New York City Active Traffic Management
Midtown in Motion

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U.S Department of Transportation
Federal Highway Administration

NEW YORK CITY DOT

TRANSCORE

KLD

Overview

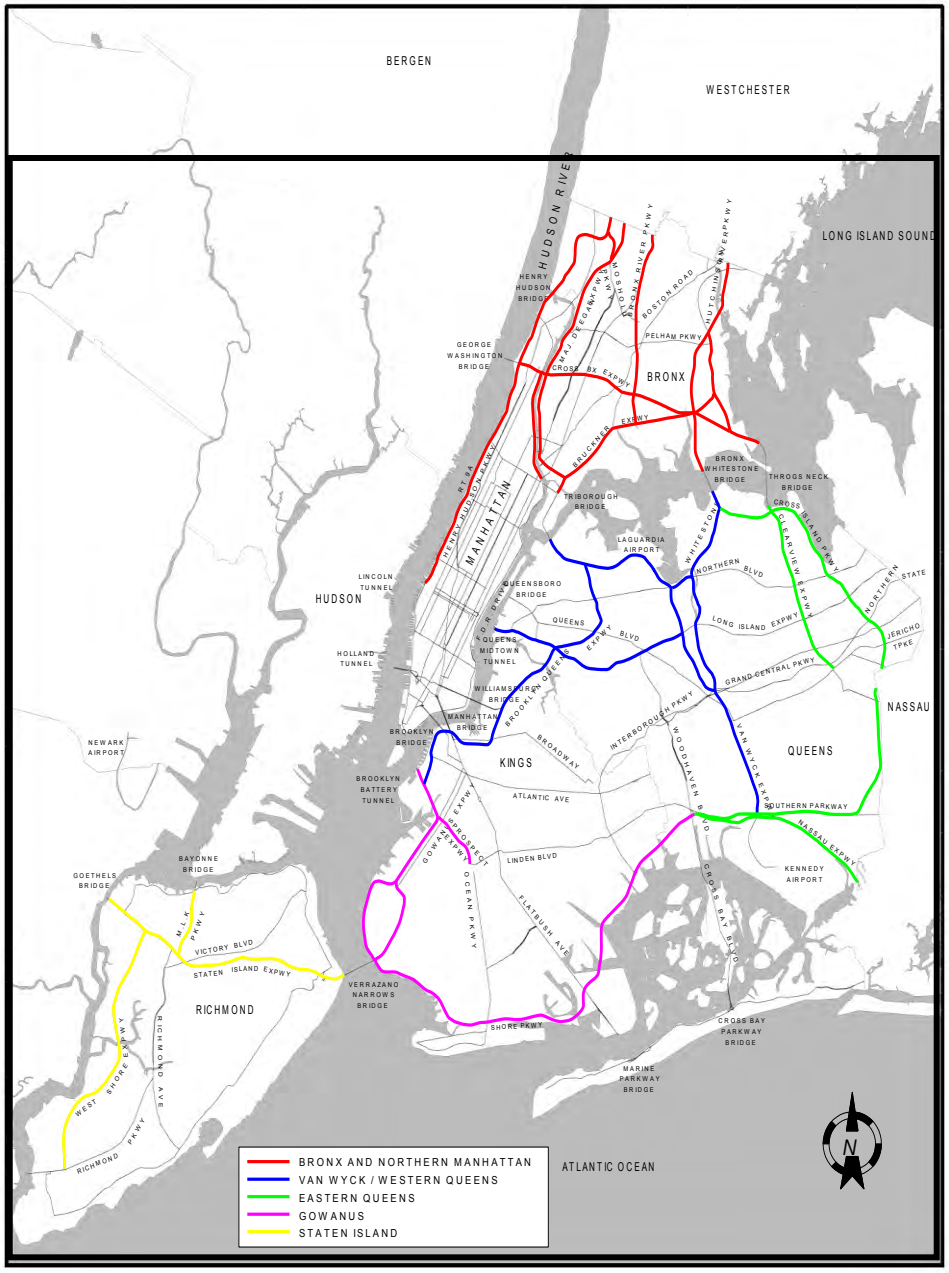
- FHWA, NYCDOT, and ITS
- Background of MIM project
- Choice of ITS Technologies Deployed
- System Design
- System Demonstration
- Algorithms, Data, Metrics
- Results to date and Wrap up

FHWA/NYCDOT TEAM PARTNERSHIP APPROACH IN ALL ITS/OPERATIONS INITIATIVES

New York City's

- Multi-agencies
- Multi-jurisdictions
- Multi-model
- Multi-centers
- Inter-modal
- Freight Corridor
- Regional

- 1 million vehicles/Day
- 5 million commuters/Day
- 16 major bridges/tunnels
- 13 tri-state TMC's



Team Partnership Approach

Time Frame	Project/Activity
1994-1996	NYSDOT/NYCDOT develop a concept and funding approach for a Joint Traffic Management Center (JTMC). With the addition of the New York Police Department, the JTMC will be a center for monitoring and management of ITS and incidents on the surface streets and limited access freeways in the 5 boroughs. The predecessor of the JTMC was the JTOC which was operational from 1999 to early 2008. Prior to the JTOC was the Gowanus TOC for the Prospect/Gowanus corridor.
1997	NY/NJ/CT Model Deployment Initiative (MDI) – With a focus on traveler information and information sharing, the MDI involved a large number of multimodal transportation stakeholders in the tri-state region.
Early 1990's-1999	NYC Early Deployment Plan (EDP) - This Federal ITS Program funded field operational tests and Early Deployment Plans in the New York City Sub-region. The NYC EDP encouraged stakeholders to assess needs, identify and prioritize ITS related projects, and plan for deployment. It served as the catalyst for all post-EDP activities (i.e. NYCSRA).

Team Partnership Approach (Contd.)

Time Frame	Project/Activity
2000	Tier I/II Workshops - The Tier I/II workshops, facilitated by the National ITS Architecture Team, provided the sub-region with an initial inventory of existing and planned ITS elements. The workshops served as the foundation for the later development of a comprehensive New York City Sub-regional ITS Architecture. The workshops led stakeholders to develop a preliminary ITS architecture and Turbo Architecture database of ITS elements.
2001	NYC Sub-regional ITS Architecture Development White Paper - The four lead agencies commissioned a white paper to outline alternatives for development of an ITS Architecture. Elements of the NYC EDP and Tier I/II Workshops were identified as essentially ground work.
2002-2004	NYMTC Integration Strategy - An ITS integration visionary strategy with a time horizon of 20 years was developed, consistent with the NYMTC region's long-range transportation plan.
2001-2005	USDOT Rule 940: NYC Sub-regional ITS Architecture: The planning & development of the ITS architecture with emphasis on the "Functional Meeting" approach.
Present	Active Transportation & Demand Management

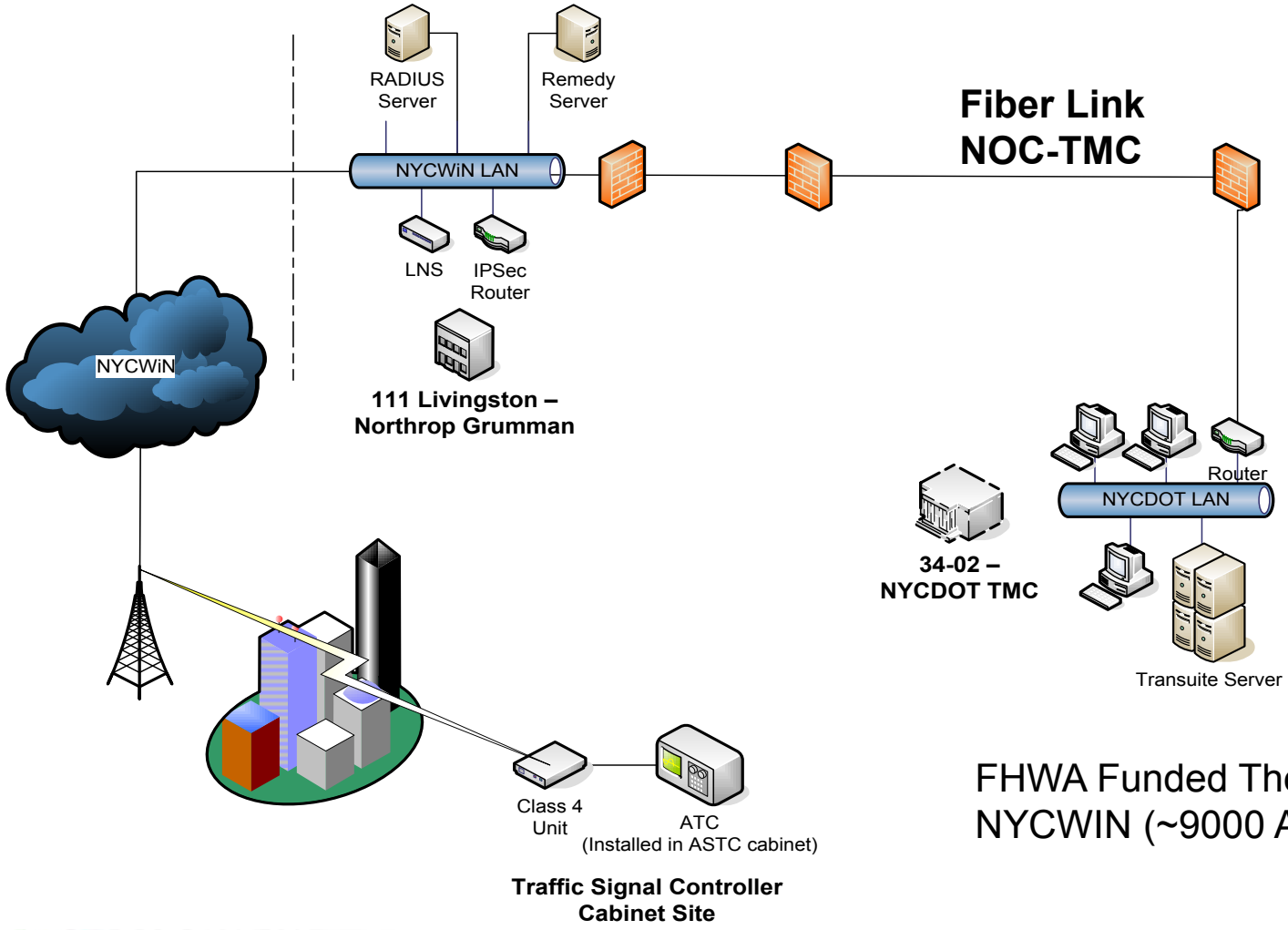
Joint Transportation Management Center (Queens)

NYSDOT, NYCDOT, NYPD

New York City Department of Transportation

- TMC in Queens (Long Island City – East of the 59th St. Bridge) - intersection management & NYPD Administration
- NY City has **~12,400 Signalized Intersections**
- Circa 1970 - 2006: VTCS central real-time active control ~6100
- Manhattan: ~2,700 Outer boroughs: ~3400
- Leased telephone lines: >$7M annually ~4000 intersections
- 2007/2009: Topics IV Computerization Expansion (~2,200) & Wireless
- Long-held favored Manhattan-bound in the AM/PM outbound

NYC Wireless Network (NYCWIN)

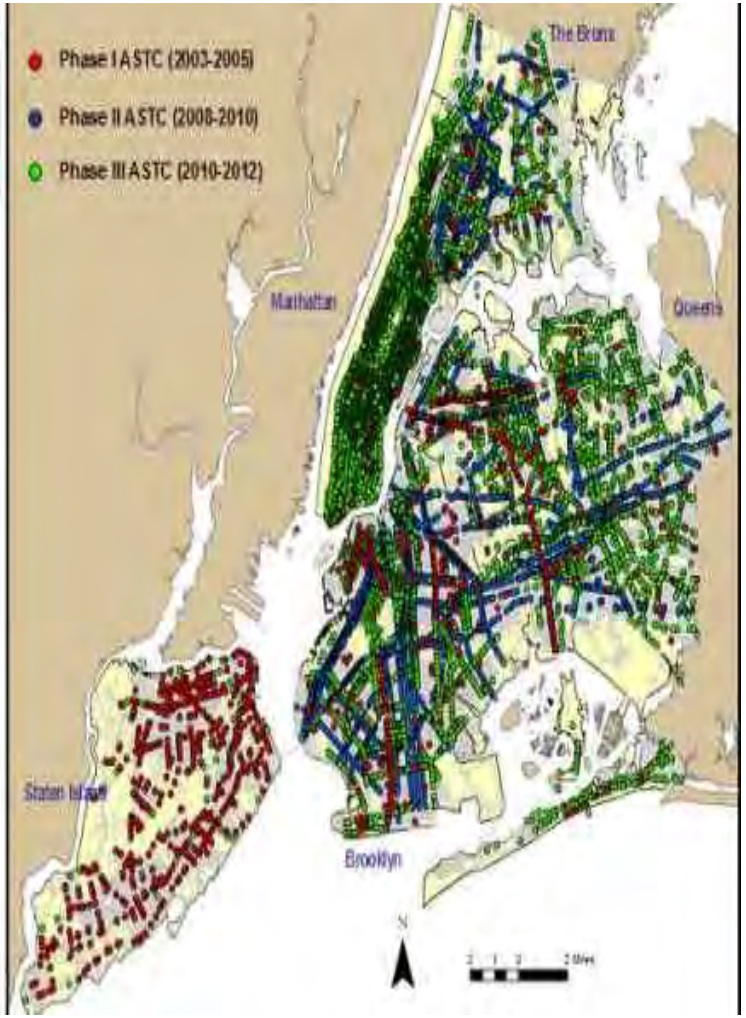


FHWA Funded The Migration to NYCWIN (~9000 ASTC's to-date).

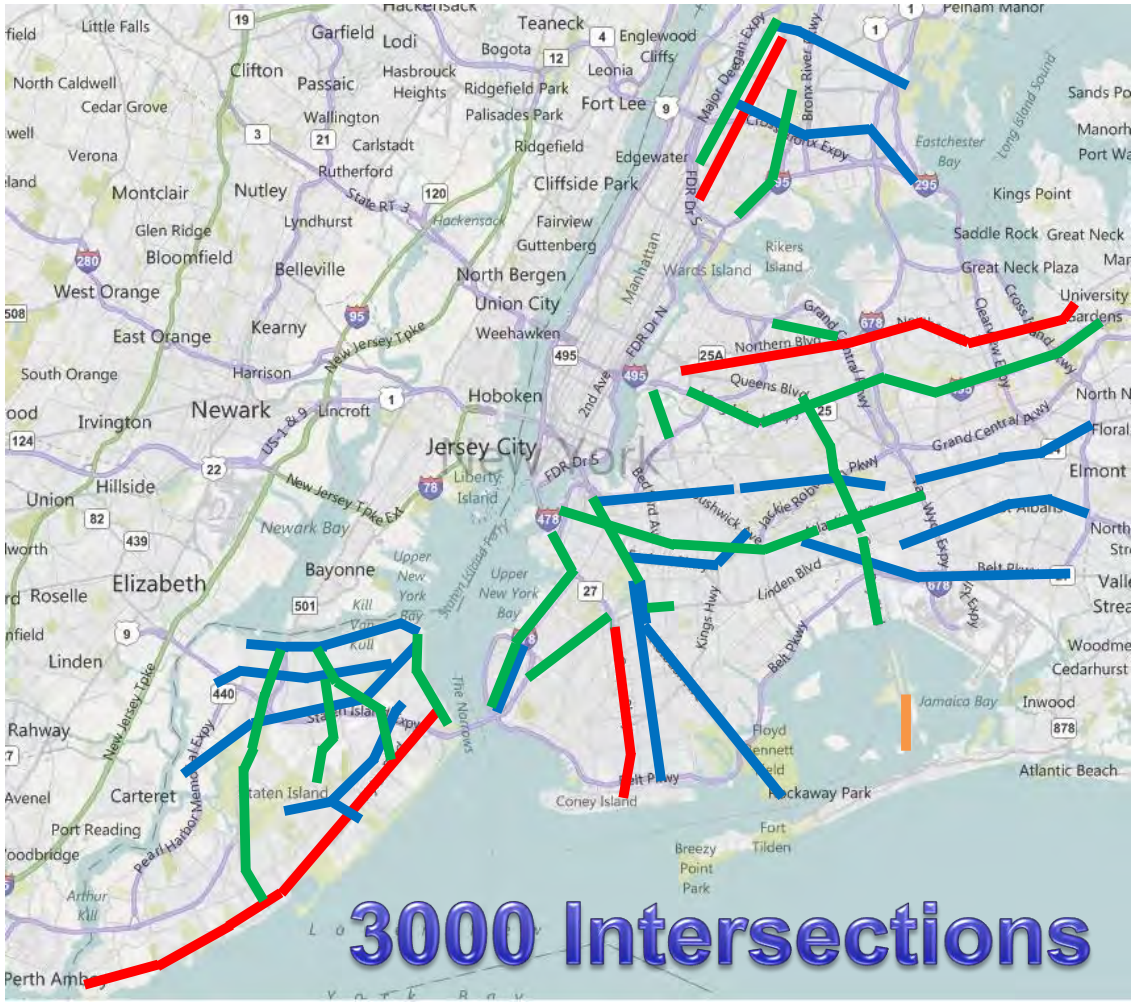
Advanced Solid-State Traffic Controllers

NEW YORK CITY DOT

Advanced Solid-state Traffic Controller Deployment Program



Traffic Signal Retiming



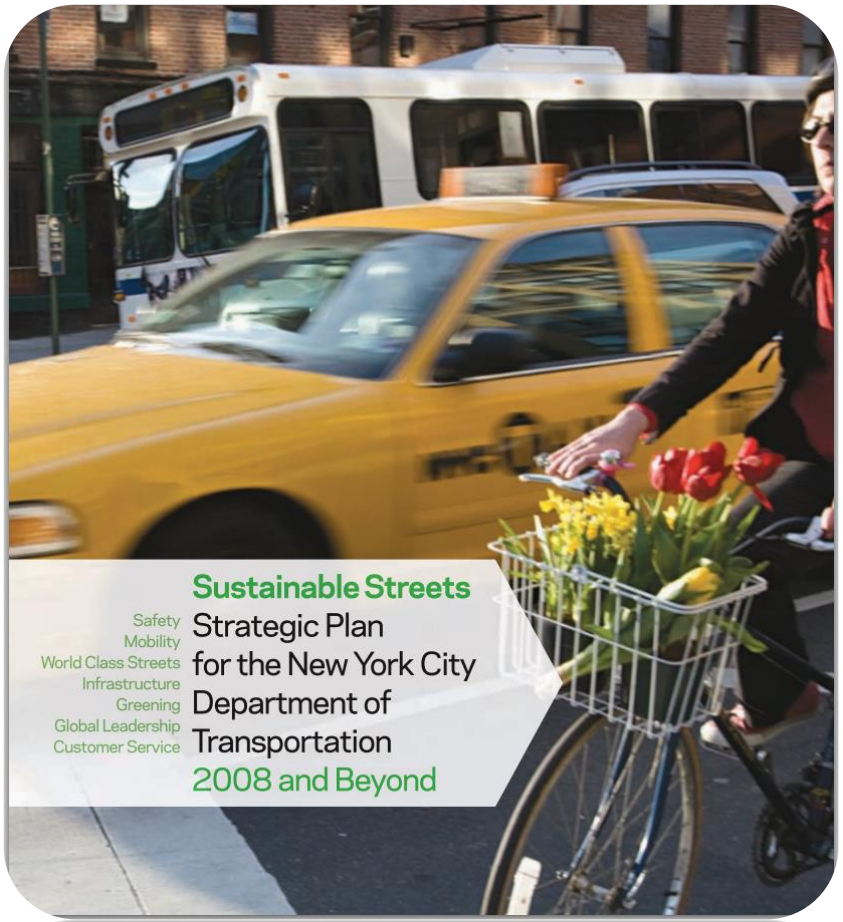
- Phase 1 Corridor
- Phase 2 Corridor
- Phase 3 Corridor
- Phase 4 Corridor

