Real-time adaptive signal control for urban road networks

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Traffic Congestion Increases Fuel Consumption and Decreases Air Quality

- Costs $121 Billion per year in lost time and fuel consumption
- Results in 56 Billion pounds of CO^2 in emissions
- 40% of time spent on surface streets in urban areas is spent idling

Smarter Traffic Signals Can Help

- Traffic signal control improvements generally provide the biggest payoff for reducing congestion on surface streets
- Although not yet in wide use, *adaptive traffic control systems* are generally believed to hold most promise for improvement

Adaptive Traffic Signal Control for Urban Road Networks

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Goal: Real-time optimization of traffic flows for urban (grid) road networks

Technical Approach:

- *Decentralized control*
- *Coordinated action*

Research Progress

- 2010-11: Development of core approach; Simulation of performance on downtown Pittsburgh network
- 2011-12: East Liberty pilot deployment
- 2013-14: Expansion of pilot test site

Benefits

- True real-time response
- Multiple dominant flows
- Scalable, incremental deployment
- Multi-modal optimization

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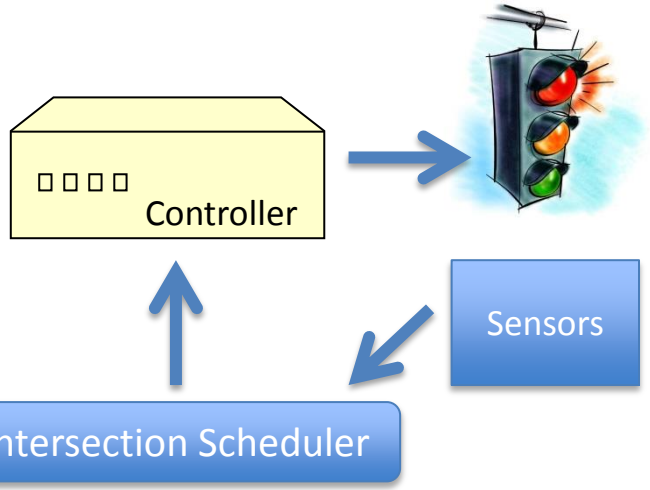
Scalable Urban Traffic Control: surtrac

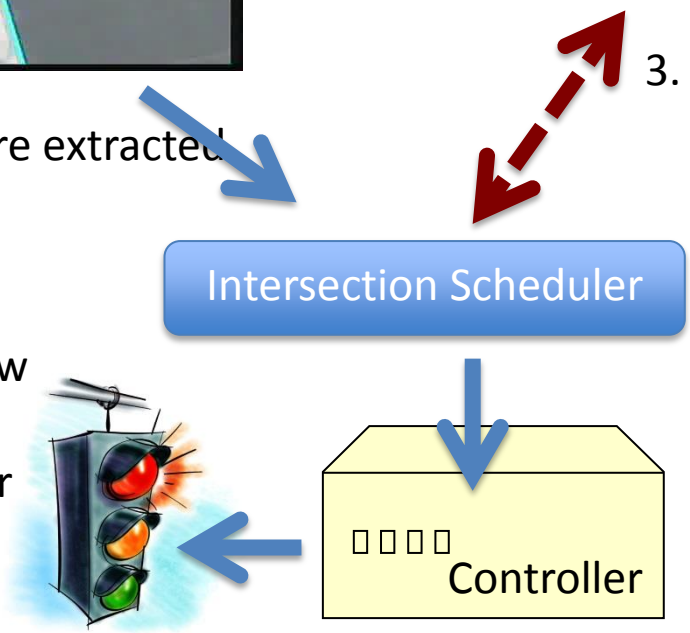
Basic Concept of Operation



1. Current traffic conditions are extracted from sensor data streams

2. System computes phase schedule that optimizes flow at intersection and sends commands to the controller when it is time to change phases

