

*Paving the Way to Capture
Traffic Flow Metrics
with Drones*

Gregory W. Jordan

NATMEC 2016



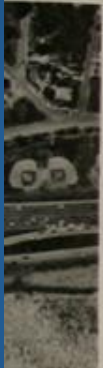
87

HIGHWAY RESEARCH BOARD
Special Report 87

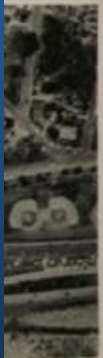
HIGHWAY
CAPACITY
MANUAL
1965

National Academy of Sciences
National Research Council
Publication 1328

enter roadway.
ft: level C,
per right:
olerable
than
ow



2



3

Right-bound 63.38 view/lane
✓ ? angle



4

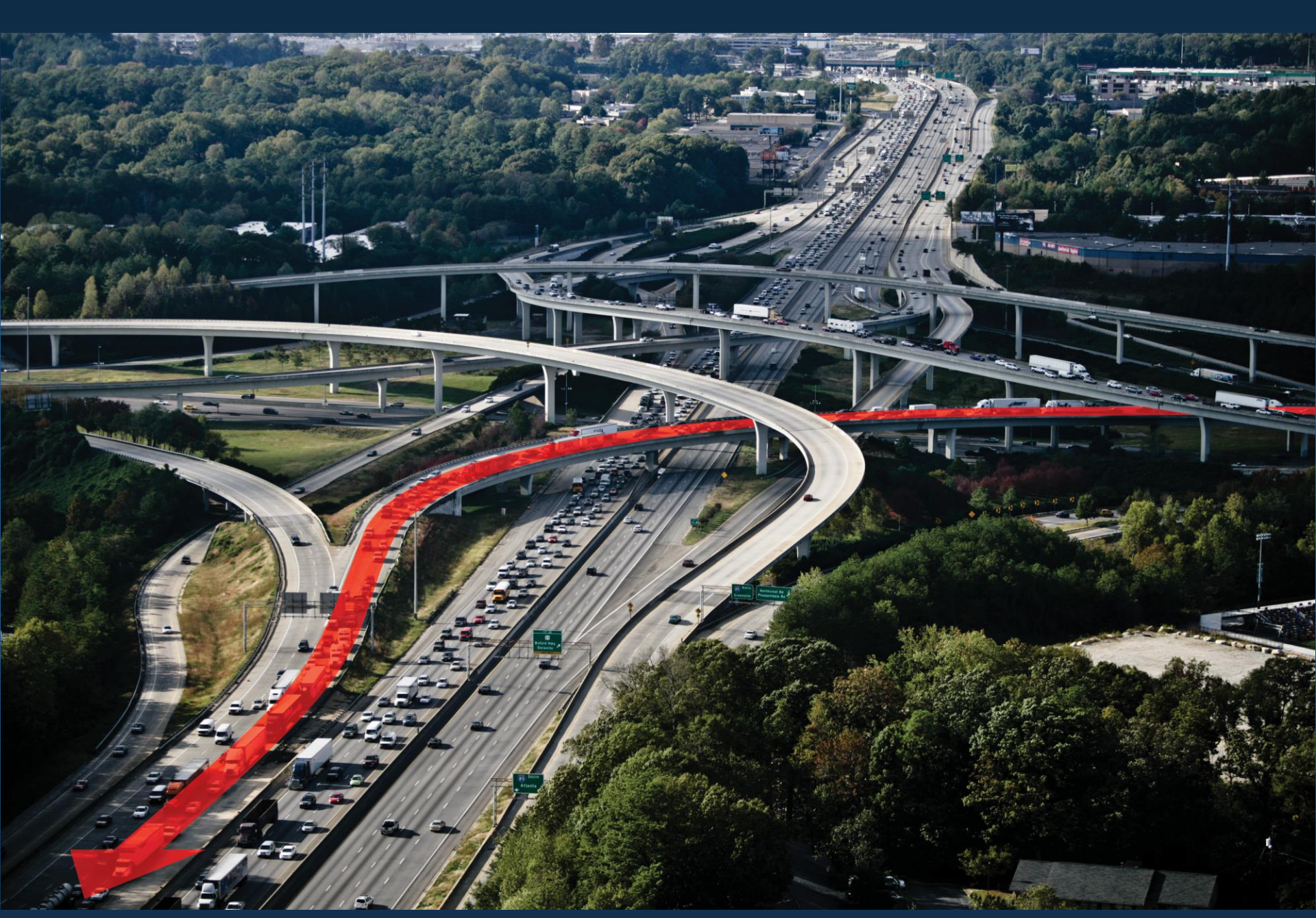


5



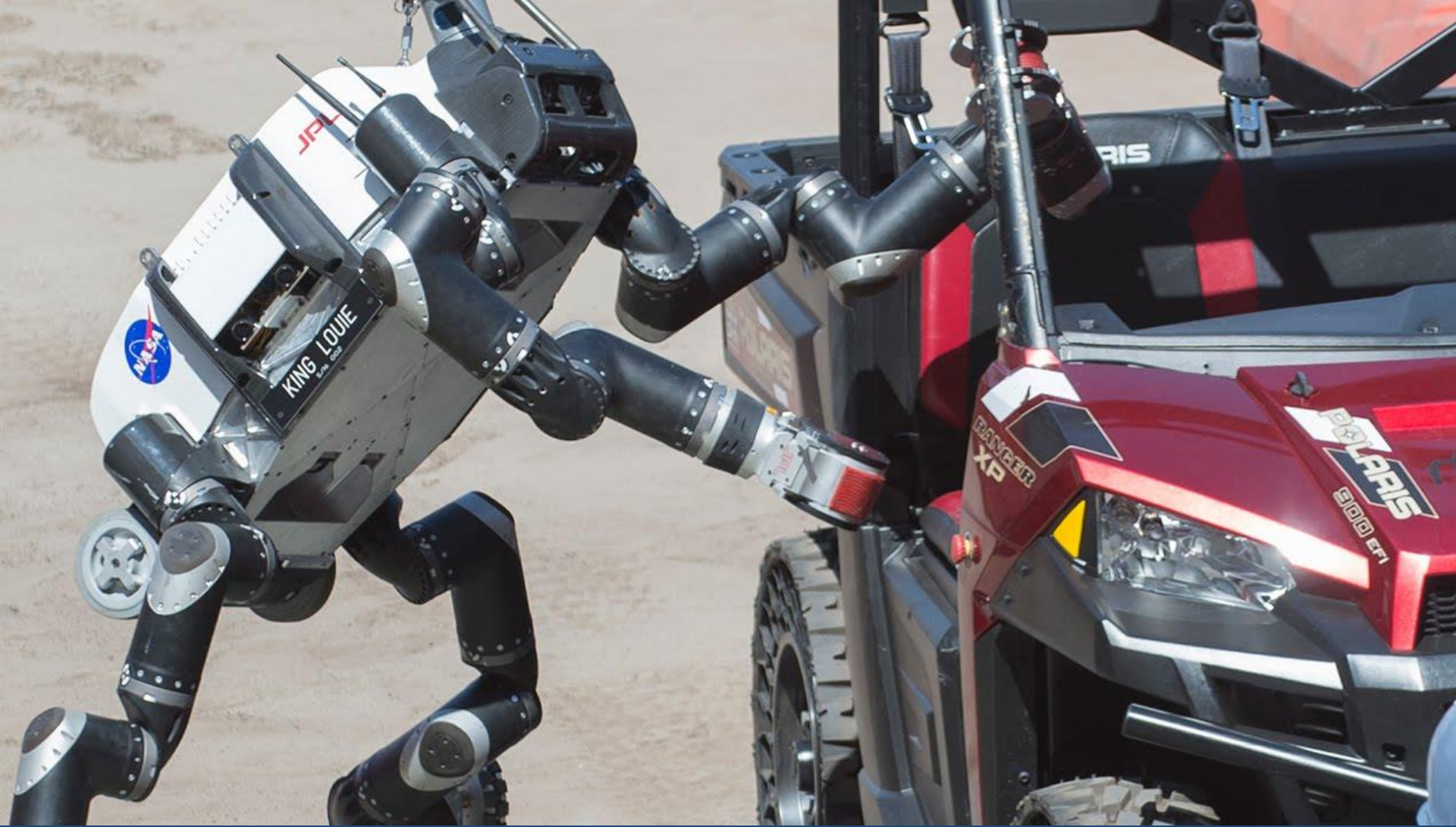
6







ROBOTS



(DARPA Challenge / NASA JPL)

on LAND...