"MIDTOWN IN MOTION" (MIM) IS AN INTEGRAL PART OF THE NYCDOT ENHANCED MOBILITY STRATEGY

Bruce Schaller
Deputy Commissioner, NYCDOT

NYCDOT

- Sustainable Streets: NYCDOT's Strategic Plan
  - Vision for NYC
  - Improve Mobility
  - Modernize ITS

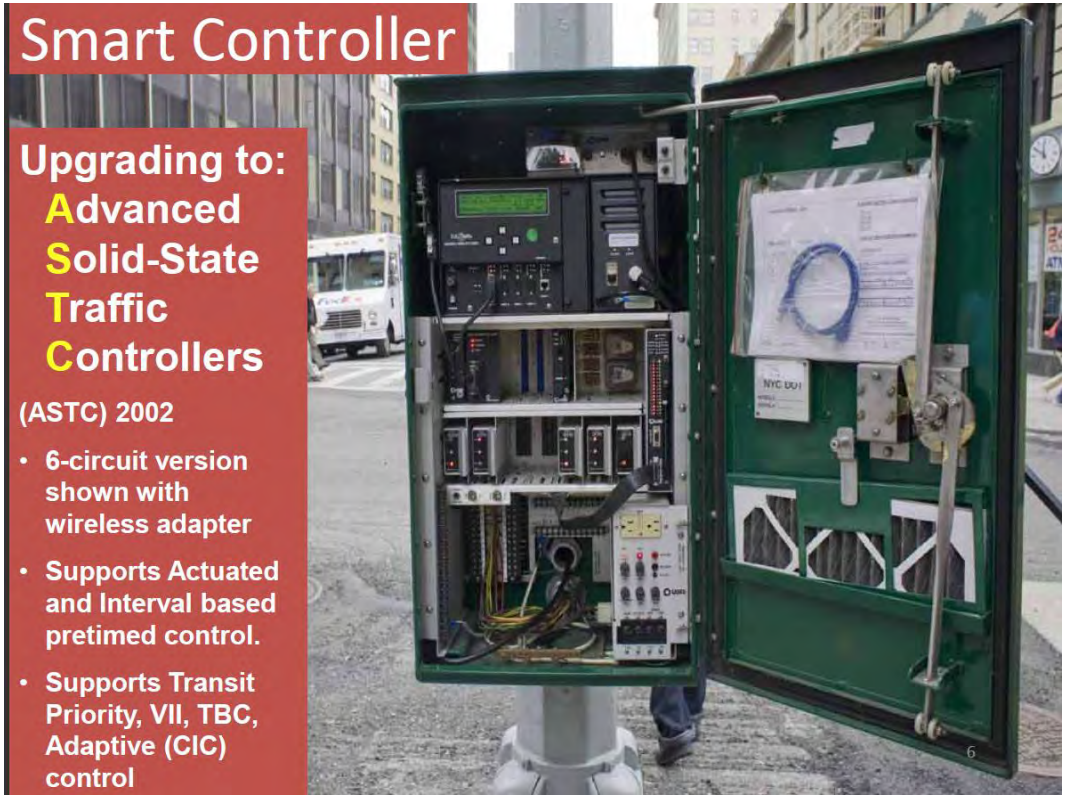


NYCDOT – Modernize ITS

State-of-the-Art ITS Infrastructure Deployment Program Goals

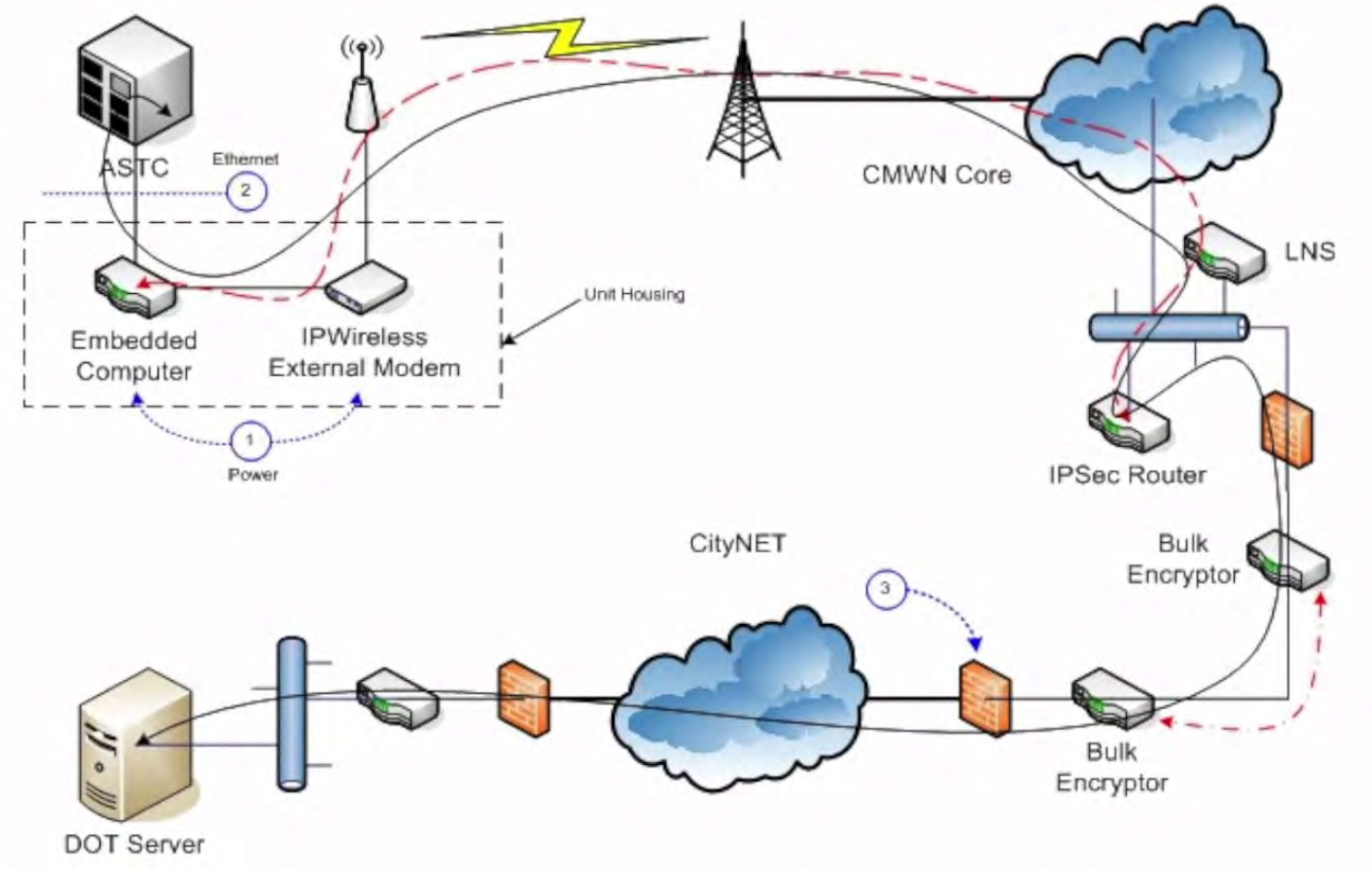
NYCDOT – Modernize ITS

- NYC has ≈ 12,400 signalized intersections
- 9,000 have been upgraded to smart controllers (ASTC) and the remaining are in progress
- World's largest scale deployment
- Use of NYCWiN – NYC's communication network



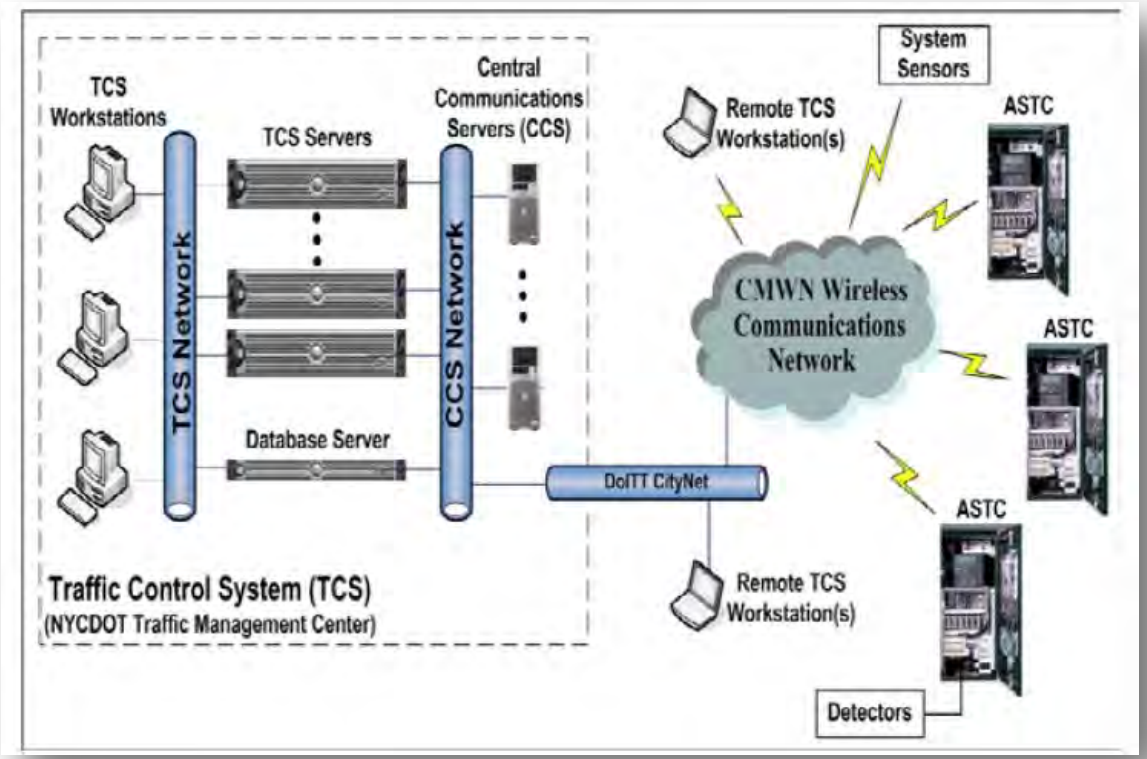
NYCDOT – Modernize ITS

- NYCWiN – New York City Wireless Network



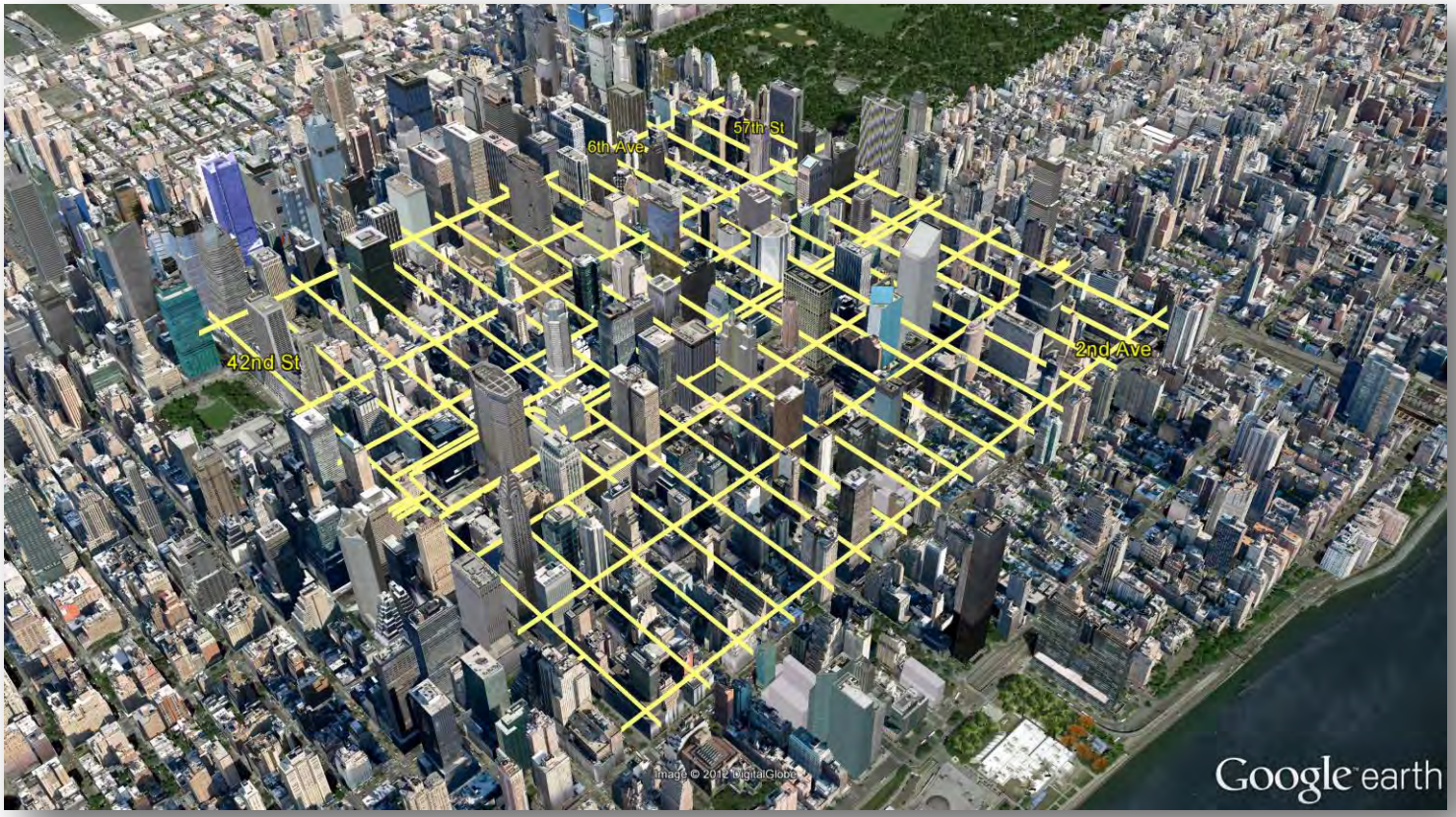
NYCDOT – Modernize ITS

- NYC Traffic Control System (TCS) to replace VTCS
- ASTC
- NTCIP field communications
- Traffic Responsive
- TSP oriented
- Real-time data collection
- Dynamic split adjustment
- Adaptive Traffic Control



Midtown in Motion (MIM)

- *MIM – An off shoot of the ITS Modernization project*
- Study Area -- Midtown Manhattan – Powerhouse of NYC
- Initial Zone: 2 Ave to 6Ave, 42St to 57St



THE LOGICAL FOUNDATION FOR THE MIM ACTIVE TRAFFIC MANAGEMENT INITIATIVE

Mohamad Talas, PhD P.E. PTOE
Deputy Director, NYCDOT ITS

Project Challenges and Approach

- Dense CBD
- Oversaturated, congested
- Low vehicle speeds (< 10 mph)

- Need reliable data to manage and assess performance

- Need a centralized system to monitor and control

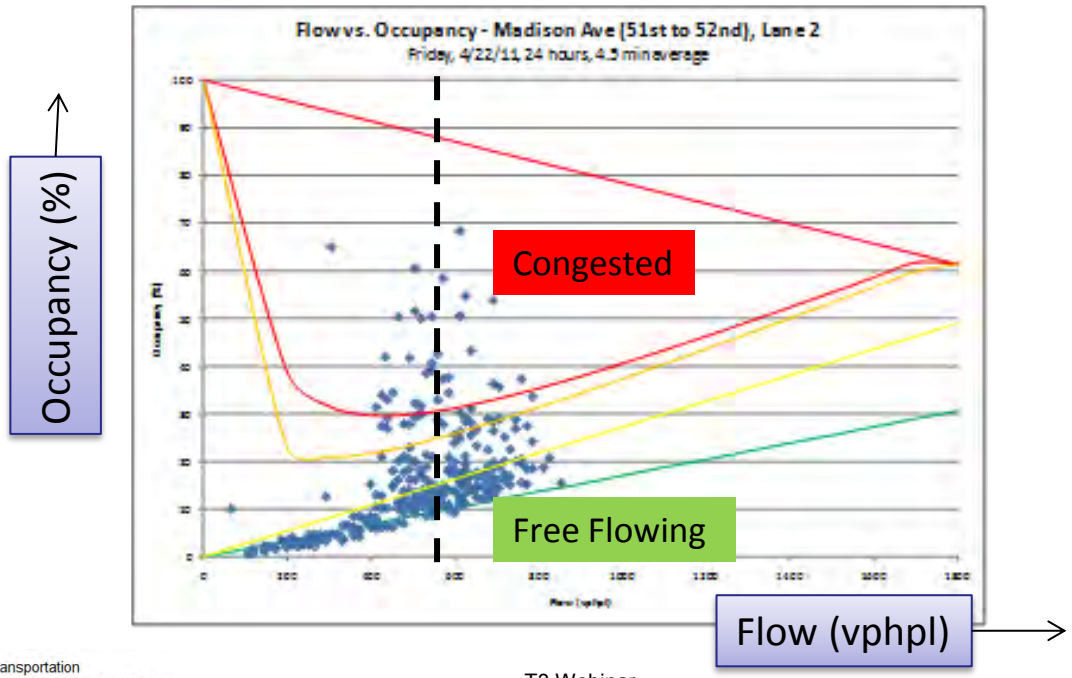
Project Challenges and Approach

- Multi-modal mobility
  - Autos, Taxis
  - Buses
  - Bikes
  - Pedestrians

- Fixed cycle lengths (90s)
  - Synchronization across dense grid
  - No pedestrian push button/actuations
  - Minimum phase requirements addressed

ITS Design

- Microwave Sensors
  - Use both flow & occupancy
  - Given flow – different occupancies, different flow conditions
  - Concept of regimes
  - Define level of congestion using both measures



