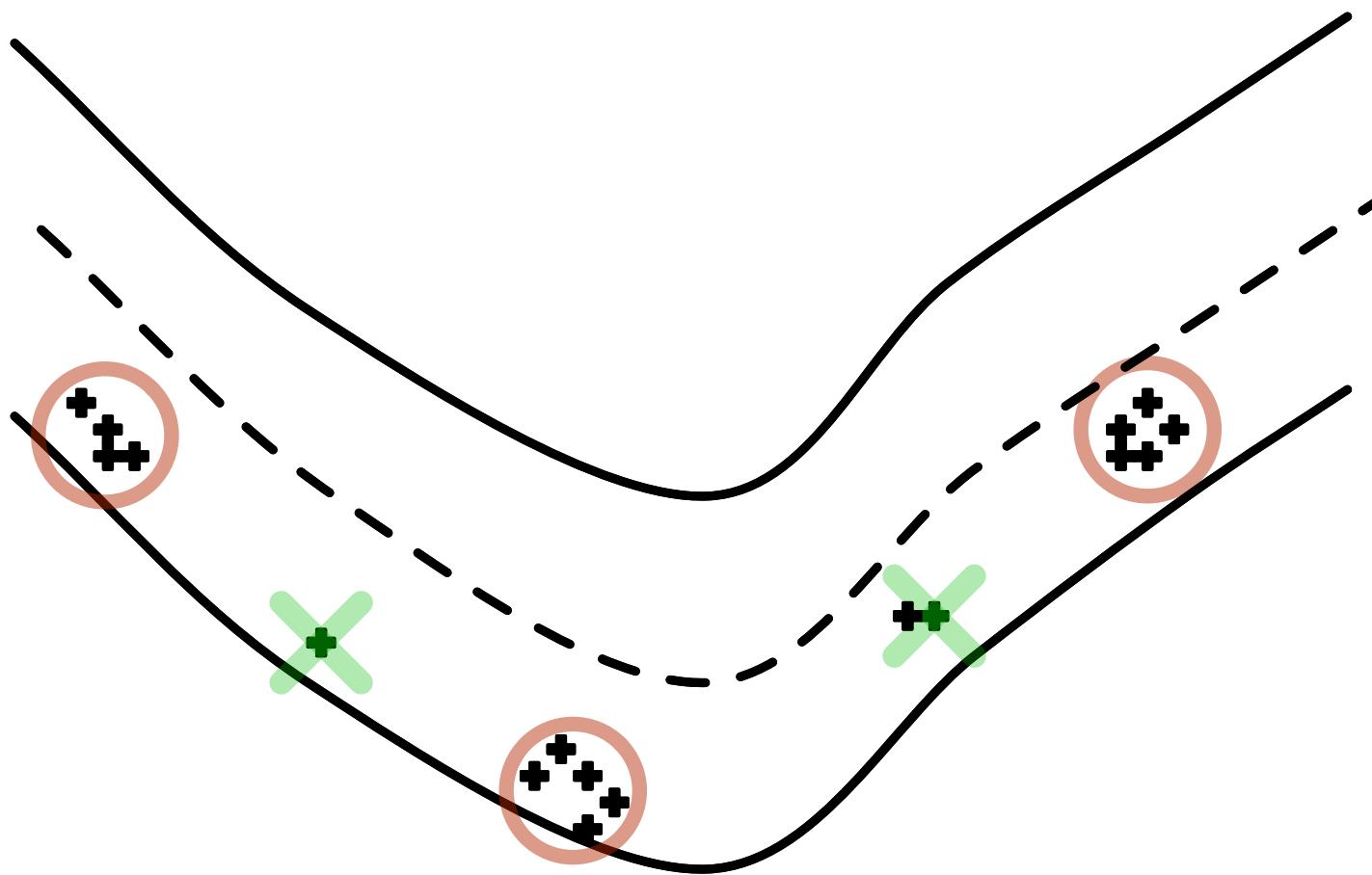
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clustering