(for safety always lock your doors)



SEA...

(Zeus / Odyssey team)



(shipwreck gold up from 7,000 feet)

AIR...



(Top Flight Technologies drone)



(Drones are just part of the robot revolution!)

Today:

DJI Phantom 4

3-axis camera stabilization

Includes built-in camera
(4K video / 12.4 MP still)

Endurance: 28 minutes

Legal altitude: 400 feet

\$1,500

(x2 for tag-team coverage)



Tomorrow... soon?

Prototype Gas / Electric Hybrid: 2 hours, 1 mile high, 1 gallon gas



(Top Flight Technologies drone)



How State DOT's are using Unmanned Aerial Systems

April 6th, 2016 2 PM, Eastern Time

*Tony Dorsey , AASHTO Manger of Media Relations
Executive Producer AASHTO Transportation TV*

tdorsey@ashto.org

*Fred Judson, Program Director
Ohio/Indiana UAS Center & Test Complex*

Fred.judson@dot.state.oh.us

*Steven Cook, P.E., Engineer of Operations and Maintenance
Michigan Department of Transportation*

CookS9@michigan.gov

Jason Siwula, Kentucky Transportation Cabinet

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Jarlath O'Neil-Dunne

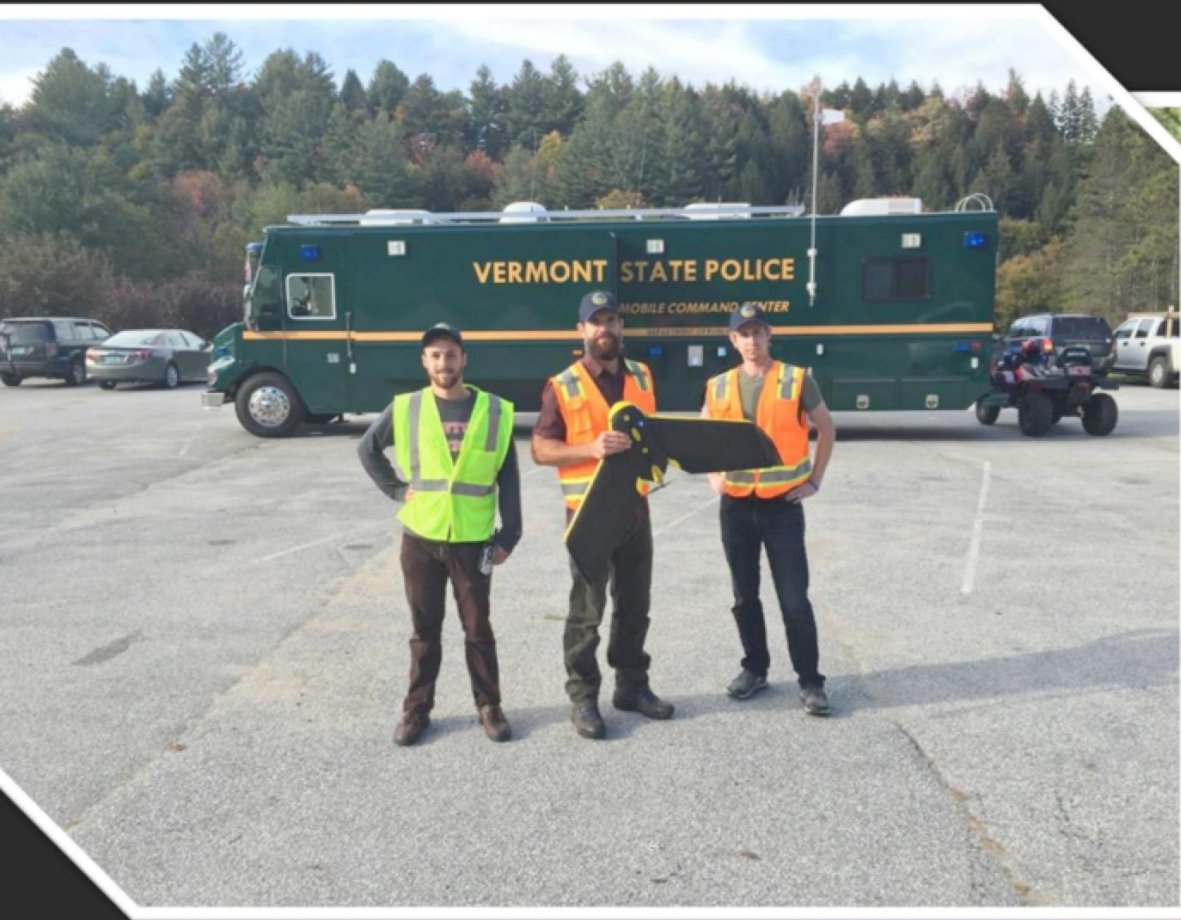
Faculty Research Associate and Director of the UVM Spatial Analysis Laboratory (SAL)