3. Schedule is communicated to downstream neighbors to indicate what is coming



4. **Rolling Horizon:** Scheduling cycle is repeated every few seconds

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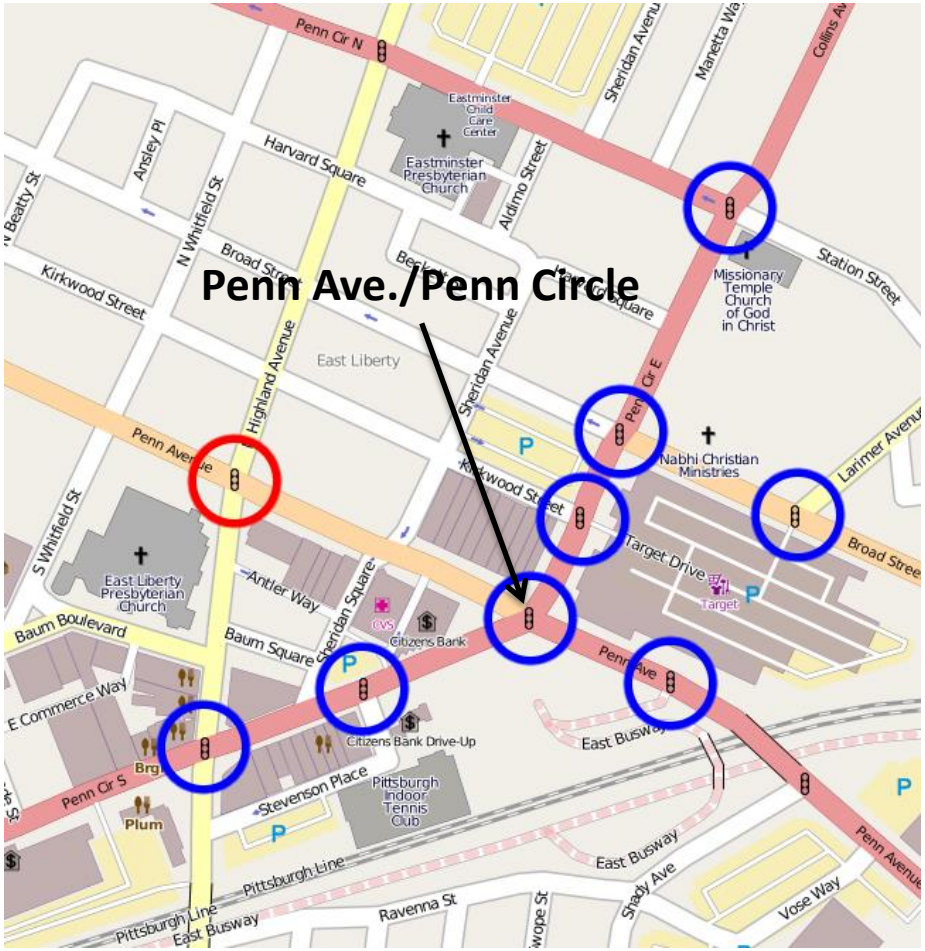
Penn Circle Pilot Study

Test Site

- Developing area of Pittsburgh with changing traffic patterns and volumes
- Mixed commercial, retail and residential land use
- 9 recently upgraded intersections with camera detection



Partners

- The Heinz Endowments
- City of Pittsburgh
- East Liberty Development Corp.
- Traficon Traffic Video Detection
- Traffic Control Products