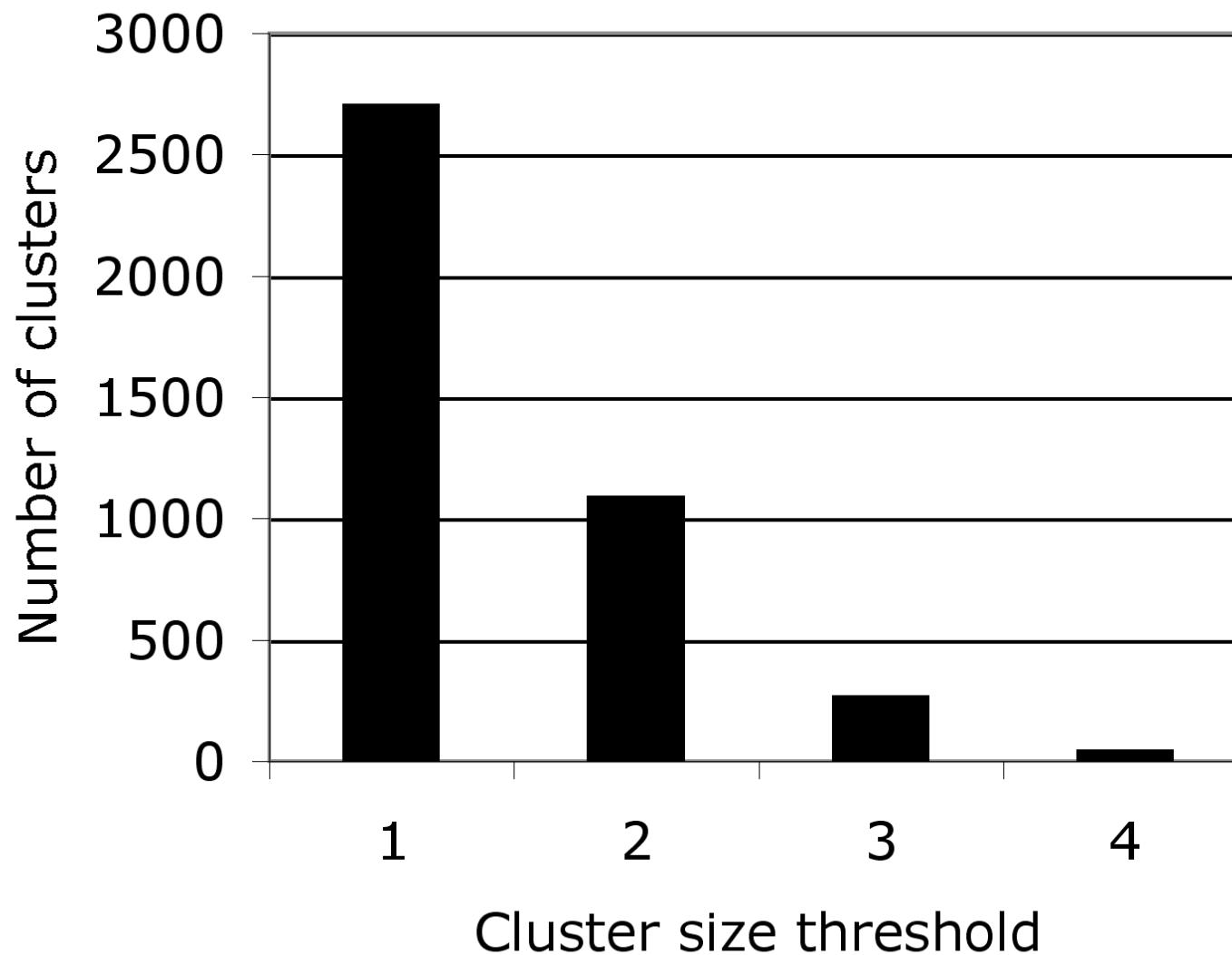


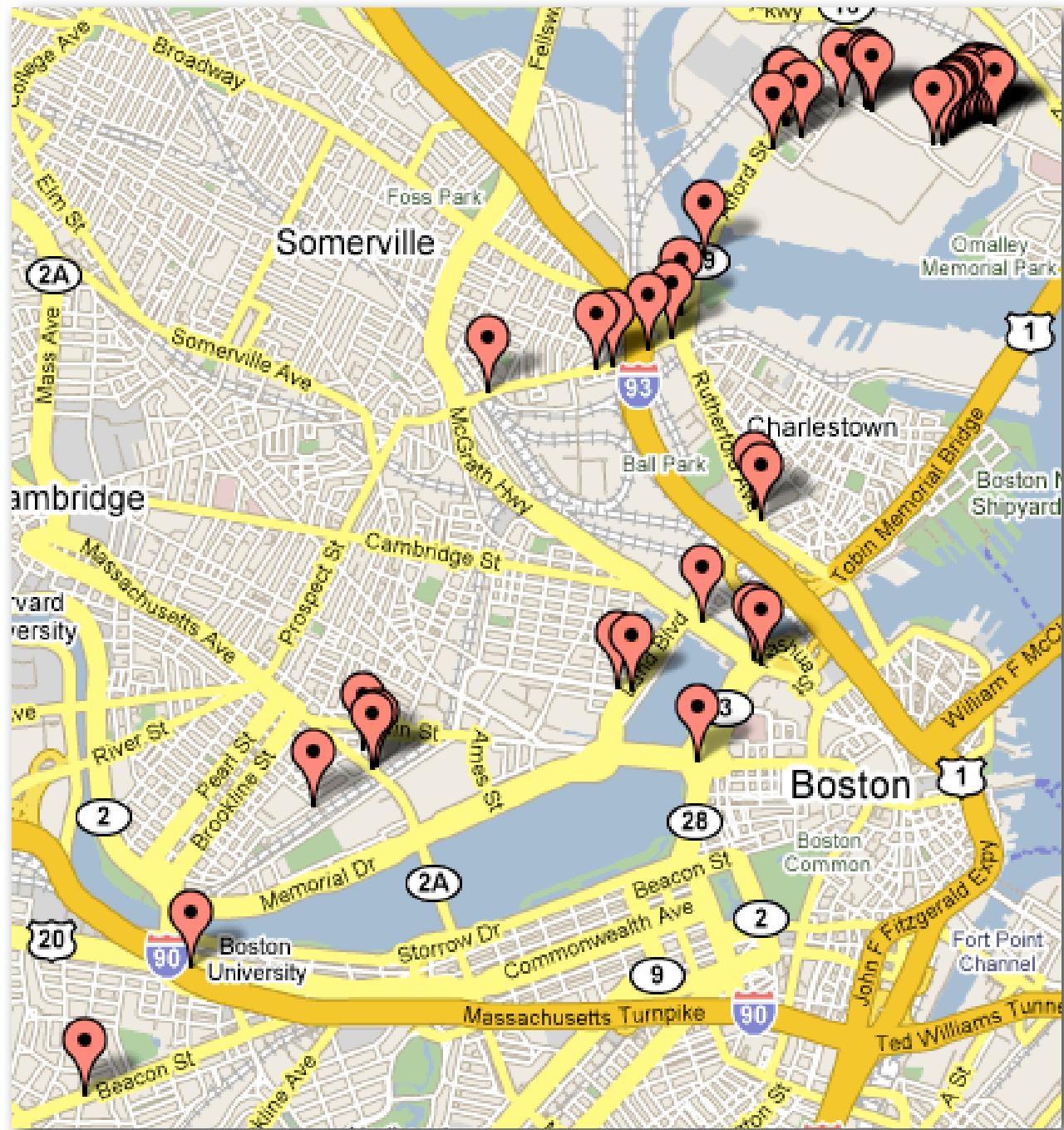
clustering



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