≈10% Occupancy

Lexington Ave between 58th and 59th Street

≈ 30% Occupancy

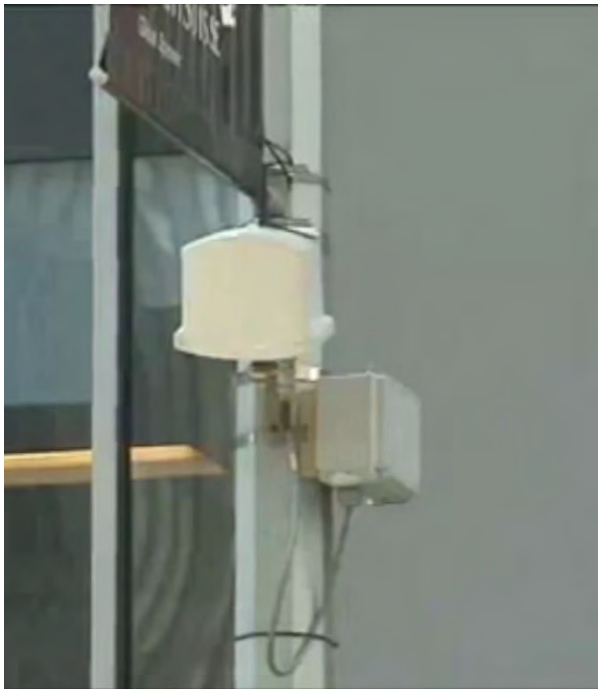
Lexington Ave between 58th and 59th Street

≈ 50% Occupancy

3rd Ave between 44th and 45th Street

ITS Design

- Microwave Sensors
  - Mid block location ideal



ITS Design

- ETC Tag Readers
  - Unique environment with high penetration of ETC tags
  - Strategic placement
  - Maximize coverage
  - 2 readers per location
  - Reliable source of travel time
  - Works under congested conditions and slow vehicle speeds

ITS Design

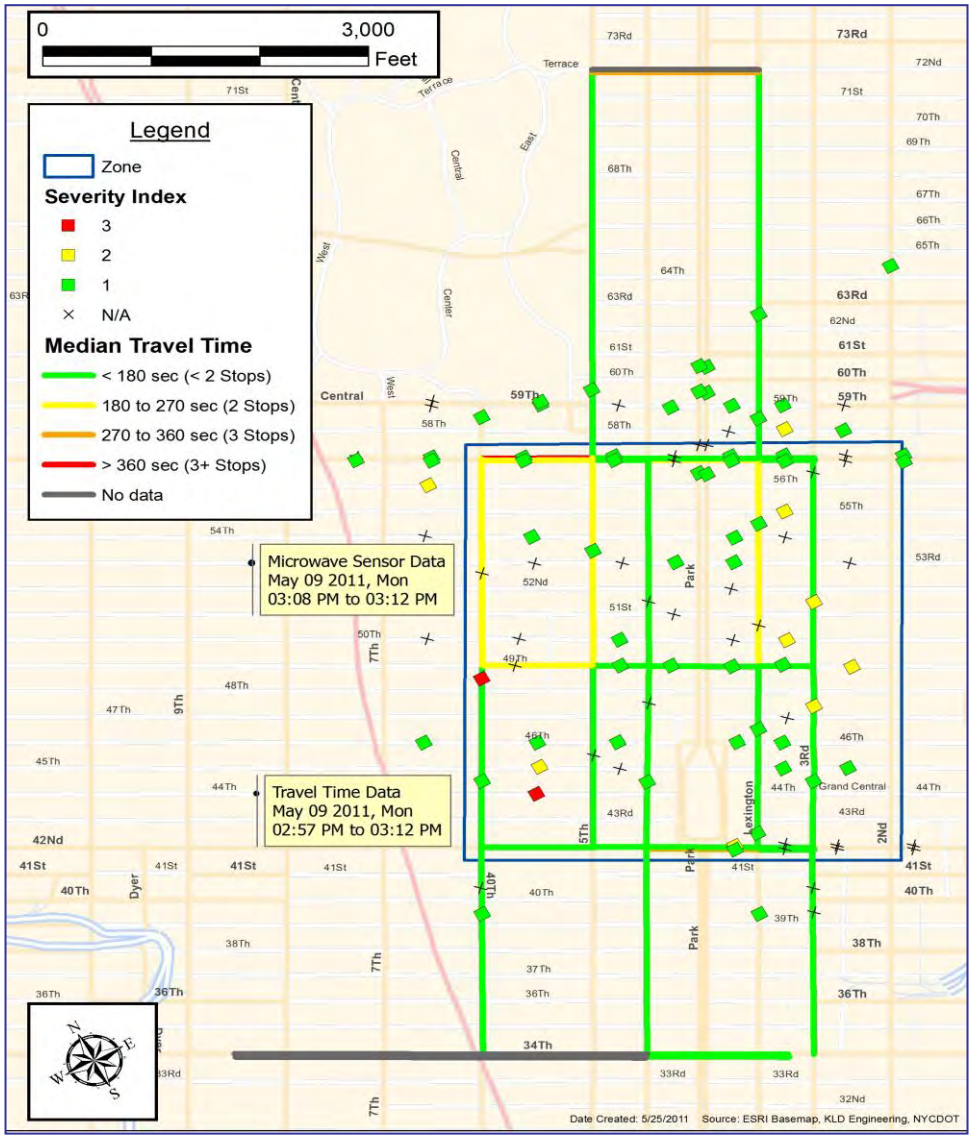
- Video Cameras
  - Observe, Verify, and Monitor

Sensor Network

- Microwave sensors, for flow and occupancy throughout the area and at key locations
  - Flow in thru lanes, as an indicator of need for action
  - Occupancy when combined with flow indicates level of congestion
- ETC readers, for travel times in segments … within the zone and on the approaches to the zone
  - Typically, 8-block segments on north-south arterials
- Video cameras for verification & monitoring

Sensor Network Deployed

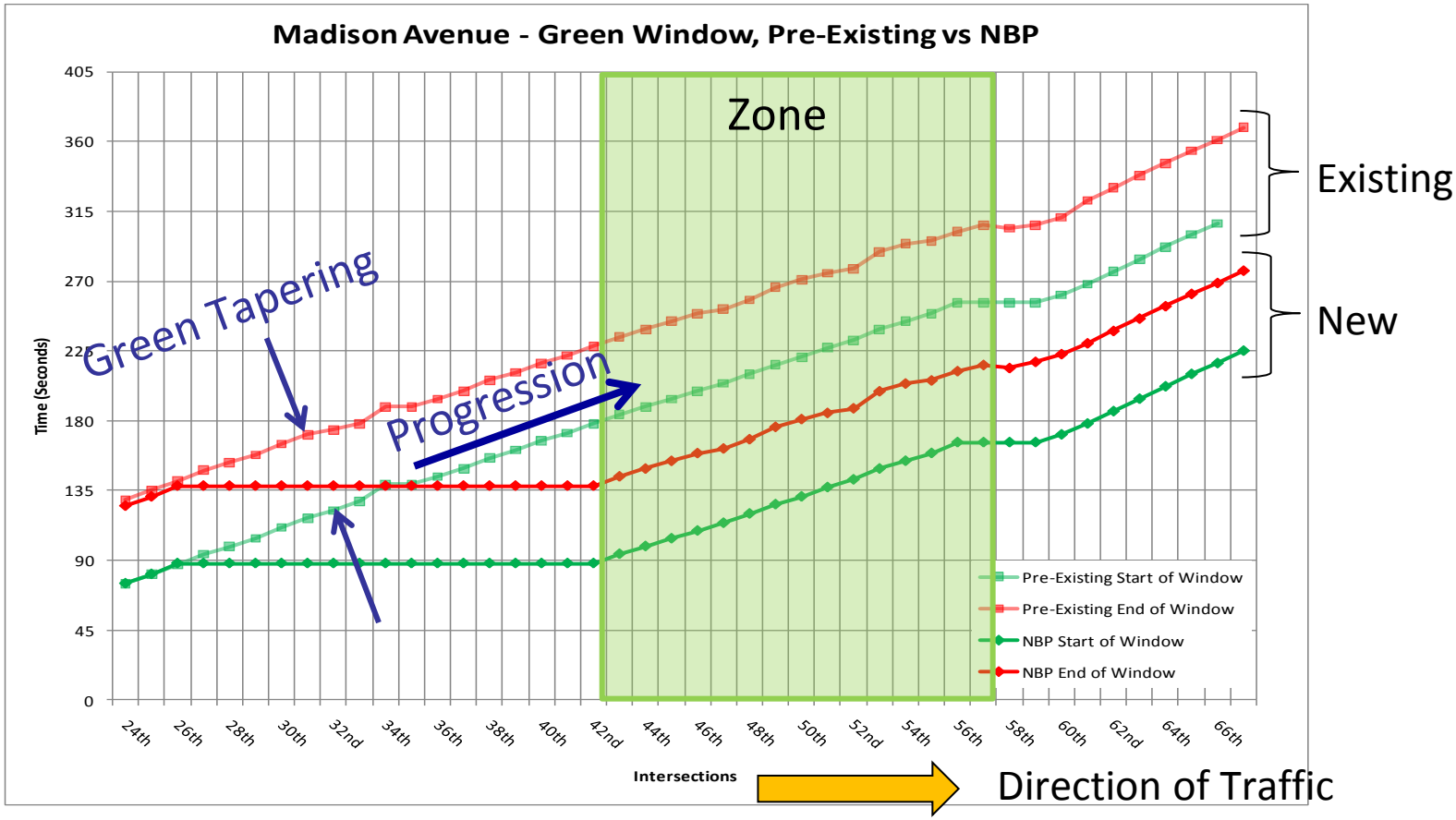
- ETC Tag Readers
  - Travel Time
  - 23 readers
- Microwave Sensors
  - Flow and Occupancy
  - 100 sensors
- Cameras
  - Field Conditions
  - 25 IP cameras



Control Policy

- For an extremely complex grid network, developed following approach
- Hierarchical Control
- Level 1 – Strategic area wide control
  - Implemented by Avenue
  - Rebalance traffic being delivered to the zone
  - Use library of carefully developed plans
- Level 2 – Tactical control
  - Implemented at intersection level
  - Complimentary to level 1
  - Balance queueing and minimize gridlock condition

Level 1 Control – Plan Library Design



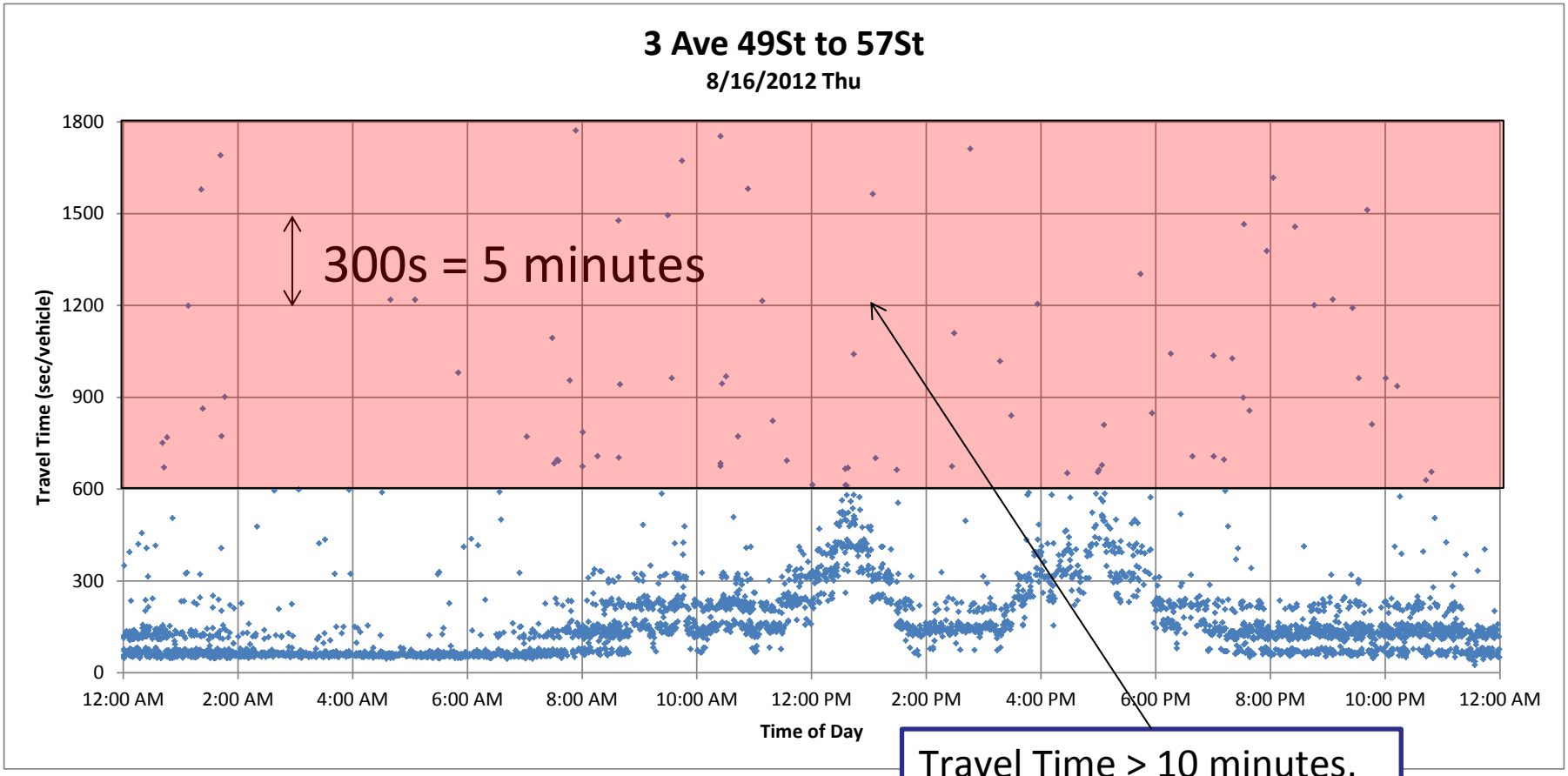
- Develop library of plans and field test
- Define trigger condition based on real time data

Travel Time – Underlying Patterns

Illustrative Section: 3rd Ave – 49St to 57St – 8 Blocks, 2000 feet – 8 traffic lights in the trip

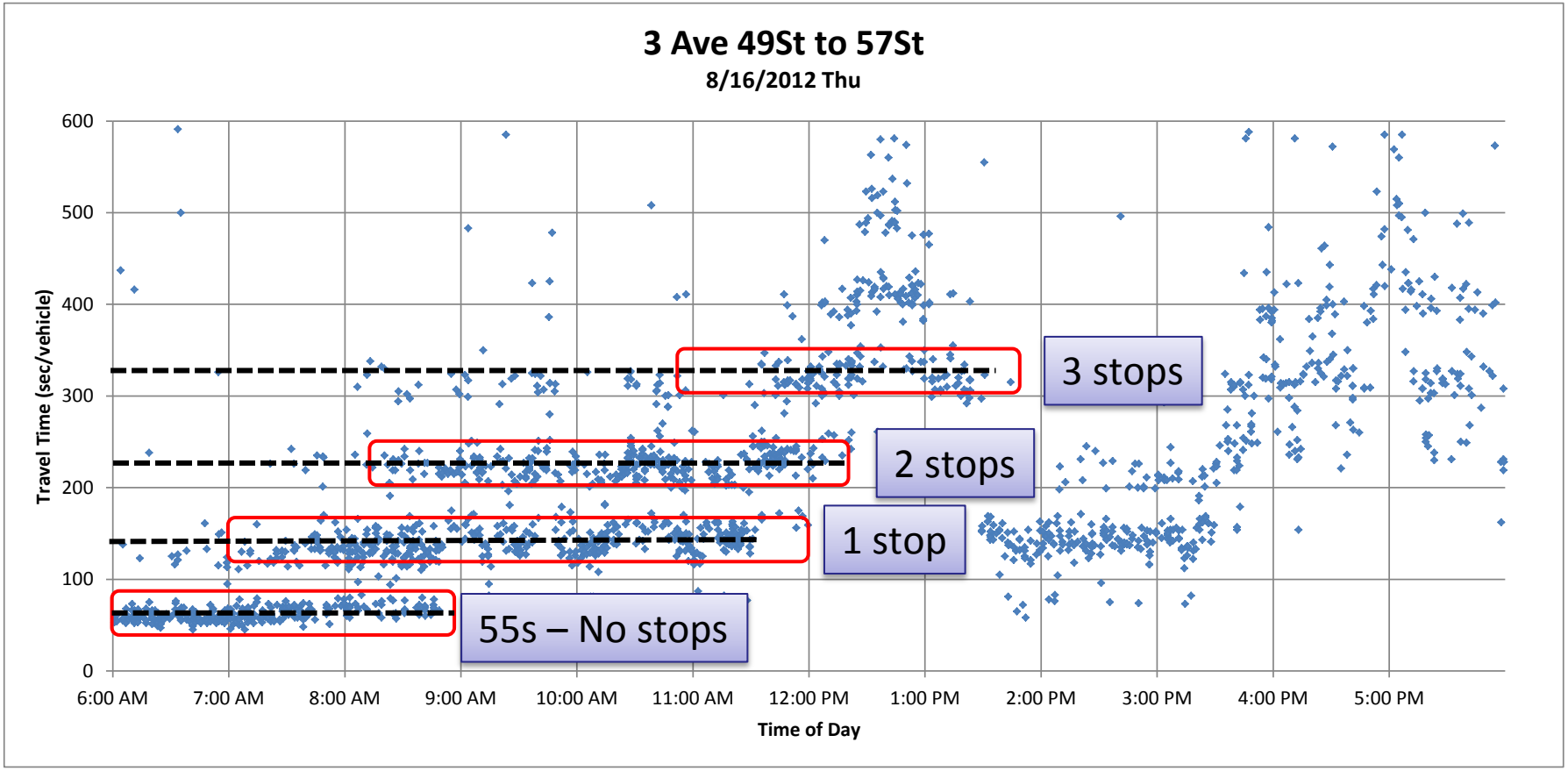
Travel Time

- One day sample
- Ideal travel time for 2000 feet at 25mph is 55 seconds

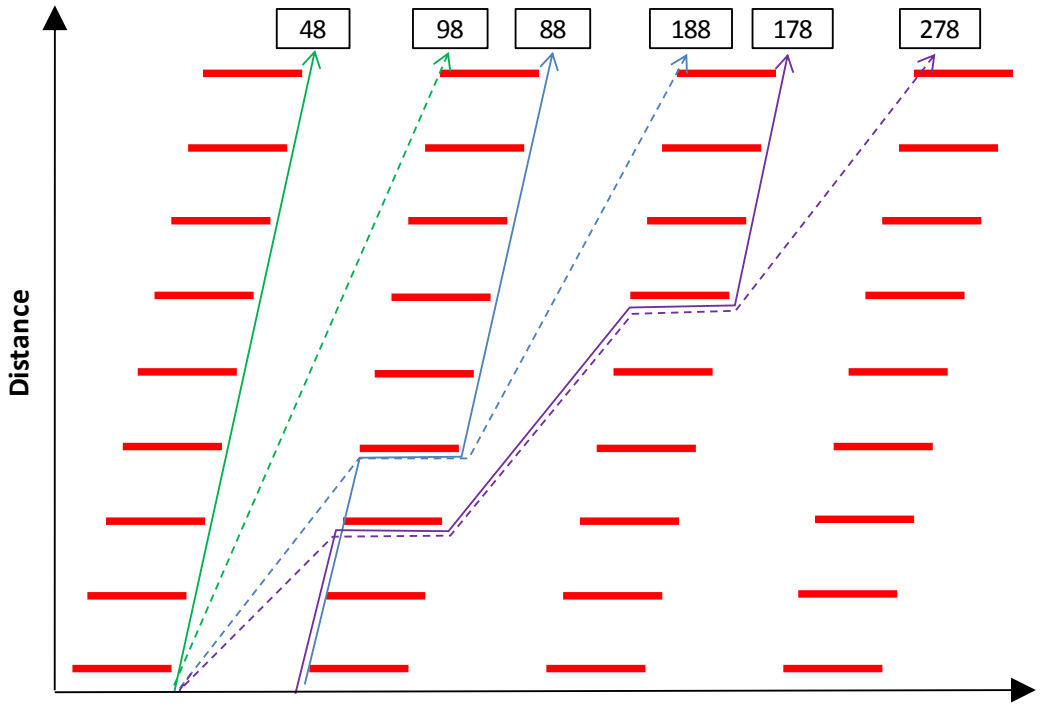


Travel Time – Underlying Patterns

- Close up view of travel time less than 10 minutes
- Clusters/groups – separated by stops