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BREATHE

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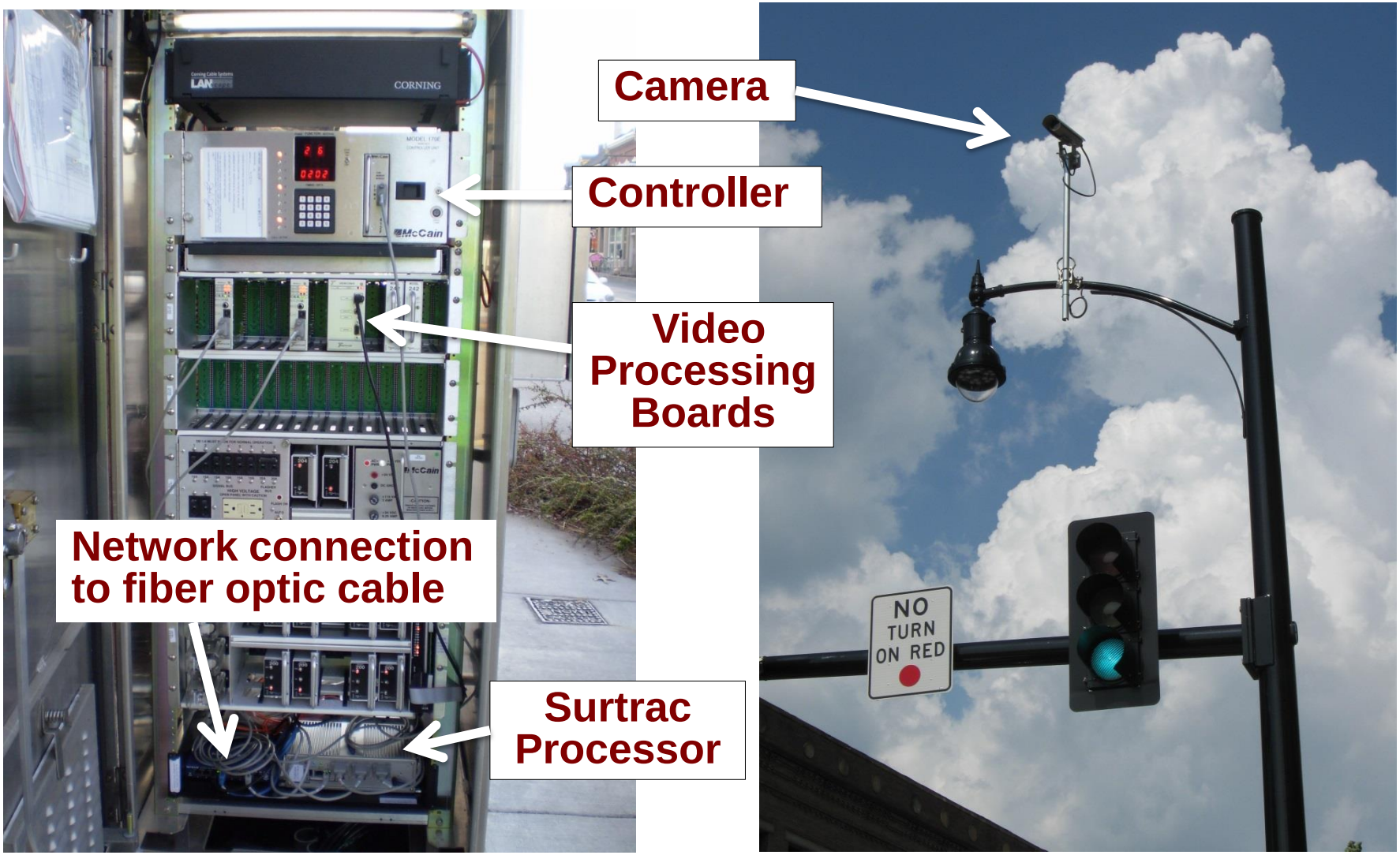
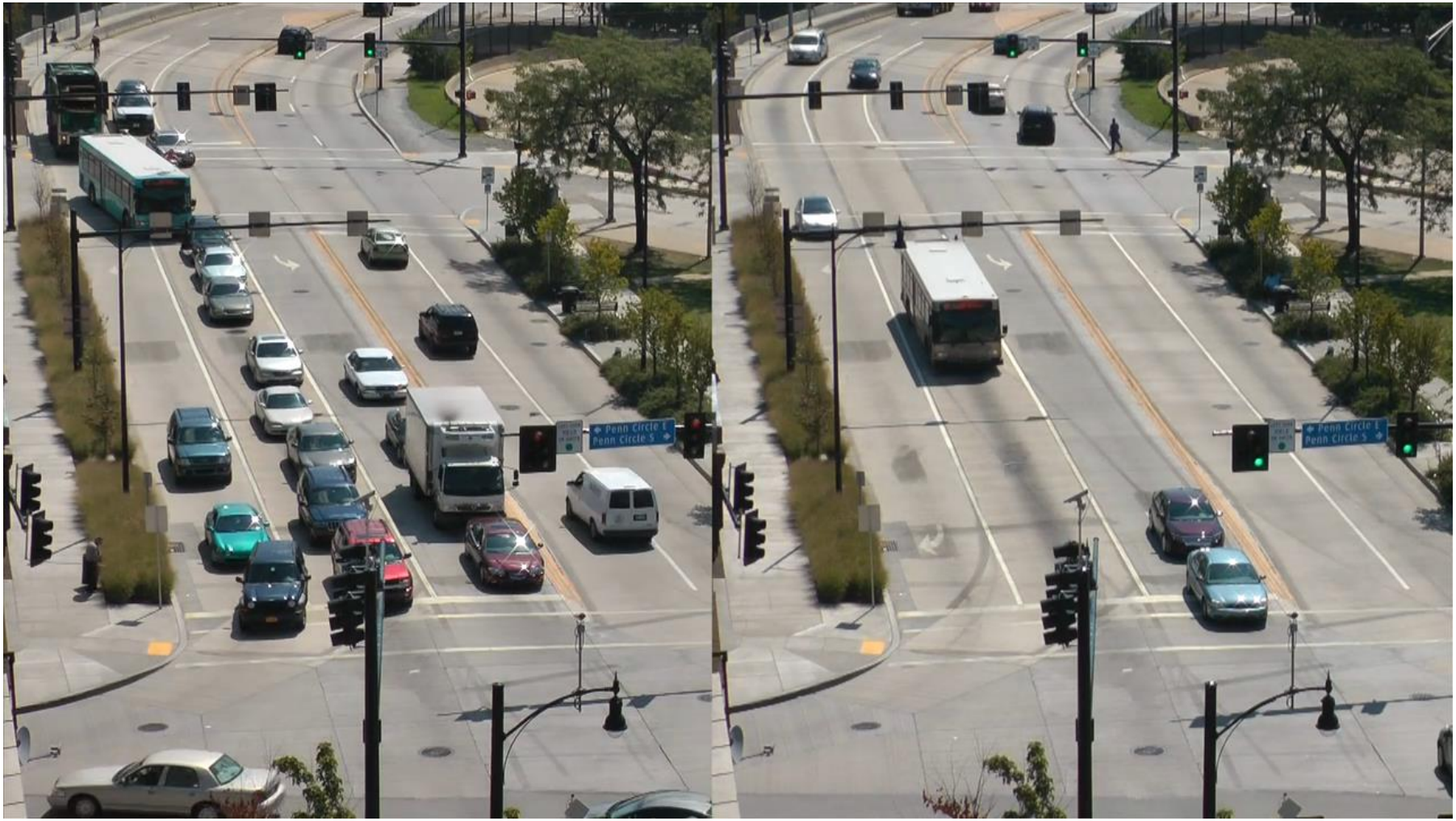
Initial Deployment