impact of cluster size





48 spot-checks

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

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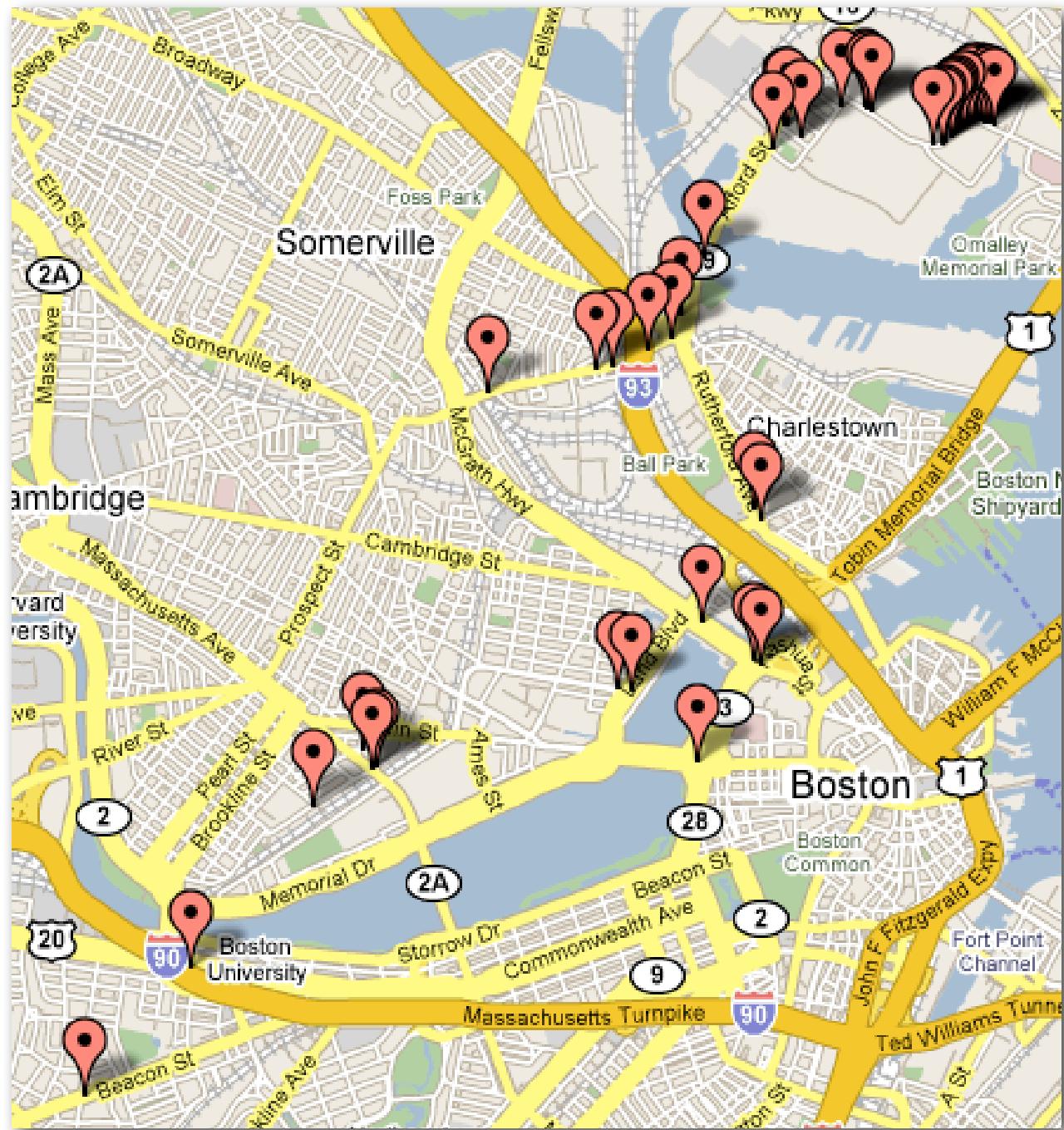
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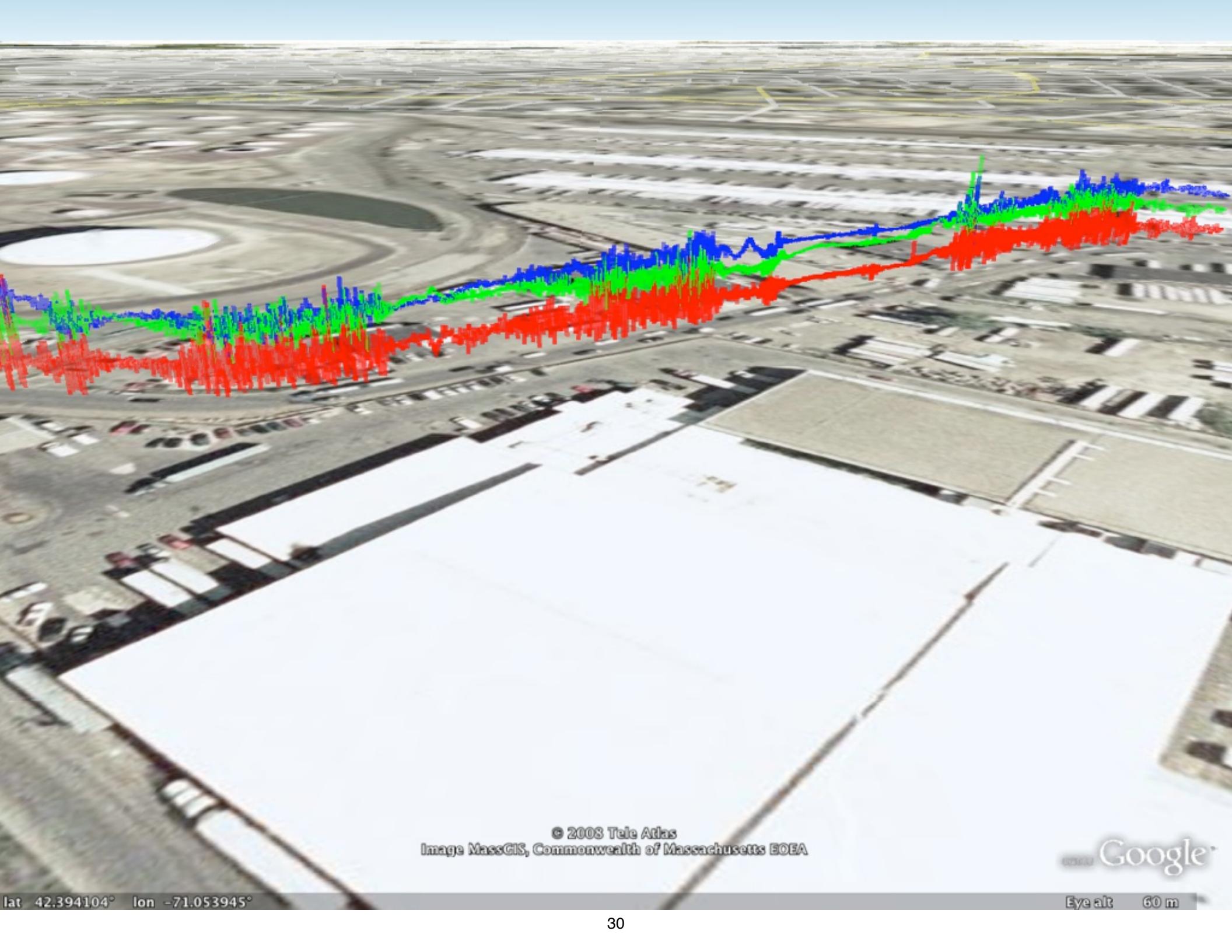


48 spot-checks

potholes	39
sunk-in manholes	3
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Google



P²: 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>