Travel Time – Underlying Patterns



Trajectory of Minimum Travel Time with No Stop

Trajectory of Maximum Travel Time with No Stop

Trajectory of Minimum Travel Time with One Stop

Trajectory of Maximum Travel Time with One Stop

Trajectory of Minimum Travel Time with Two Stops

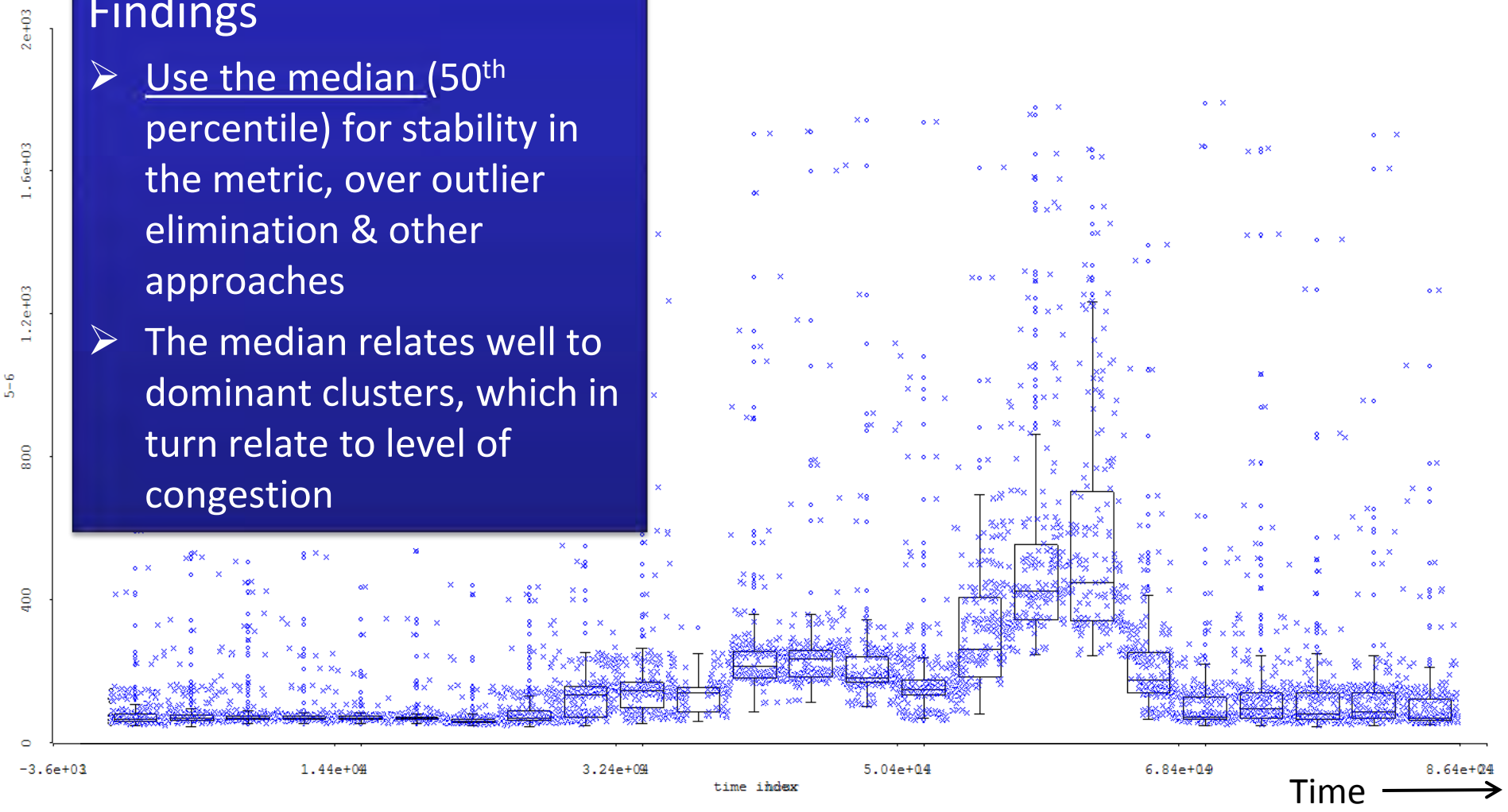
Trajectory of Maximum Travel Time with Two Stops

XX Estimate of Travel Time

Travel Time – Selecting a Metric

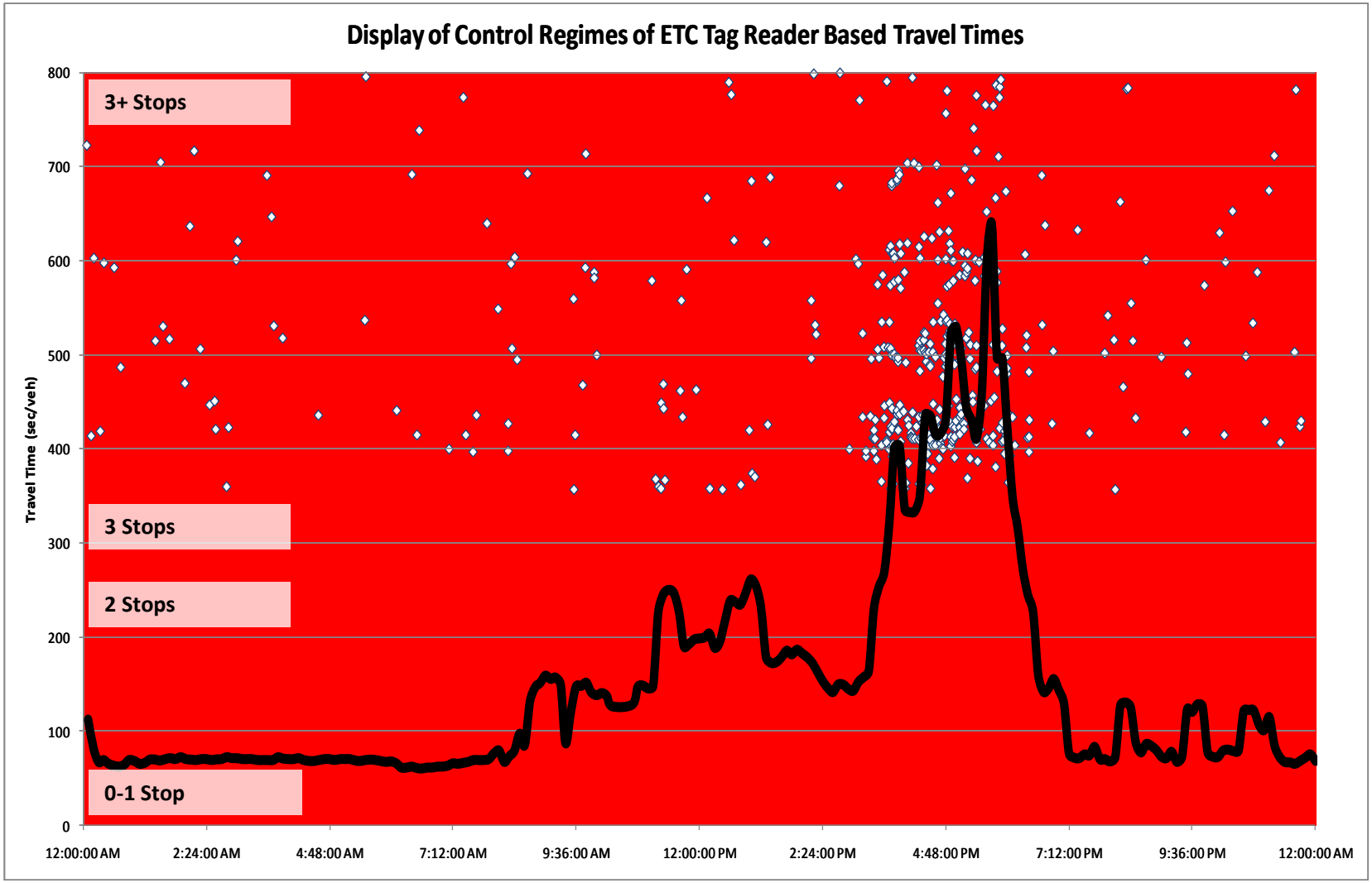
Findings

- Use the median (50th percentile) for stability in the metric, over outlier elimination & other approaches
- The median relates well to dominant clusters, which in turn relate to level of congestion



Box and Whisker Plot and Raw Data

Relation of Travel Time to # of Stops



Solid line = Median

Level 1 Control

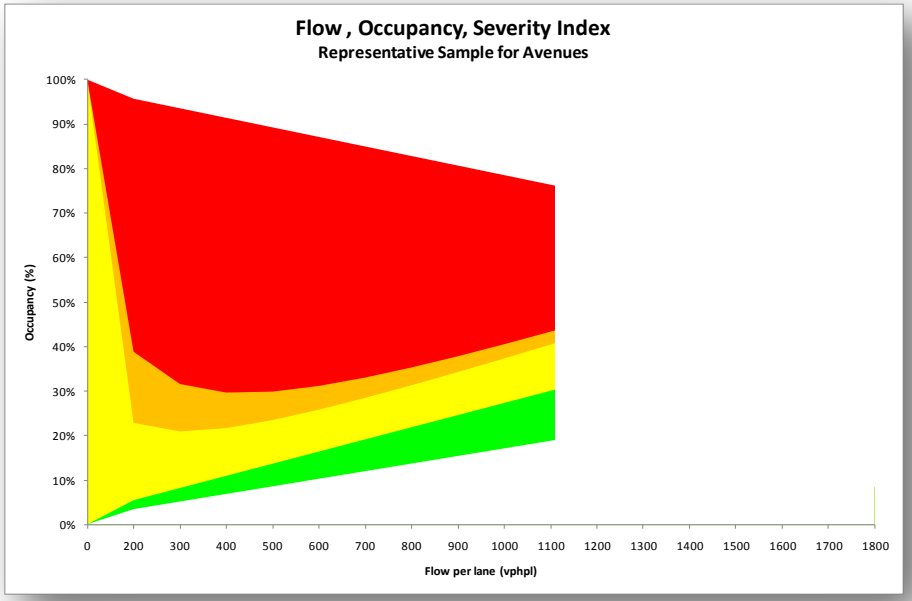
- Define trigger conditions based on real time data

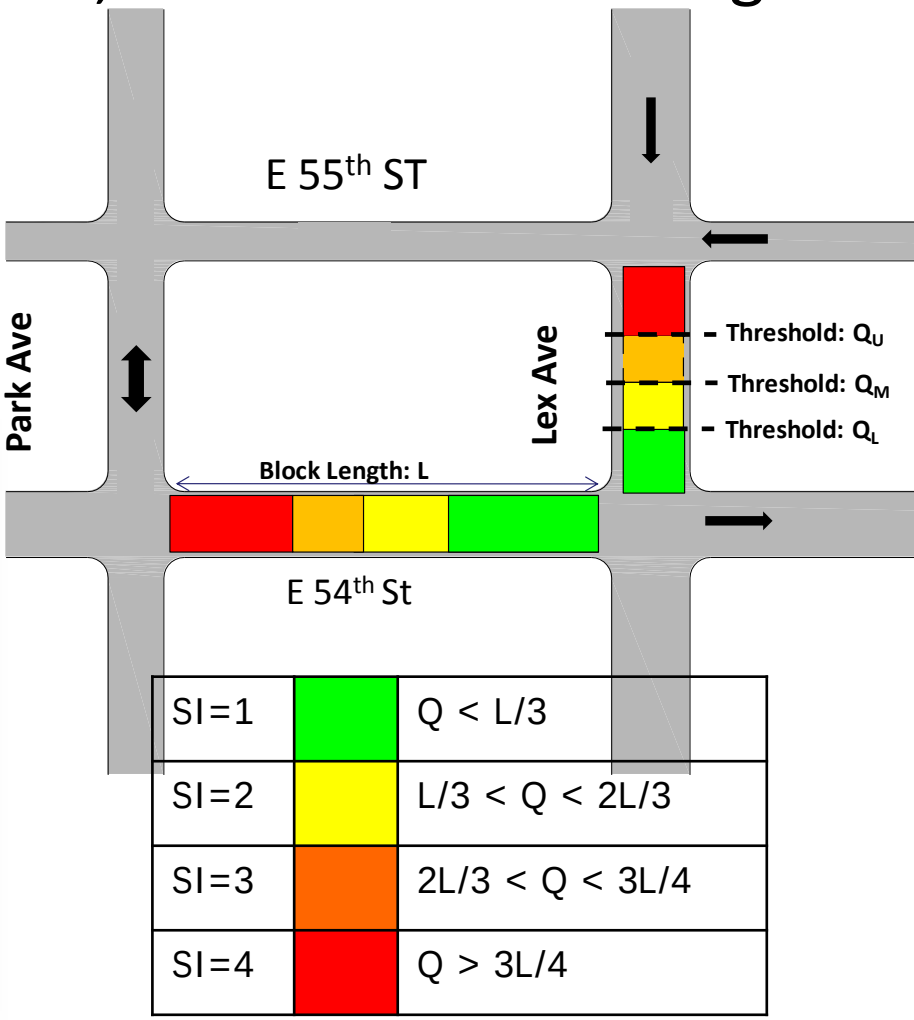
Travel Time	Area Wide Control Plan
2 Stops	Network Balancing Plan (NBP)
3 Stops	Advanced Control Plan (AC1)
3+ Stops	Advanced Control Plan (AC2)

- NBP – Simultaneous offset, minimal green tapering
- AC1 – Simultaneous offset, increased green tapering
- AC2 – Simultaneous offset, higher green tapering

Level 2 Control

- Measure of queuing condition, relative to block length
- Estimate queue using flow/occupancy and then calculate Severity Index





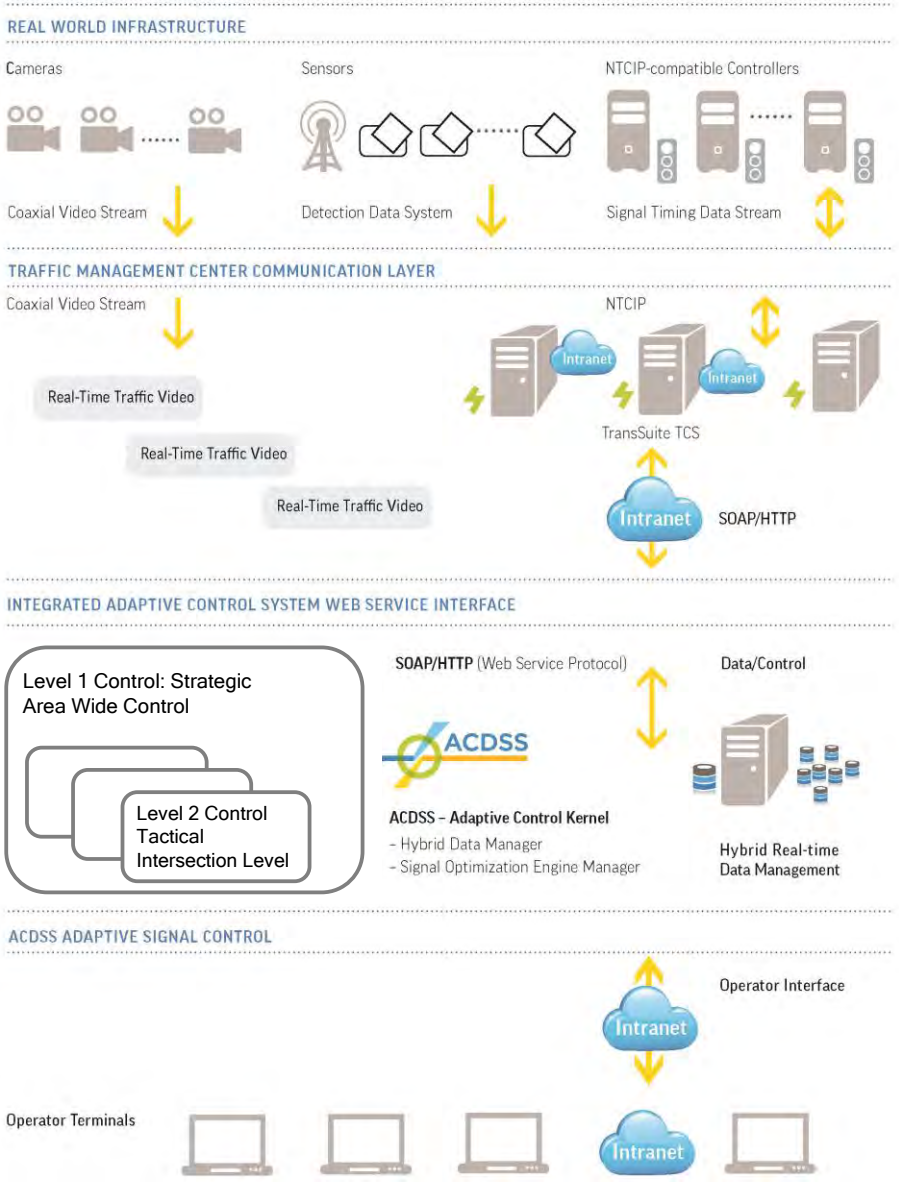
SI=1		Q < L/3
SI=2		L/3 < Q < 2L/3
SI=3		2L/3 < Q < 3L/4
SI=4		Q > 3L/4

Key Concepts

- Median travel time is a good and effective metric
- Travel time can be shown in 4 control zones based upon number of stops, as a basic user-perceived metric
- Hierarchical control on two levels, to respond in different time frames and different spatial extent
  - Level 1 recommends time plans to the operator, by street
  - Level 2 reallocates green at critical locations, opportunistically