SURTRAC in Action



Before

After

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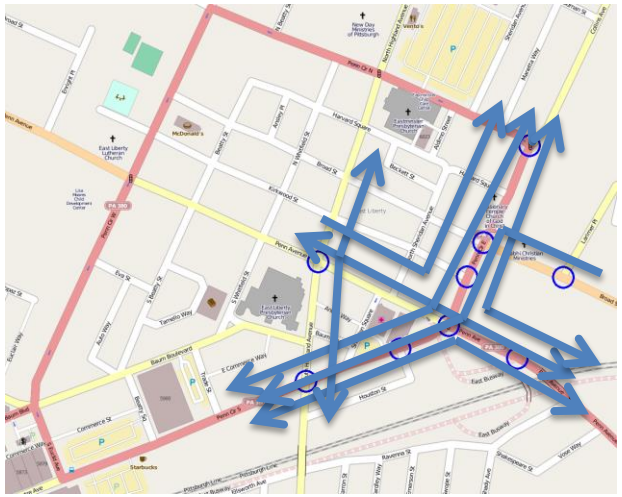
East Liberty Pilot Test Results

- **Performance comparison to current coordinated-actuated timing plans**
  - Series of before and after drive-through runs over 12 routes at 4 different periods of the day
  - GPS tracking of travel times and number of stops
  - Traffic volume data used to combine data from different routes