Jarlath.ONeil-Dunne@uvm.edu

Gary Cathey, Chief

Division of Aeronautics, California Department of Transportation

gary.cathey@dot.ca.gov

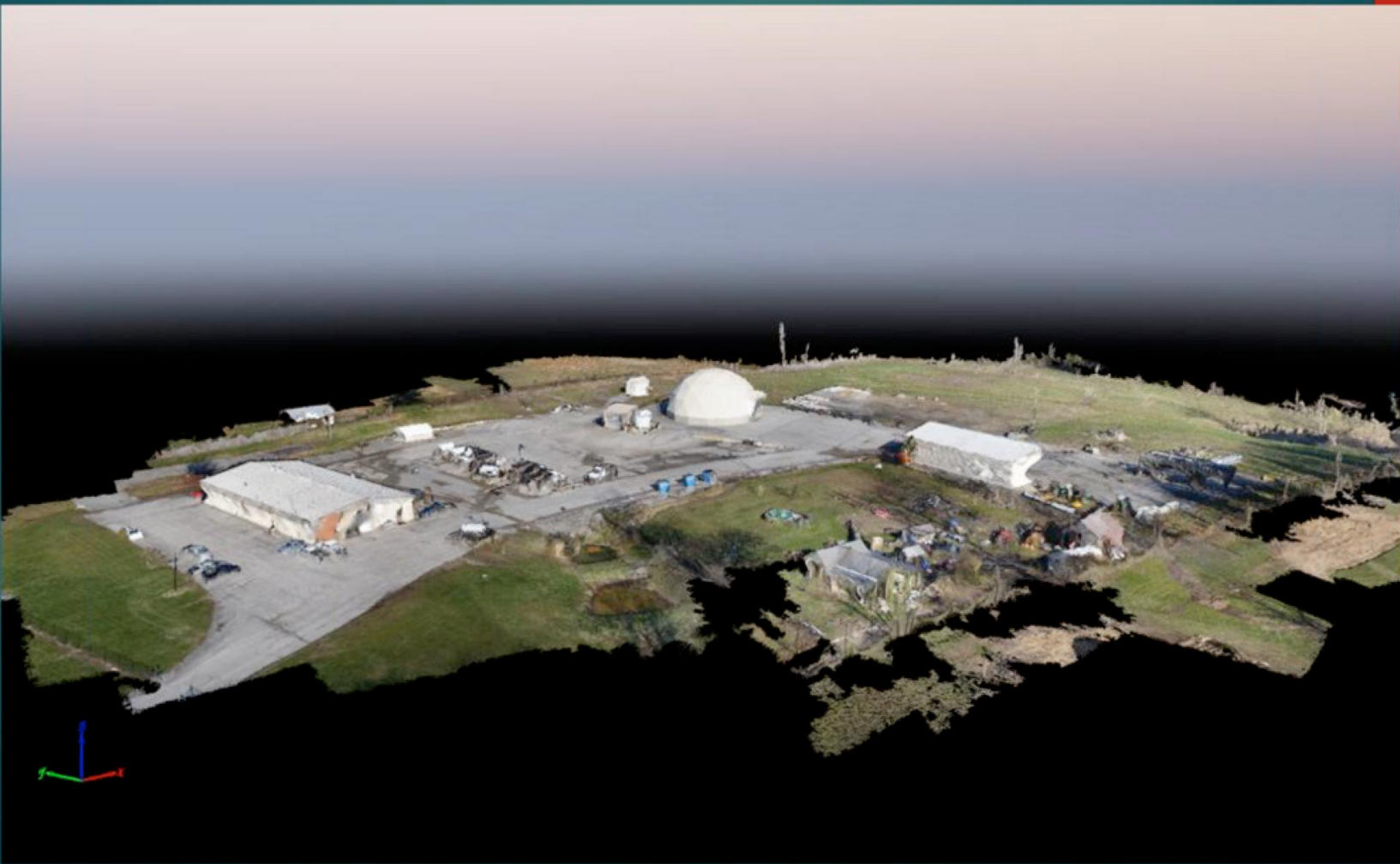


(Vermont)



(Vermont)

After a few hours of processing you have a 3D color point cloud, DTM and mesh



(Kentucky)

MDOT UAS Phase II Research (April 2016 – 2 year project)

1. Data collection capabilities
2. Use broad sensing technologies for three (3) MDOT assets
3. Ensure data collected accuracy/quality compared to current data collection systems at MDOT
4. Provide Implementation Plan, User Guidance Document, and Training
5. Determine the return on investment (benefit/cost analysis)
6. Received a FAA COA and Section 333 Exemption
7. Final Report Phase I: “RC-1616 Evaluating the Use of Unmanned Aerial Vehicles for Transportation Purposes” on MDOT website



Potential Applications within the Transportation Cabinet

- Surveying
- Design - Digital Terrain Models
- Construction Monitoring
- As-Built Plans
- Structure Inspections
- Stockpile Volume Measurement
- Crash Scene Management and Clearing
- GIS
- Archeology
- Public Meetings



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- Public Meetings



No traffic flows!

Caltrans UAS Proposed Operations

- Landslide and other steep terrain investigations
- Vegetation and soil investigations
- Disaster response (fires, floods, earthquakes, etc.)
- Bridge inspections (photos and thermograms)
- Topographic and hydrologic surveys
- Roadside and roadway inspections
- Public Affairs/Media Relations
- Confined area inspections (bridge columns)



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NO traffic flows!

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2. Can't see much from the 400-foot altitudes that are permitted.
3. Can't stream BIG DATA from small domestic drones.
4. The prospects seem dim that persistent, high-altitude drones will be approved, at least for many years....

When the rules change to allow drone flights over people (near future), what traffic flow survey types make sense?

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1. Parking turnover and occupancy.









When the rules change to allow drone flights over people (near future), what traffic flow survey types make sense?

- 1.
2. Before-and-after photos to document project ROI.



2010 Update: Mobility Assessment and Bottleneck Changes

Traffic Quality on the Metro-Atlanta State Highway System

An aerial photograph of a complex multi-level highway interchange. The roads are filled with cars, indicating heavy traffic. The interchange is surrounded by dense green trees, with some buildings and parking lots visible in the lower-left and lower-right corners. The lighting suggests it's either early morning or late afternoon, with long shadows cast across the road surfaces.