System Architecture

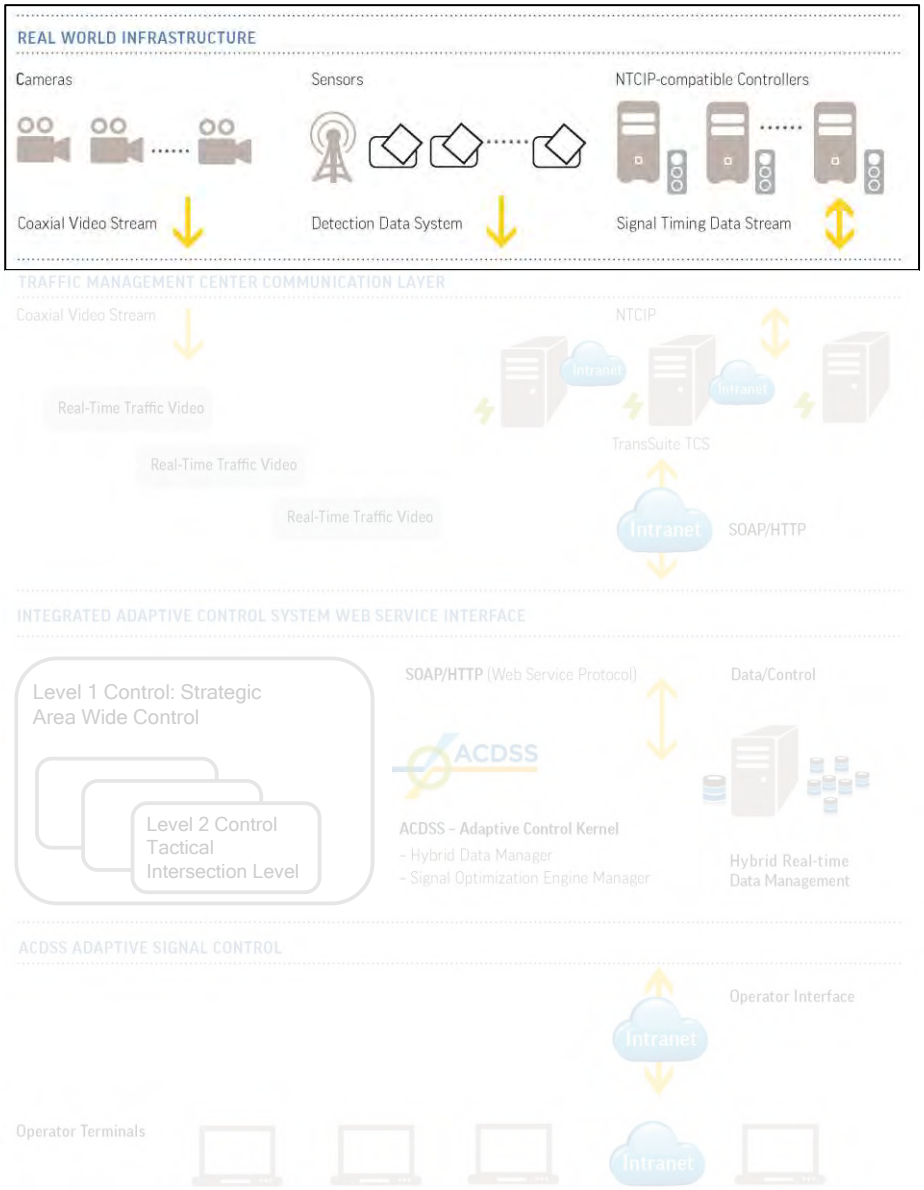
4 Components



Acknowledgements to TransCore ITS, with Ray Martinez here for the Q&A

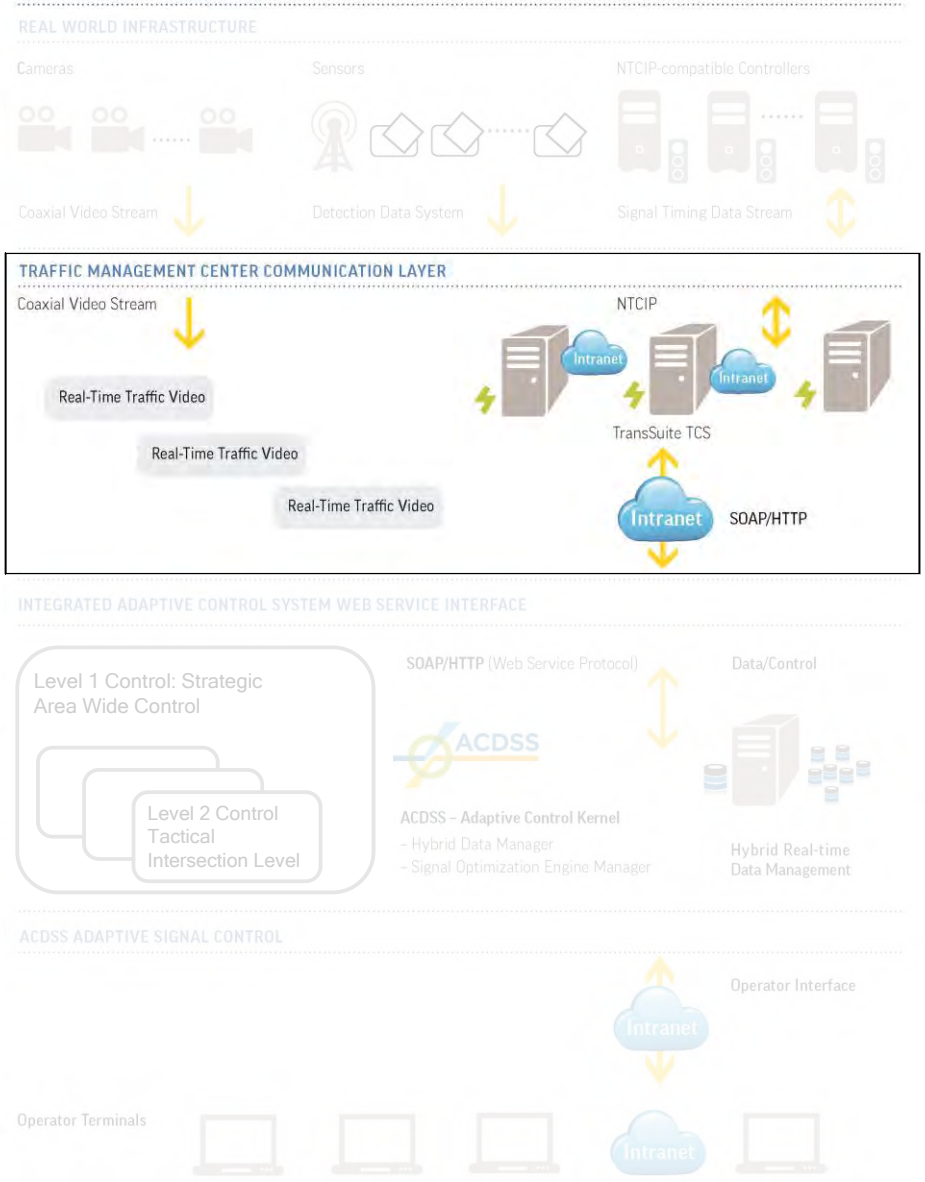
System Architecture

1. ITS in Field



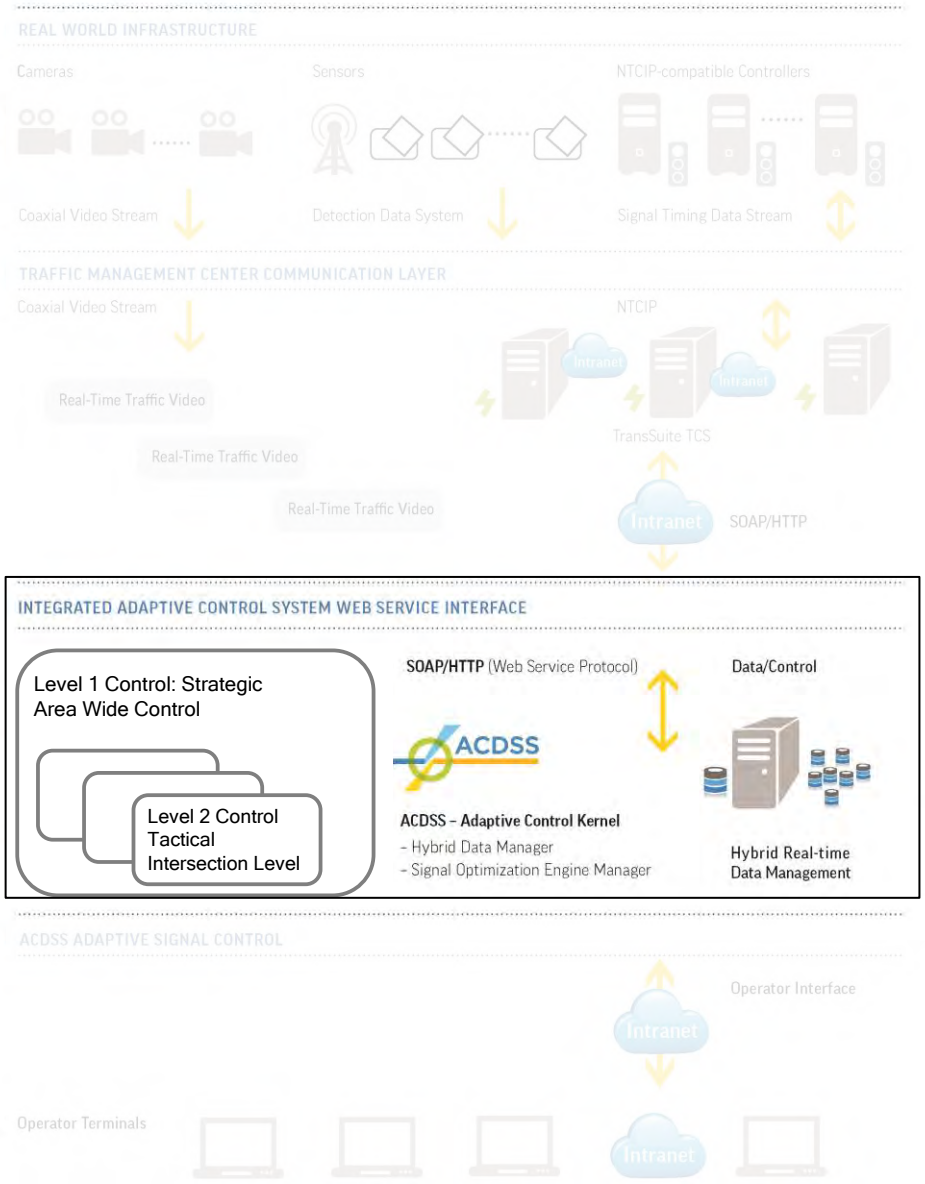
System Architecture

2. Communication Layer

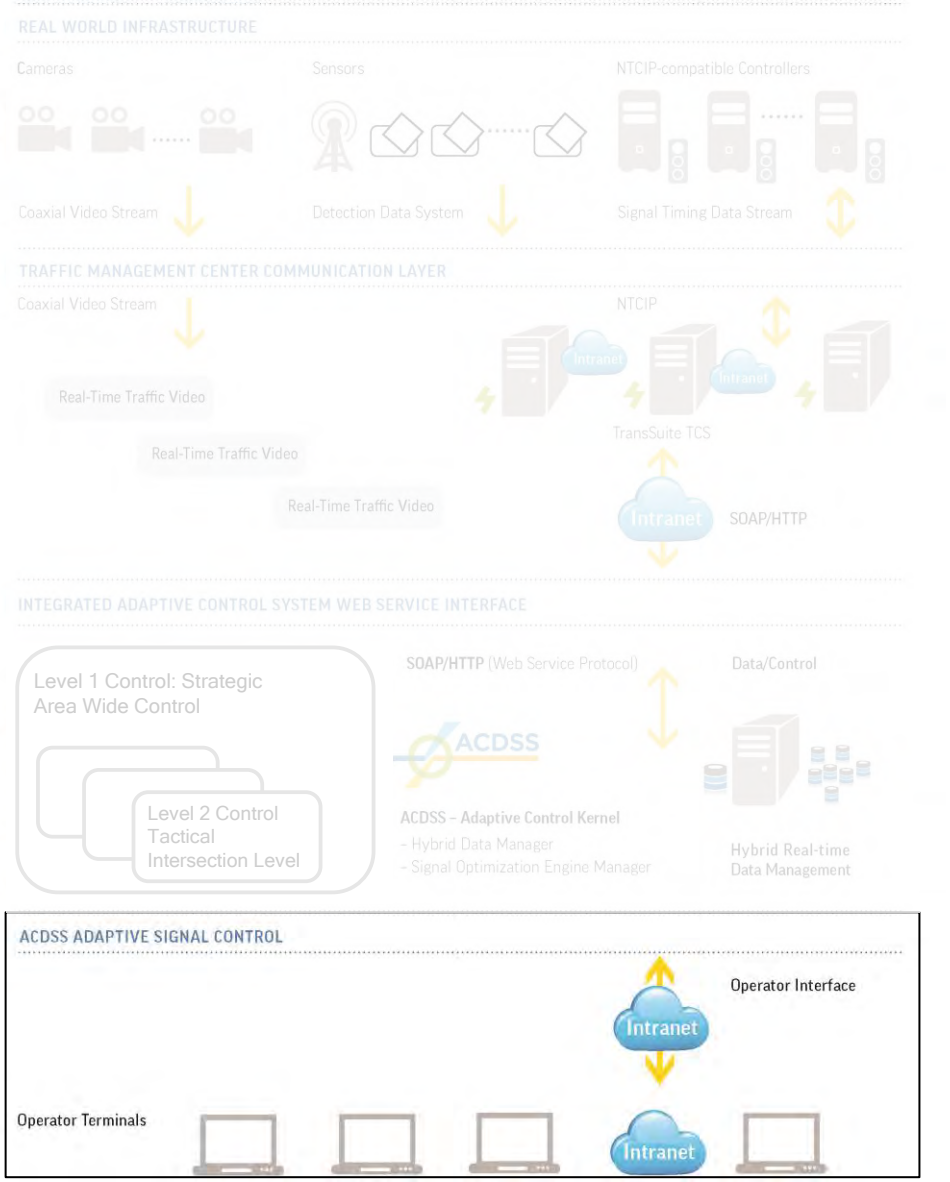


System Architecture

3. ATM Component



System Architecture



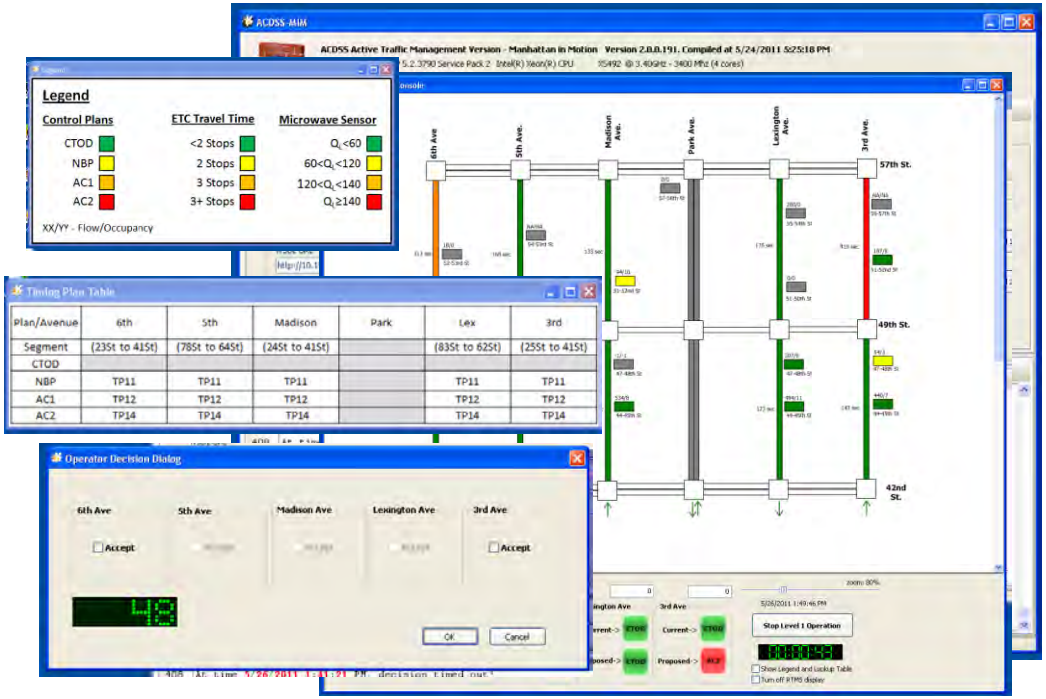
4. Operator and GUI

MIM ACTIVE TRAFFIC MANAGEMENT INITIATIVE AS IMPLEMENTED & USED

John Tipaldo, PhD P.E.
Director, NYCDOT ITS

Live @ TMC

- Real time data processed
- ATM system recommends changes to operator
- Operator reviews field video
- Action taken, if deemed necessary