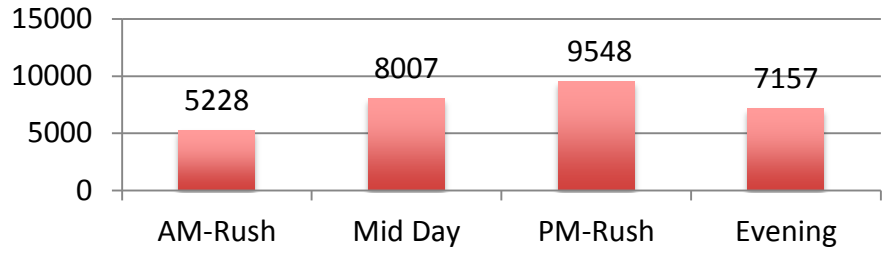


- **Summary Results:**

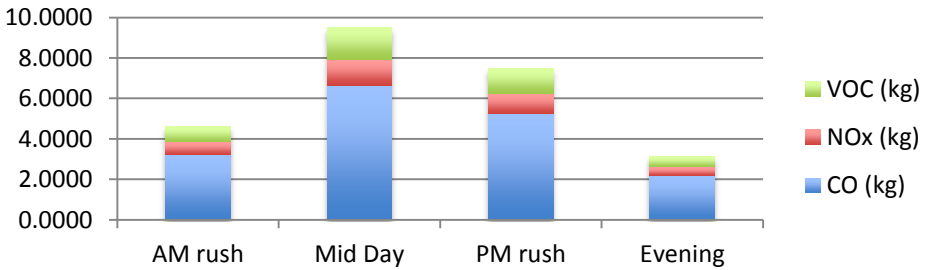
% Improvement	Travel Time	Speed	# of Stops	Wait Time	Emissions
AM rush	30.11%	33.78%	29.14%	47.78%	23.83%
Mid Day	32.83%	48.55%	52.58%	49.82%	29.00%
PM rush	22.65%	27.45%	8.89%	35.60%	18.41%
Evening	17.52%	27.81%	34.97%	27.56%	14.01%
Overall	25.79%	34.02%	31.34%	40.64%	21.48%

CO, NOx and VOC Emissions

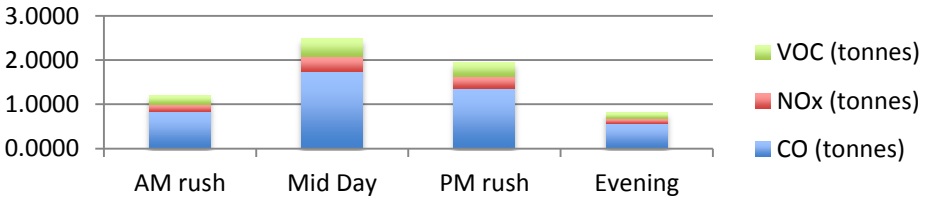
- **Per Day**
  - Number of vehicles: 29,940
  - Fuel savings: 247 gallons
  - Reduction in toxic emissions (CO, NOx, VOC): 24.67 kg
  - Reduction in CO^2 emissions: 2.2 metric tons
- **Per year**
  - Fuel savings: 64,580 gallons
  - Toxic emissions: 6.44 m. tons
  - CO^2 emissions: 577.8 m. tons