MIM In Action

REAL TIME DATA

Sensors

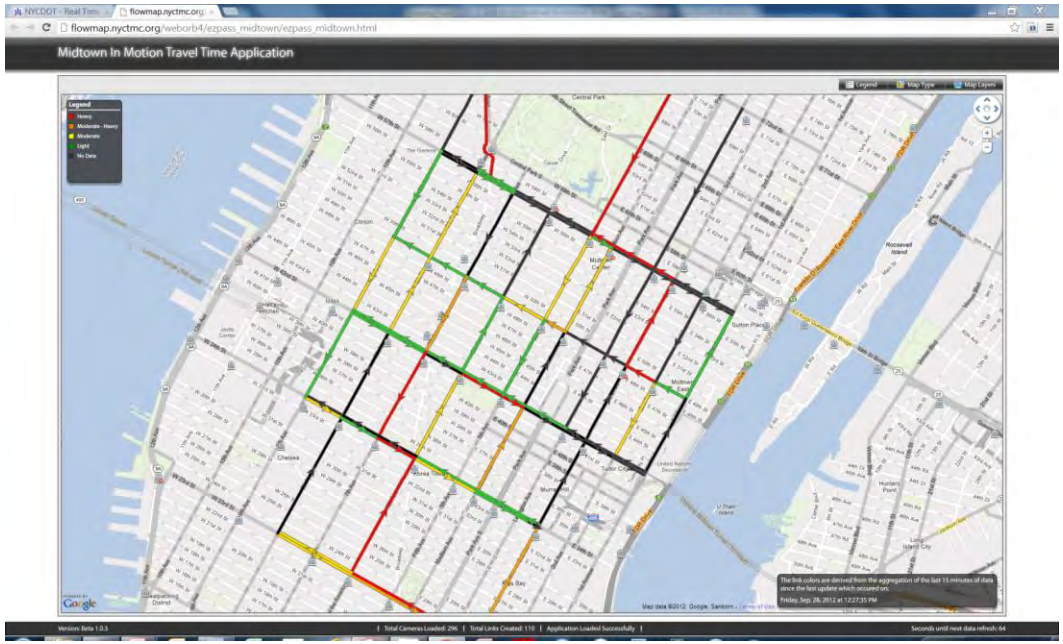
Travel Time

Flow, Occupancy

ANALYSIS + RECOMMENDATIONS

REVIEW FIELD CONDITIONS

TAKE ACTIONS BASED ON REVIEW



MIM In Action

REAL TIME DATA

↓

ANALYSIS + RECOMMENDATIONS

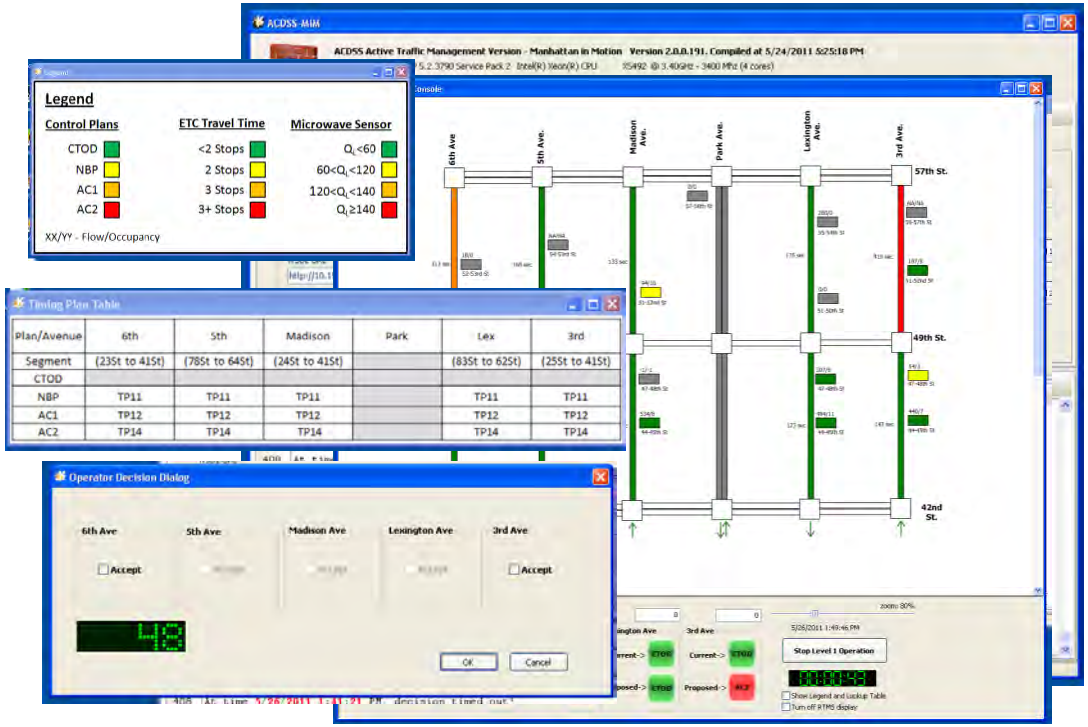
↓

REVIEW FIELD CONDITIONS

↓

TAKE ACTIONS BASED ON REVIEW

Recommend New Signal Timing Plans



MIM In Action

REAL TIME DATA

↓

ANALYSIS + RECOMMENDATIONS

↓

REVIEW FIELD CONDITIONS

↓

TAKE ACTIONS BASED ON REVIEW

Madison Avenue and 49St

Lexington Avenue and 49St

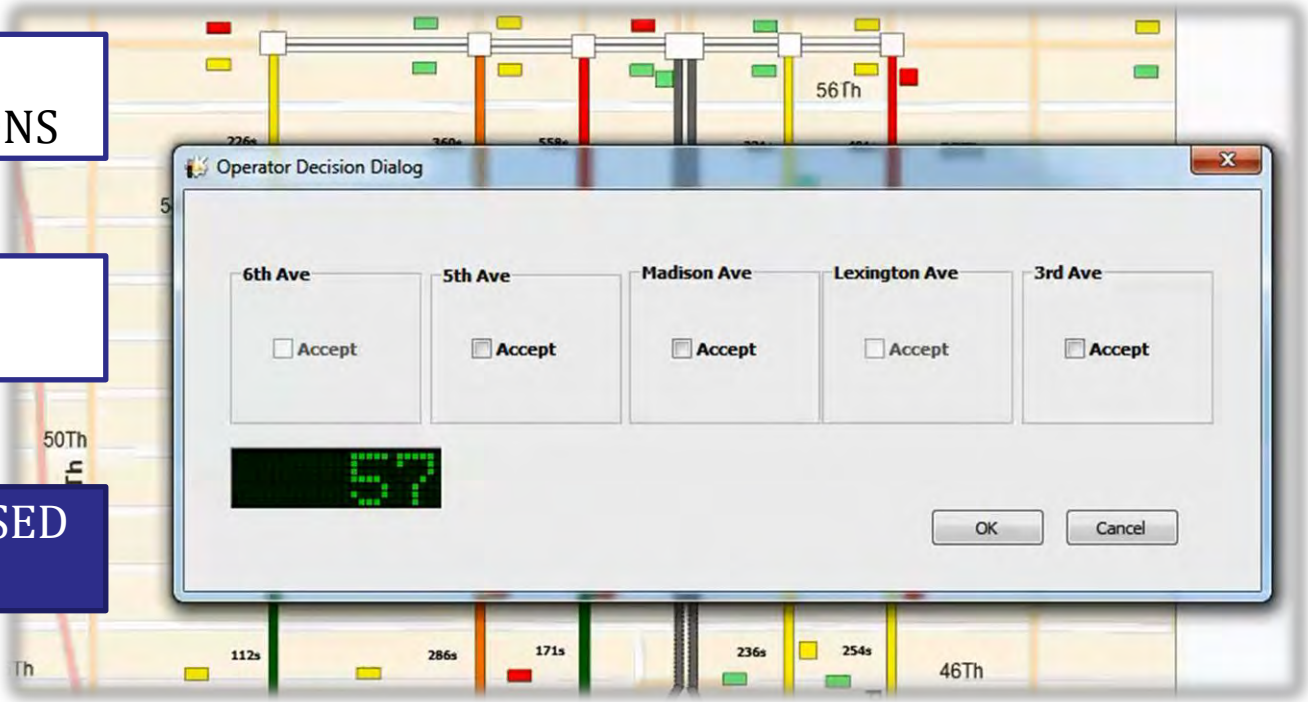
MIM In Action

REAL TIME DATA

ANALYSIS + RECOMMENDATIONS

REVIEW FIELD CONDITIONS

TAKE ACTIONS BASED ON REVIEW



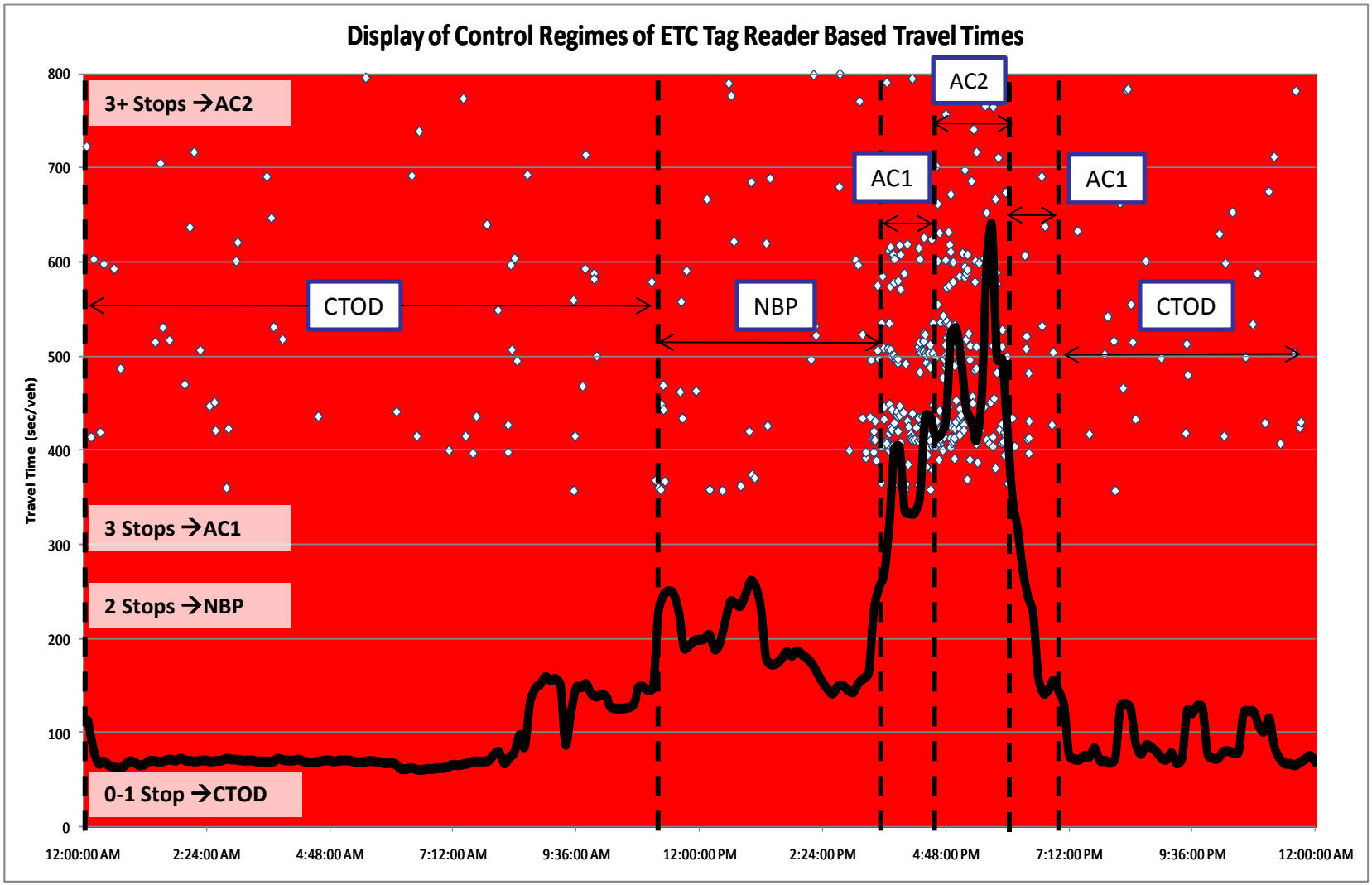
ALGORITHMS AND METRICS OF THE MIM ACTIVE TRAFFIC MANAGEMENT INITIATIVE

Satya Muthuswamy, P.E. PTOE
President, KLD

Metrics

- Level of System Usage
- Travel Time
  - Calendar Format
  - “Coffee Spill” plot
- Queue length and Severity Index
  - Relative Distribution
  - Average SI
  - Equity Ratio

Level of Activity



Level of Activity

- TMC staff using the tool
- Acting on recommendations
- Decisions are made individually for each arterial

Average no. of plan changes per day

year	Month	6 Ave	5 Ave	Madison Ave	Lexington Ave	3 Ave
2011	Aug	0	4	2	3	3
2011	Sep	2	4	4	6	6
2011	Oct	3	4	4	3	4
2011	Nov	2	4	2	4	4
2011	Dec	3	5	2	5	6
2012	Jan	2	3	3	3	4
2012	Feb	1	3	3	3	2
2012	Mar	2	3	5	2	3
2012	Apr	0	3	1	2	3
2012	May	4	5	5	5	4
2012	Jun	3	4	4	4	4

Max no. of plan changes per day

year	Month	6 Ave	5 Ave	Madison Ave	Lexington Ave	3 Ave
2011	Aug	2	10	7	7	6
2011	Sep	7	11	14	16	10
2011	Oct	9	8	8	7	9
2011	Nov	6	9	7	8	10
2011	Dec	9	10	10	10	14
2012	Jan	6	8	9	5	10
2012	Feb	6	9	10	8	8
2012	Mar	9	7	9	4	9
2012	Apr	1	4	2	3	4
2012	May	7	8	10	10	6
2012	Jun	7	8	6	8	6

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Max no. of plan changes per day

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2012	Feb	6	9	10	8	8
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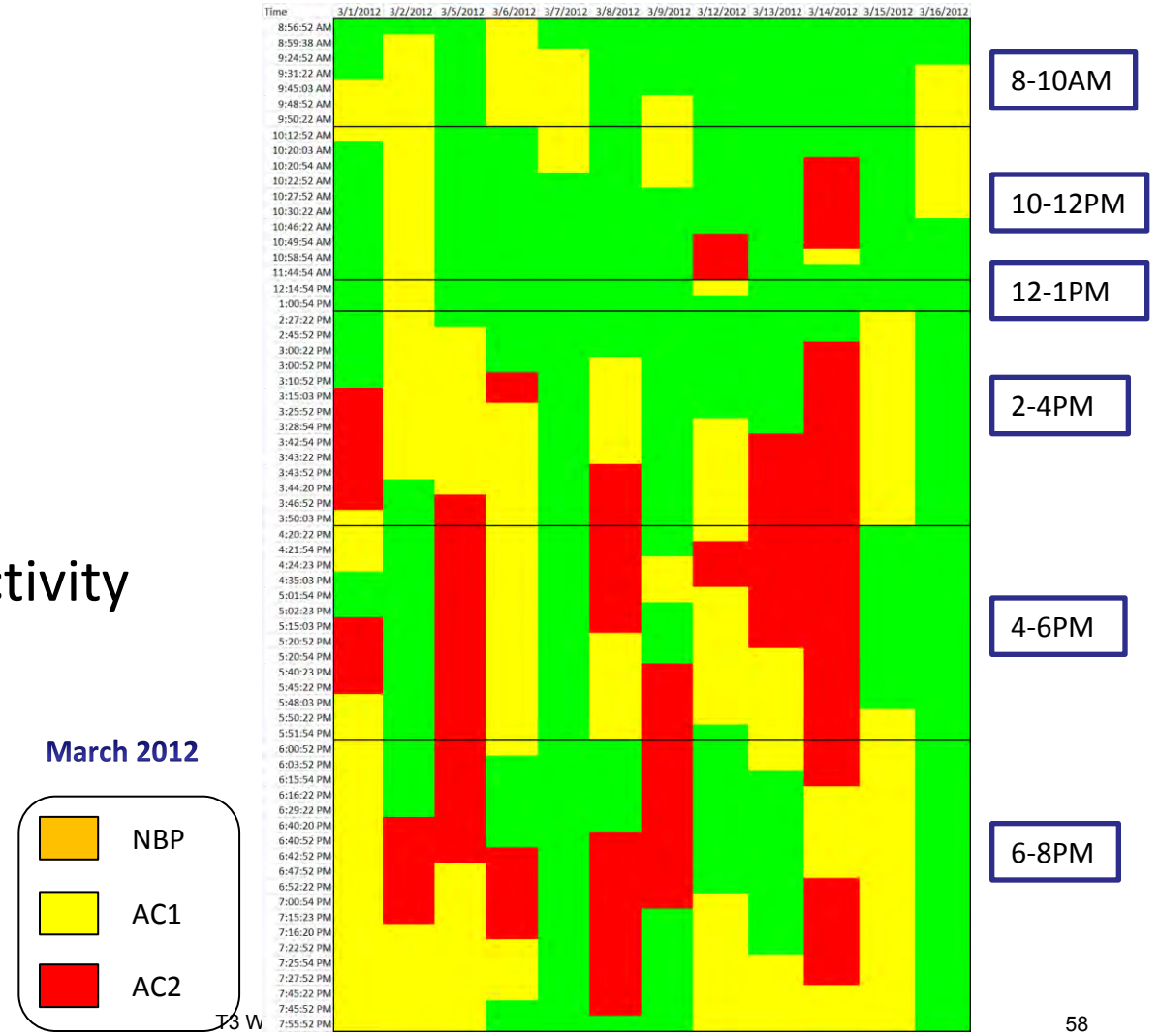
Level of Activity

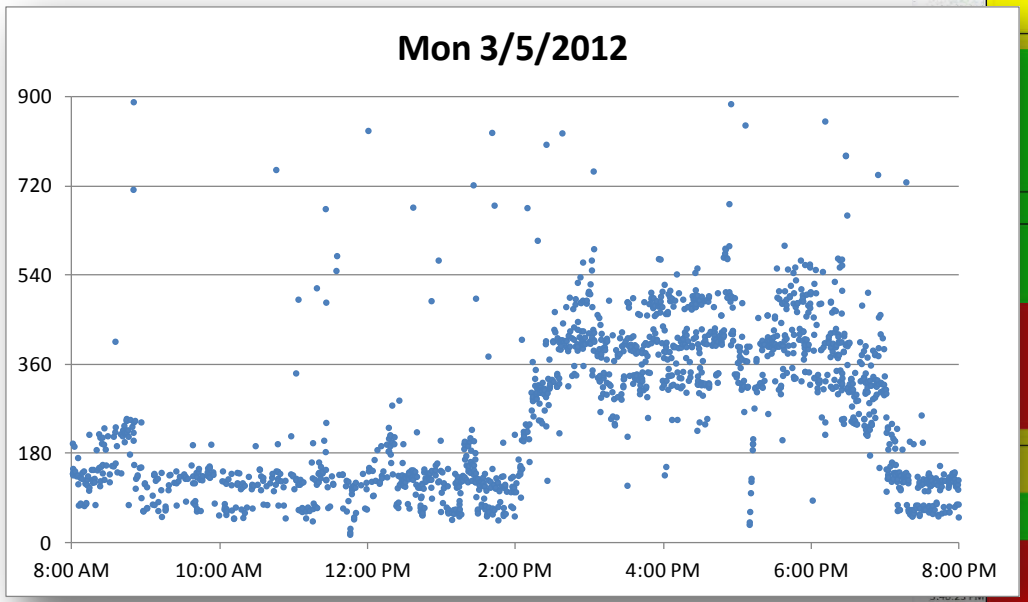
- Madison Avenue – Sample of control decisions

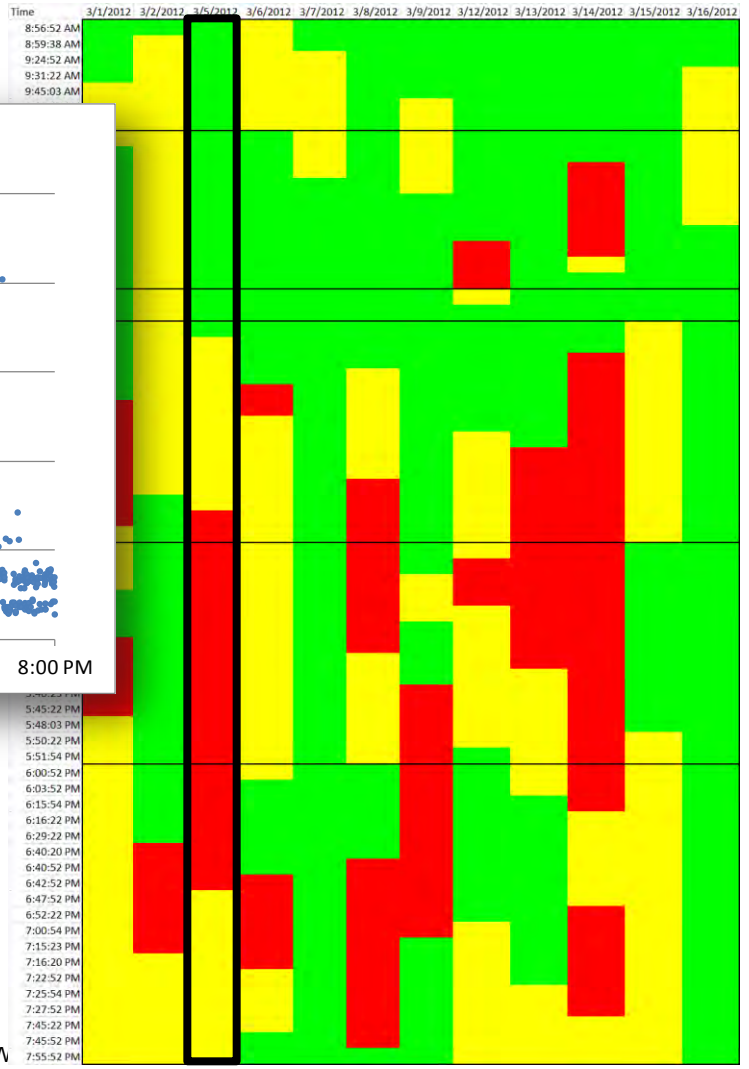
- Varying levels of activity



Level of Activity

- Madison Avenue – Sample of control decisions





March 2012

NBP

AC1

AC2

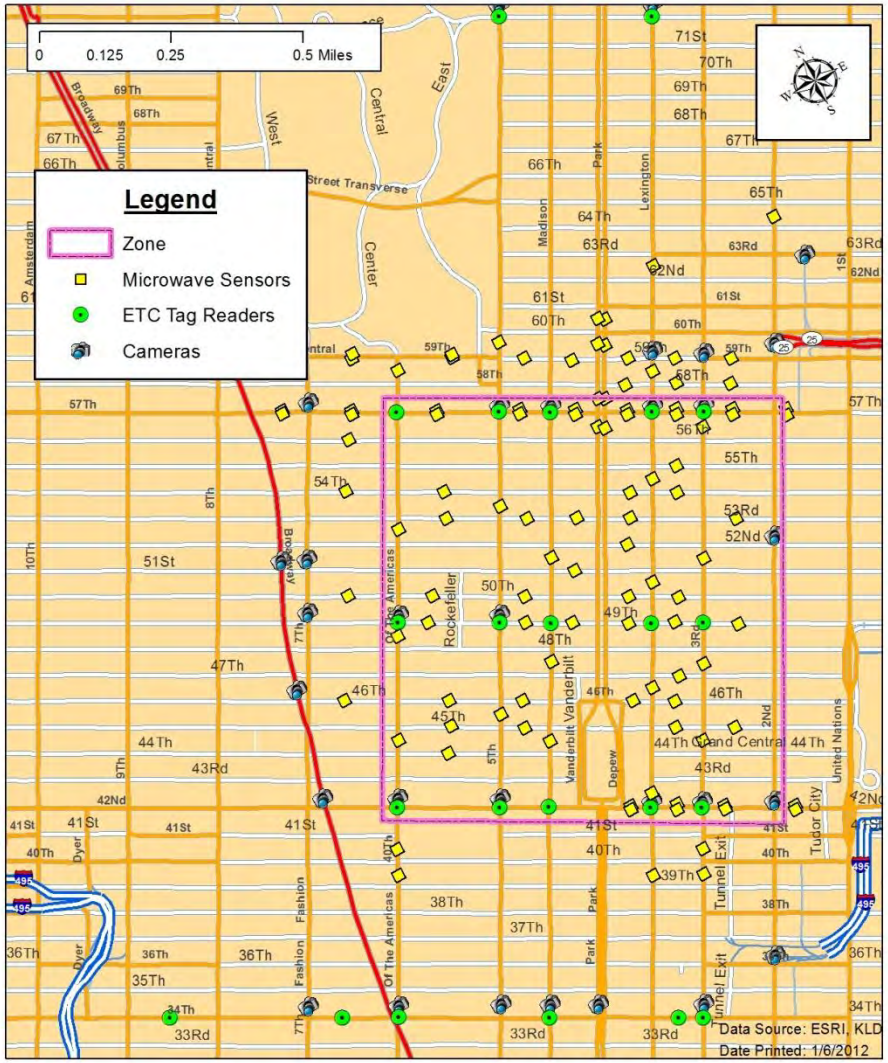
T3 W

Real-Time Data Sources

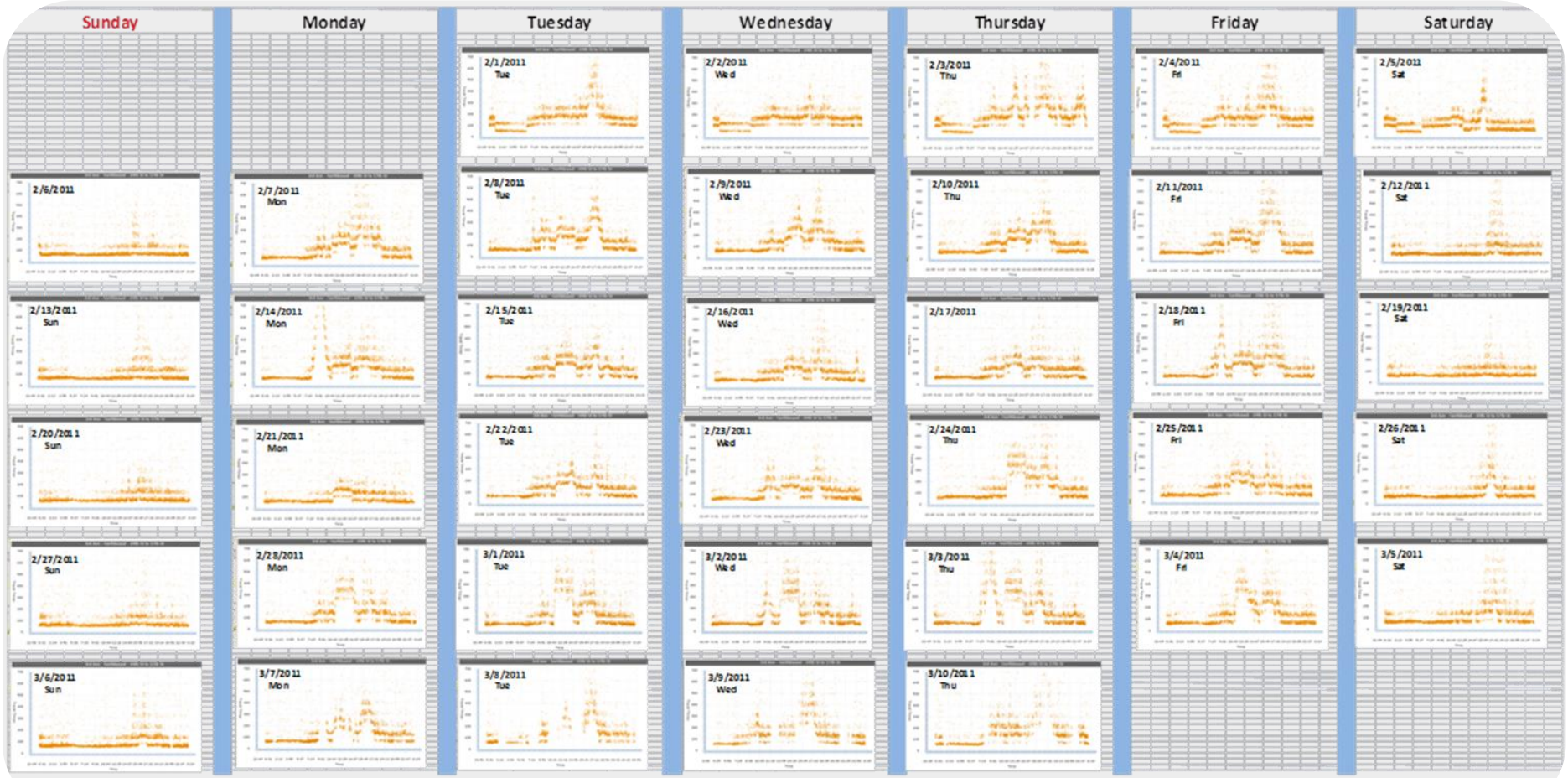
- ETC Tag Readers
  - Travel Time
  - 23 readers
  - 43 segments
  - **24,000 records per day**

- Microwave Sensors
  - Flow and Occupancy
  - 100 sensors
  - Up to 4 lanes per location
  - **743,000 records per day**

Midtown in Motion
Sensors, Readers, Cameras



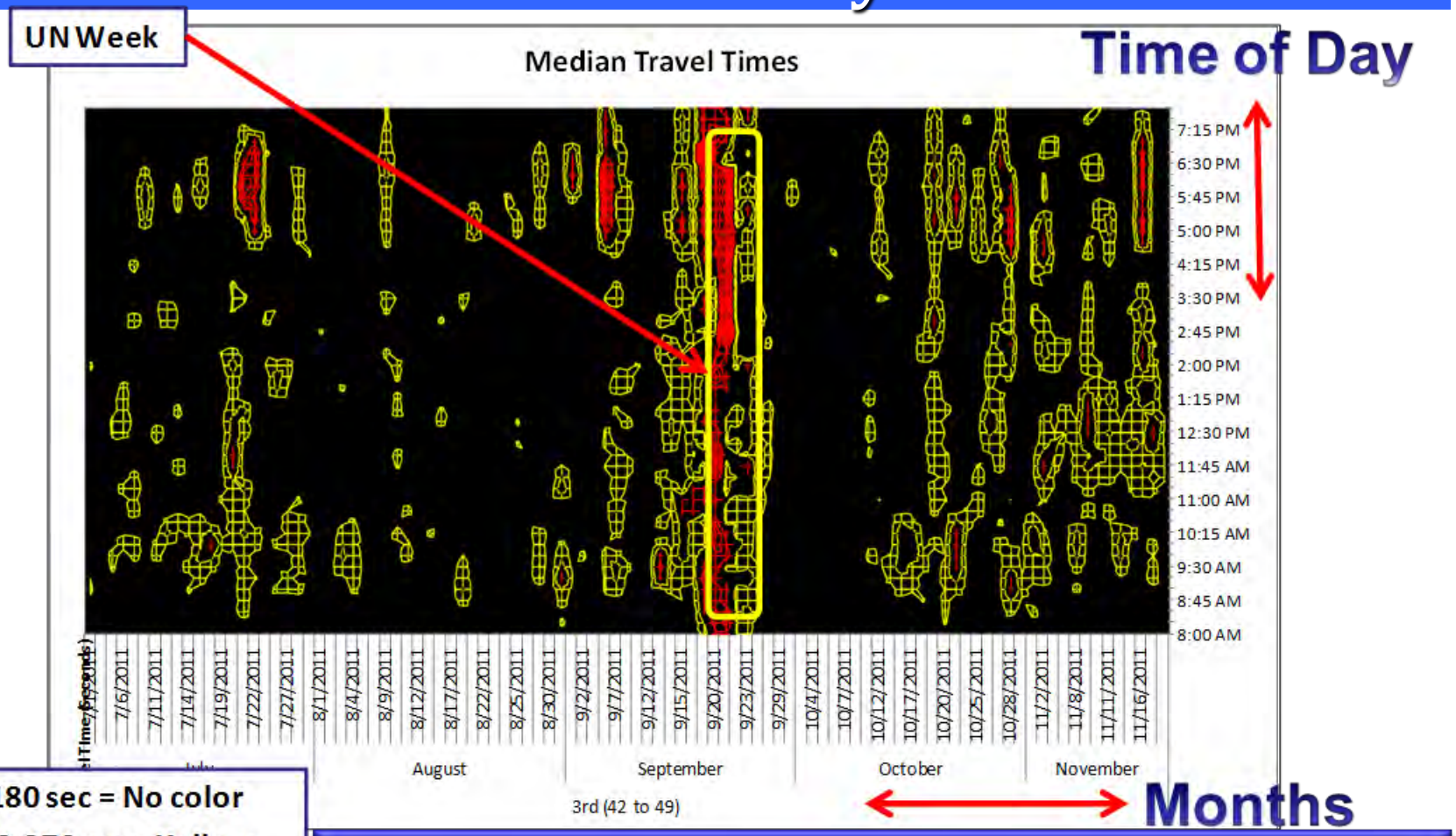
Travel Time: Variability is the Norm



One Month data (Feb 1 to March 10, 2011) for one segment

Variability, is the norm

Travel Time – History over Time



0-180 sec = No color

180-270 sec = Yellow

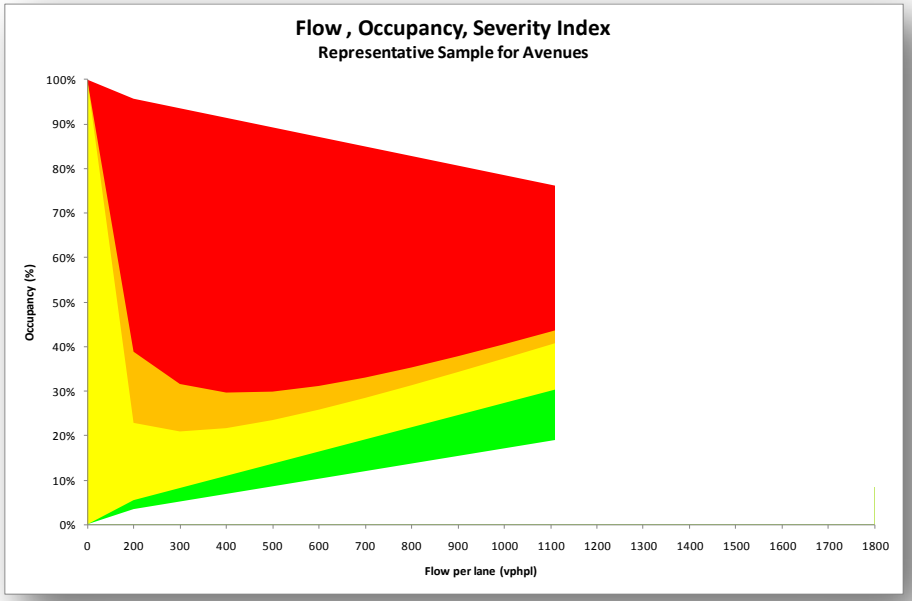
270-360 sec = Orange

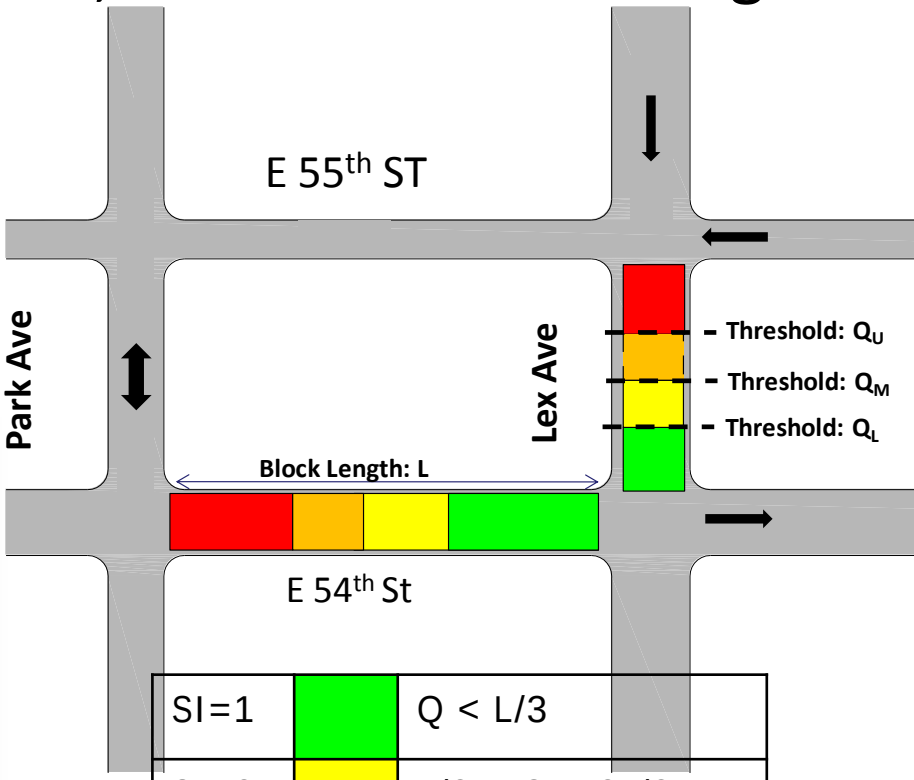
> 360 sec = Red

- Median travel time across months, shown above
- Seasonal demand, Special events, incidents, etc. trigger some congestion despite ATM
- Care must be exercised in before/after evaluation

Severity Index (SI)

- Measure of queuing condition, relative to block length
- Estimate queue using flow/occupancy and then calculate SI

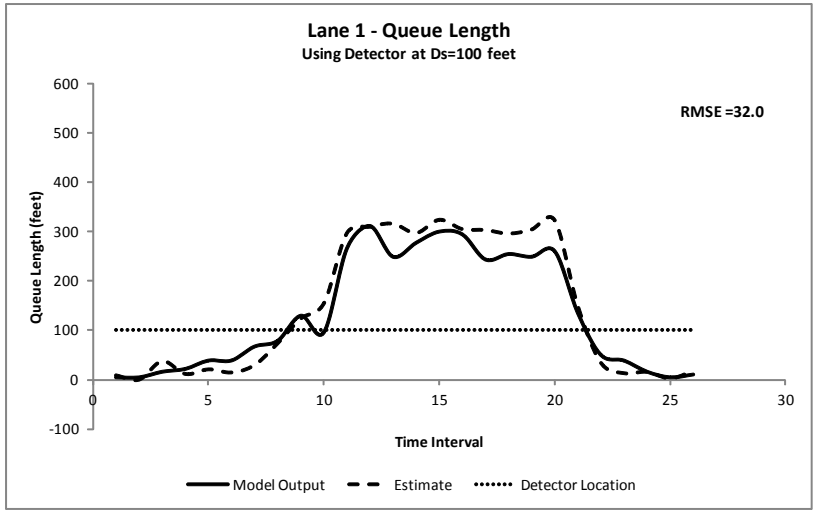


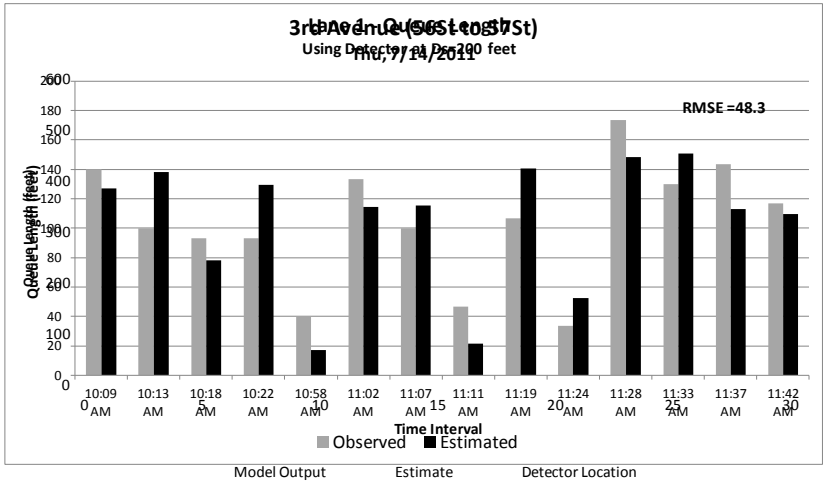


SI=1		Q < L/3
SI=2		L/3 < Q < 2L/3
SI=3		2L/3 < Q < 3L/4
SI=4		Q > 3L/4

Queue Estimation Algorithm

- Developed methodology to estimate queue using flow and occupancy
- Minimal set of inputs
- Robust queue estimates for real time control
- Tested using simulated and real world data
- 2013 TRB paper