# of vehicles per day



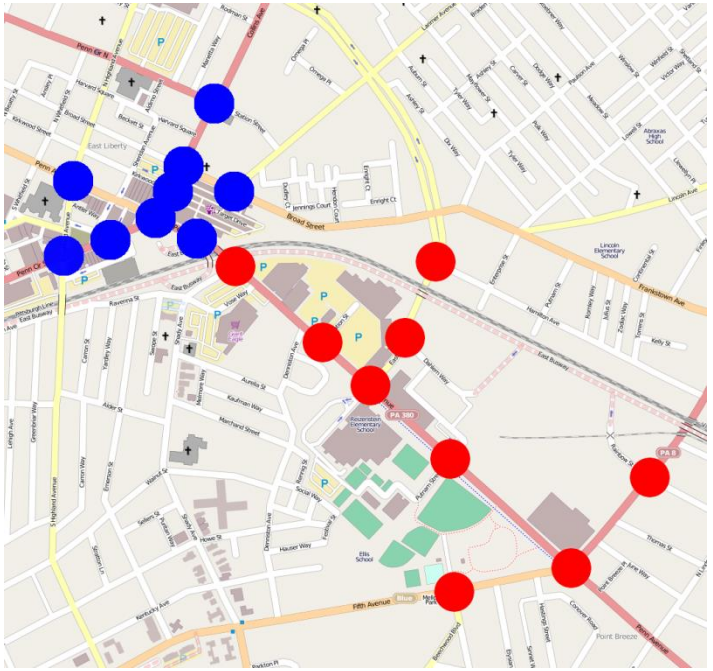
CO, NOX, VOC Reduction per day



CO, NOX, VOC Reduction per year

Bakery Square Expansion

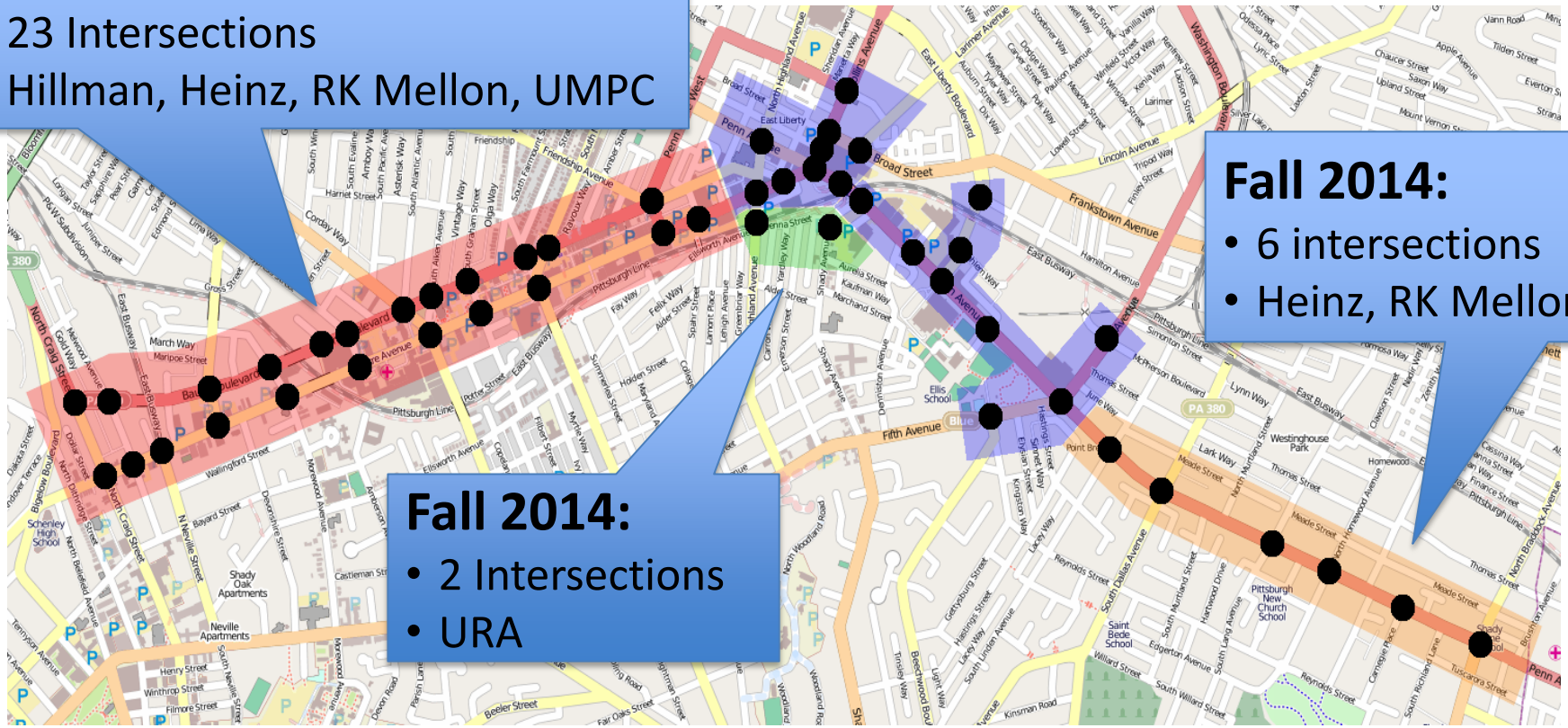
- **Operational since Nov. 2013**
- **Nine additional intersections**
  - Moving east along Penn Ave. around Bakery Square to Fifth Ave.
- **Same evaluation methodology**
- **Summary Results:**



% Improvement	Travel Time	Delay	# of Stops	Wait Time	Emissions
AM rush	17.02%	26.31%	33.81%	32.76%	16.21%
Mid Day	21.35%	34.04%	37.23%	38.09%	17.62%
PM rush	28.61%	39.35%	44.87%	46.40%	24.77%
Overall	24.10%	35.41%	40.42%	41.59%	20.69%

2014-15 Expansion Plans

2014-15:
- 23 Intersections
- Hillman, Heinz, RK Mellon, UMPC



- Scalability test of 49 intersections in early 2015

Current Research Directions

- Multi-modal traffic flow optimization
  - Real-time detection and response to buses and pedestrians
- Optimization for environmental impact
- Monitoring and shaping traffic flows
  - Communication with vehicles and integration with route choice
  - Real-time incident detection and congestion mitigation
- Real-time use of traffic data
  - Self-monitoring traffic networks