Severity Index (SI) and Control Policy

Travel Time <= 1 stop

		Cross Street SI			
		1	2	3	4
Avenue SI	1	Do Nothing	Street + Δ_1	Street + Δ_2	Street + Δ_2
	2	Ave + Δ_1	Do Nothing	Street + Δ_1	Street + Δ_1
	3	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default
	4	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default

Travel Time > 1 stop

		Cross Street SI			
		1	2	3	4
Avenue SI	1	Reset to Default	Reset to Default	Reset to Default	Reset to Default
	2	Ave + Δ_1	Reset to Default	Reset to Default	Reset to Default
	3	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default
	4	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default

- Use travel time and Severity Index
- Adjust signal splits – user defined
- Four policy actions
  1. Do Nothing
  2. Change by Δ_1
  3. Change by Δ_2
  4. Reset to default

SI and Control Policy

Travel Time <= 1 stop

		Cross Street SI			
		1	2	3	4
Avenue SI	1	Do Nothing	Street + Δ_1	Street + Δ_2	Street + Δ_2
	2	Ave + Δ_1	Do Nothing	Street + Δ_1	Street + Δ_1
	3	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default
	4	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default

Travel Time > 1 stop

		Cross Street SI			
		1	2	3	4
Avenue SI	1	Reset to Default	Reset to Default	Reset to Default	Reset to Default
	2	Ave + Δ_1	Reset to Default	Reset to Default	Reset to Default
	3	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default
	4	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default

- Use travel time and SI
- Adjust signal splits – user defined
- Four policy actions
  1. Do Nothing
  2. Change by Δ_1
  3. Change by Δ_2
  4. Reset to default

SI and Control Policy

Travel Time <= 1 stop

		Cross Street SI			
		1	2	3	4
Avenue SI	1	Do Nothing	Street + Δ_1	Street + Δ_2	Street + Δ_2
	2	Ave + Δ_1	Do Nothing	Street + Δ_1	Street + Δ_1
	3	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default
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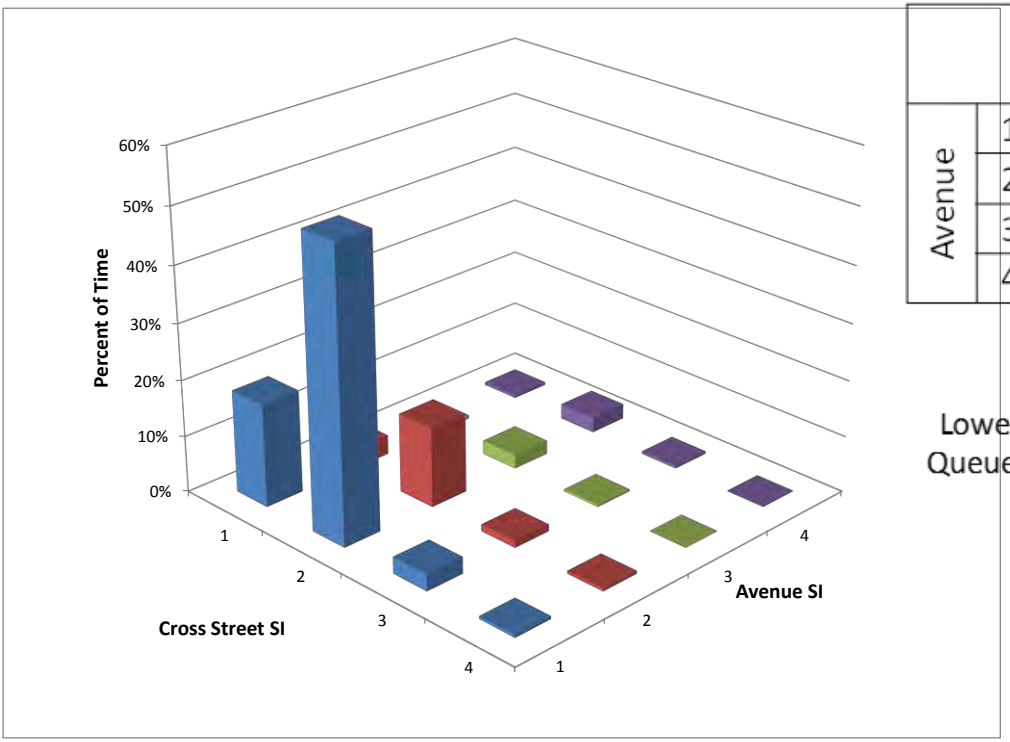
Travel Time > 1 stop

		Cross Street SI			
		1	2	3	4
Avenue SI	1	Reset to Default	Reset to Default	Reset to Default	Reset to Default
	2	Ave + Δ_1	Reset to Default	Reset to Default	Reset to Default
	3	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default
	4	Ave + Δ_2	Ave + Δ_1	Reset to Default	Reset to Default

- Use travel time and SI
- Adjust signal splits – user defined
- Four policy actions
  1. Do Nothing
  2. Change by Δ_1
  3. Change by Δ_2
  4. Reset to default

New Metrics

- Relative Distribution of SI



		Crosstown St			
		1	2	3	4
Avenue	1	15%	15%		
	2	13%	21%		
	3	2%	1%%		
	4	8%	25%		

Lower SI, Shorter Queues on Crosstown Street

Same SI on Ave and Crosstown Street => Balanced Operations

Lower SI, Shorter Queues on Avenue

- Average SI – Avg. of SI by approach by interval
- Equity Ratio – Avg. SI (Cross St) / Avg. SI (Ave)

RESULTS & CONCLUDING REMARKS

Mohamad Talas, PhD P.E. PTOE
Deputy Director, NYCDOT ITS

Results to date

- Phase A
  - Initial results show an improvement of speeds around 10% within the study area
  - The overall speeds considering both inside study area and approaching study area were comparable
  - Level 2 control, has been helping to reduce queuing (and in turn gridlock) while achieving equity

Results to Date

- Comparison of average speed
- AM = 8AM to 10AM, MD = 11AM to 1PM, PM = 4PM to 6PM
- Highlighted cells for improved speed

		6th Avenue		5th Avenue		Madison Avenue		Lexington Avenue		3rd Avenue	
		Before	After	Before	After	Before	After	Before	After	Before	After
AM	Zone	7.4	8.5	6.9	7.1	6.9	7.8	5.3	5.3	5.6	6.5
	Outside	7.7	7.2	8.1	7.9	5.8	5.3	7.9	7.7	5.3	5.9
	Overall	7.5	8	7.5	7.5	6.5	6.7	6.3	6.2	5.5	6.3
MD	Zone	7.3	8	7.6	7.8	6.3	10.6	6.7	9.2	5.7	7.9
	Outside	9.2	7.7	5.3	5.6	5.6	7.7	6.7	6.1	5.7	6.3
	Overall	7.9	7.9	6.3	6.6	6	9.4	6.7	7.3	5.7	7.3
PM	Zone	6.6	7	5.2	6	7.6	8.2	8.6	8.8	5.1	5.3
	Outside	8.8	7.4	7	6.3	8.6	7.3	5.9	5.6	7.7	7
	Overall	7.2	7.1	5.9	6.1	7.9	7.8	7	6.8	5.8	5.8

Project Accolades

- Awards
  - IRF, ACEC, ITS America
- Public Profile
  - Favorable media coverage

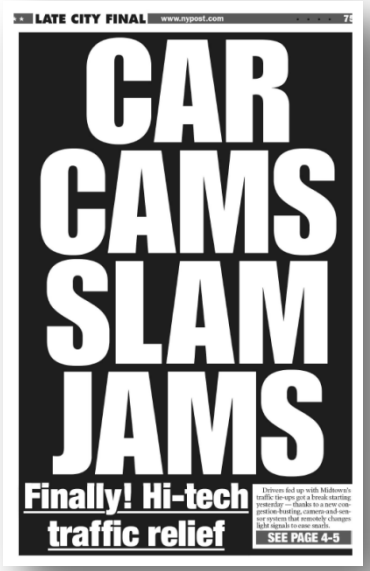
IRF GRAA

ITS AMERICA

Smart Solution Spotlight Award

ACEC
American Council of Engineering Companies
100 Years of Excellence

Diamond Award for Engineering Excellence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CAR CAMS SLAM JAMS

Finally! Hi-tech traffic relief

SEE PAGE 4-5


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sacrificing generous RELIABLE

compassionate BRAVE UNSUNG

humble DEDICATED

A New High-Tech Assault on Midtown Traffic Jams

Traffic in Times Square. The city's Midtown management system uses microwave sensors, video cameras and E-ZPass readers.

By CHRISTINE HAUGHNEY

It is an all-too-common sight in Midtown Manhattan: cars, taxis and


Briefing Room

FHWA Administrator Mendez Joins Mayor Bloomberg to Launch Nation's Most Sophisticated Traffic Management System

U.S. Department of Transportation
Office of Public Affairs
Washington, D.C.
www.dot.gov/affairs/briefing.htm

News

FHWA 33-11
Saturday, July 16, 2011
Contact: Kelly Hanahan
Tel: 202-366-0660

FHWA Administrator Mendez Joins Mayor Bloomberg to Launch Nation's Most Sophisticated Traffic Management System

Federal dollars used to create "Midtown In Motion" to improve New York City traffic, protect pedestrians

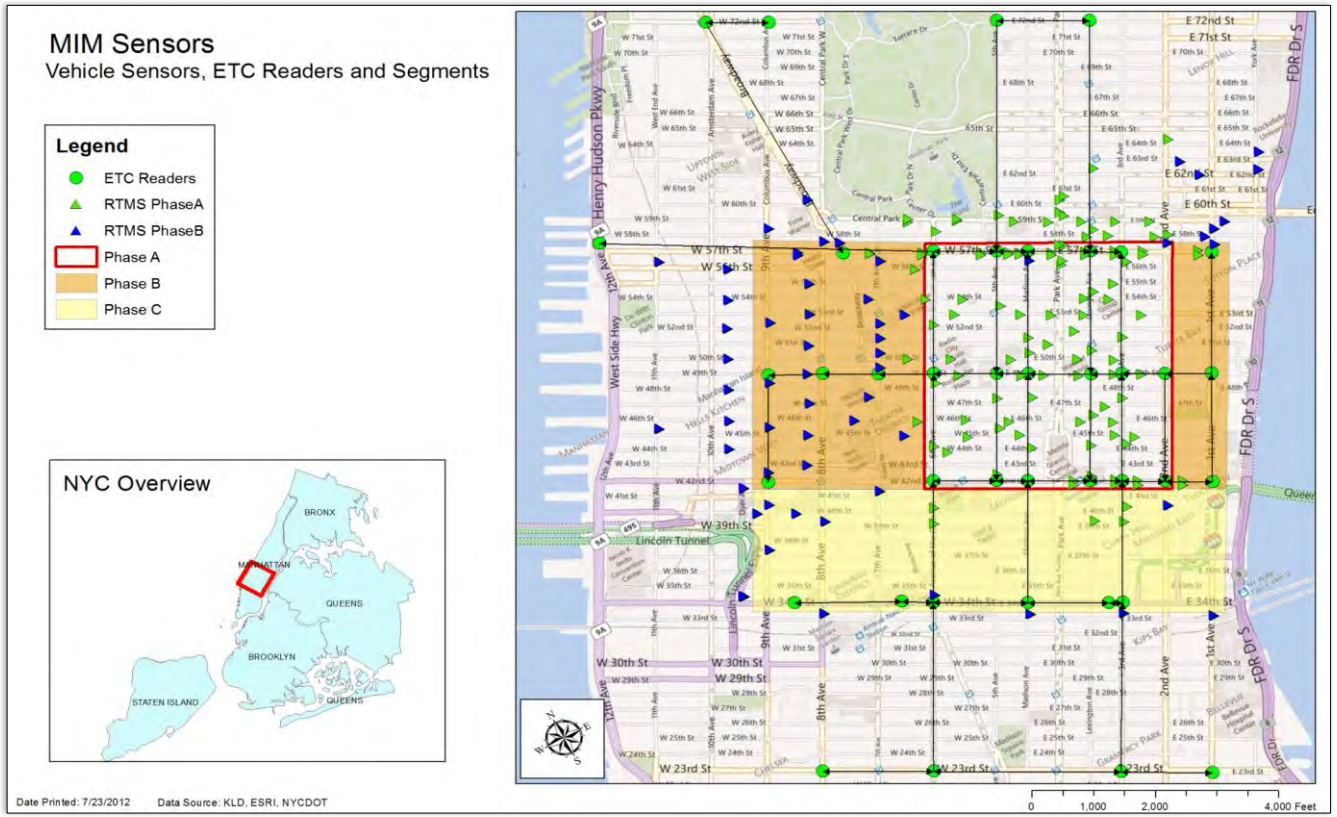
NEW YORK CITY- Federal Highway Administrator Victor Mendez joined Mayor Michael Bloomberg, Transportation Commissioner Janette Sadik-Kahn and other local officials today to launch "Midtown In Motion," a sophisticated new system to improve the flow of traffic and safeguard pedestrians in the 110-square-block heart of New York City.

"This new state-of-the-art system will let New York City show how major cities can reduce traffic congestion and improve pedestrian safety," said U.S. Transportation Secretary Ray LaHood.

The "Midtown In Motion" project will improve the ability of local traffic engineers to respond to changes in traffic flow caused by construction, special events, crashes and other activities based on real-time data transmitted from sensors and video cameras to the Joint Traffic

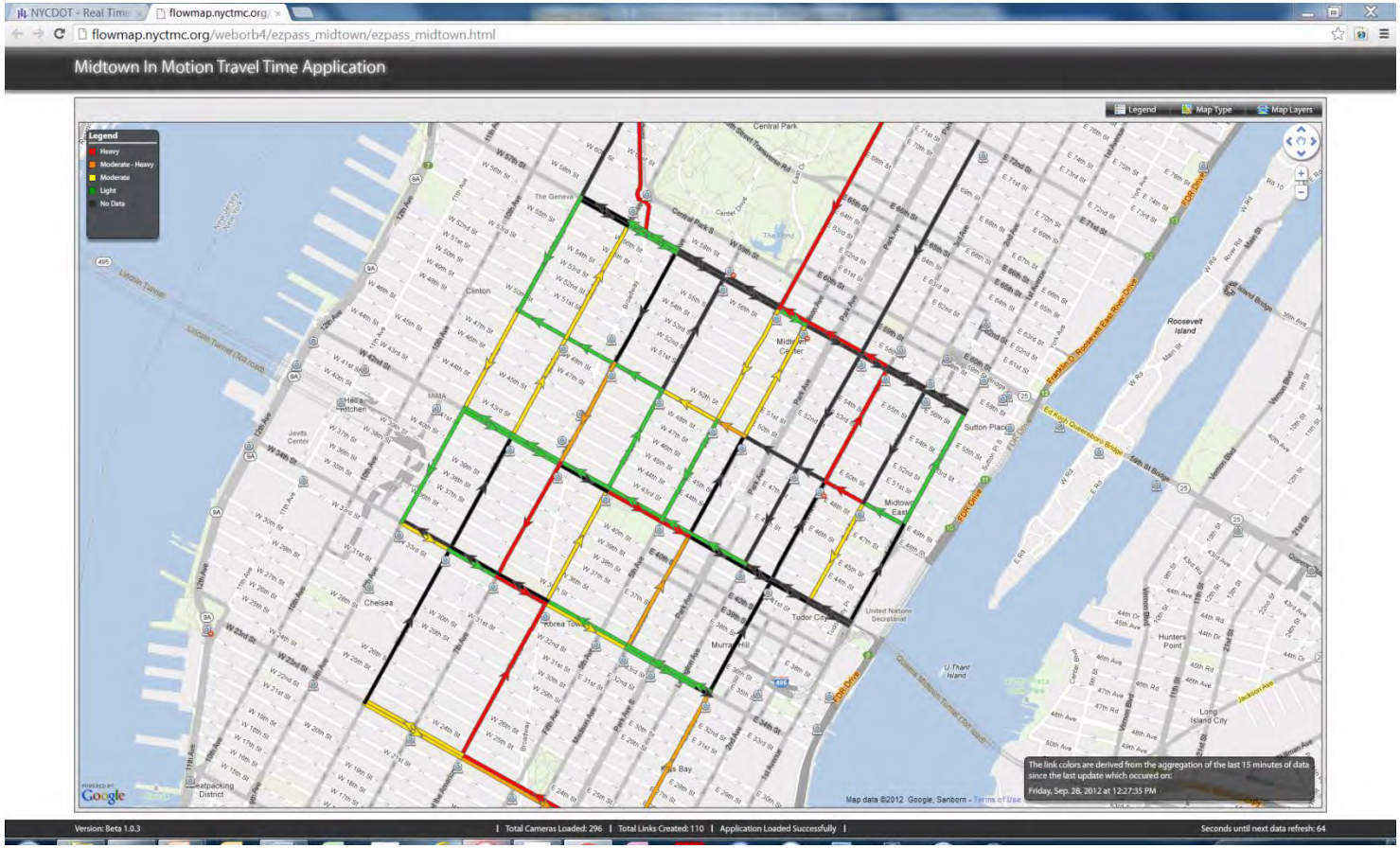
Next Steps

- Planned Expansion
  - Phase B will be live shortly
  - Phase C underway



Data Sharing

- NYCDOT developed a tool to view travel time data
- NYCDOT will share information with app developers



Lessons Learned

- Cost effective solution, built on existing ITS
- Rapid deployment of ITS in record time
- ITS design adapted to conditions
  - Mid block vehicle sensors
  - Optimized ETC tag readers locations
- Centralized control and monitoring
  - Integrate technologies in operations
  - ATM makes recommendations
  - Operator review using cameras
  - Decision making and action

Lessons Learned

- Reliable data source for real time control
  - Travel time data using ETC tag readers
  - Flow and occupancy from microwave sensors
- Robust metrics for real time control
  - Median travel time for control decisions
  - Severity Index
- Hierarchical control is very effective to minimize gridlock and congestion
  - Strategic – Level 1
  - Tactical – Level 2

Acknowledgements

We wish to thank all team members of this project:

- FHWA
- New York City DOT
- TransCore
- KLD
- Peek Traffic
- ISS/EIS

Participant Q&A