MORNING BOTTLENECK MAPS

(Congested southbound flow at the I-85/SR 400 merge)

2008



SOUTHBOUND

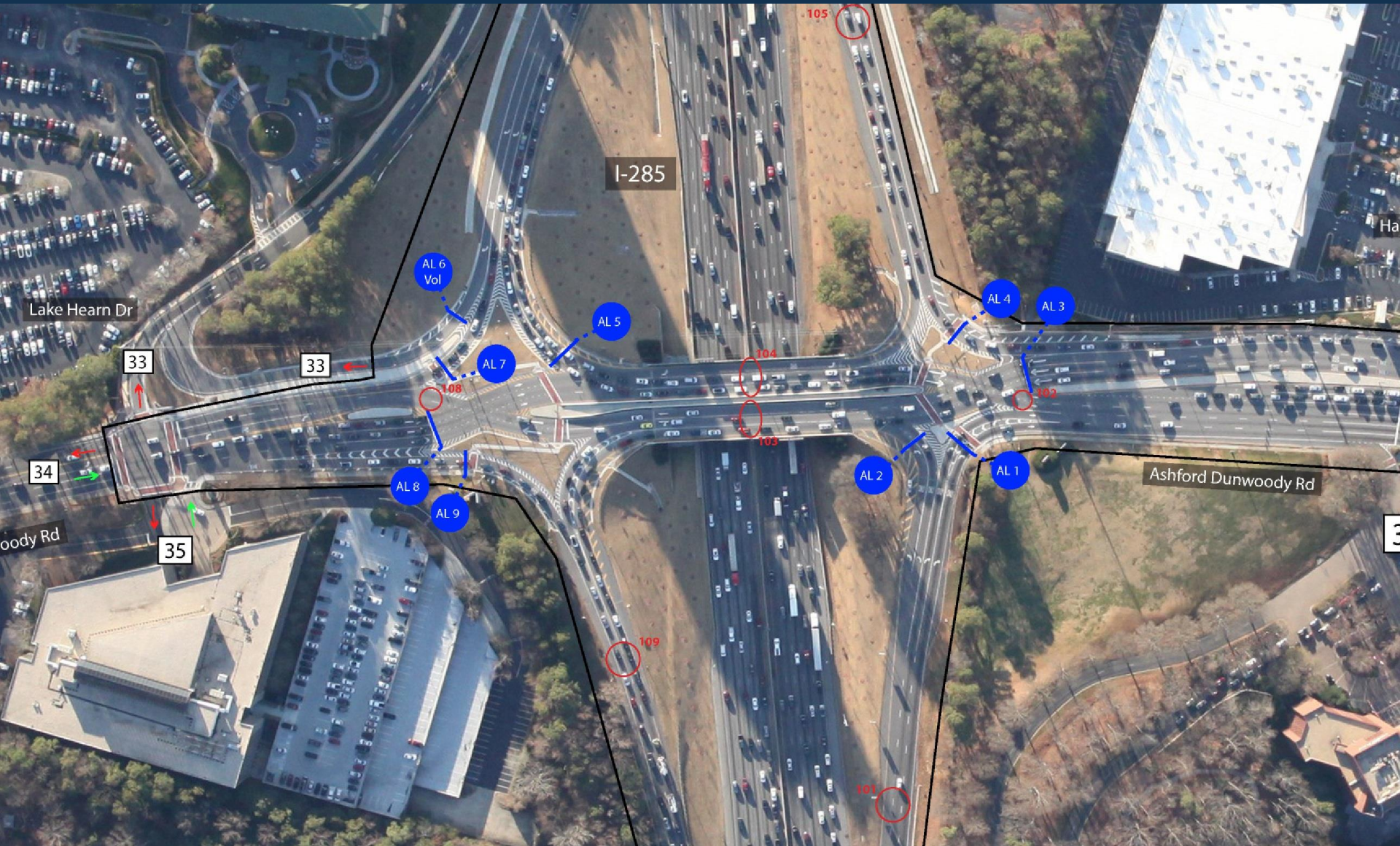
2010



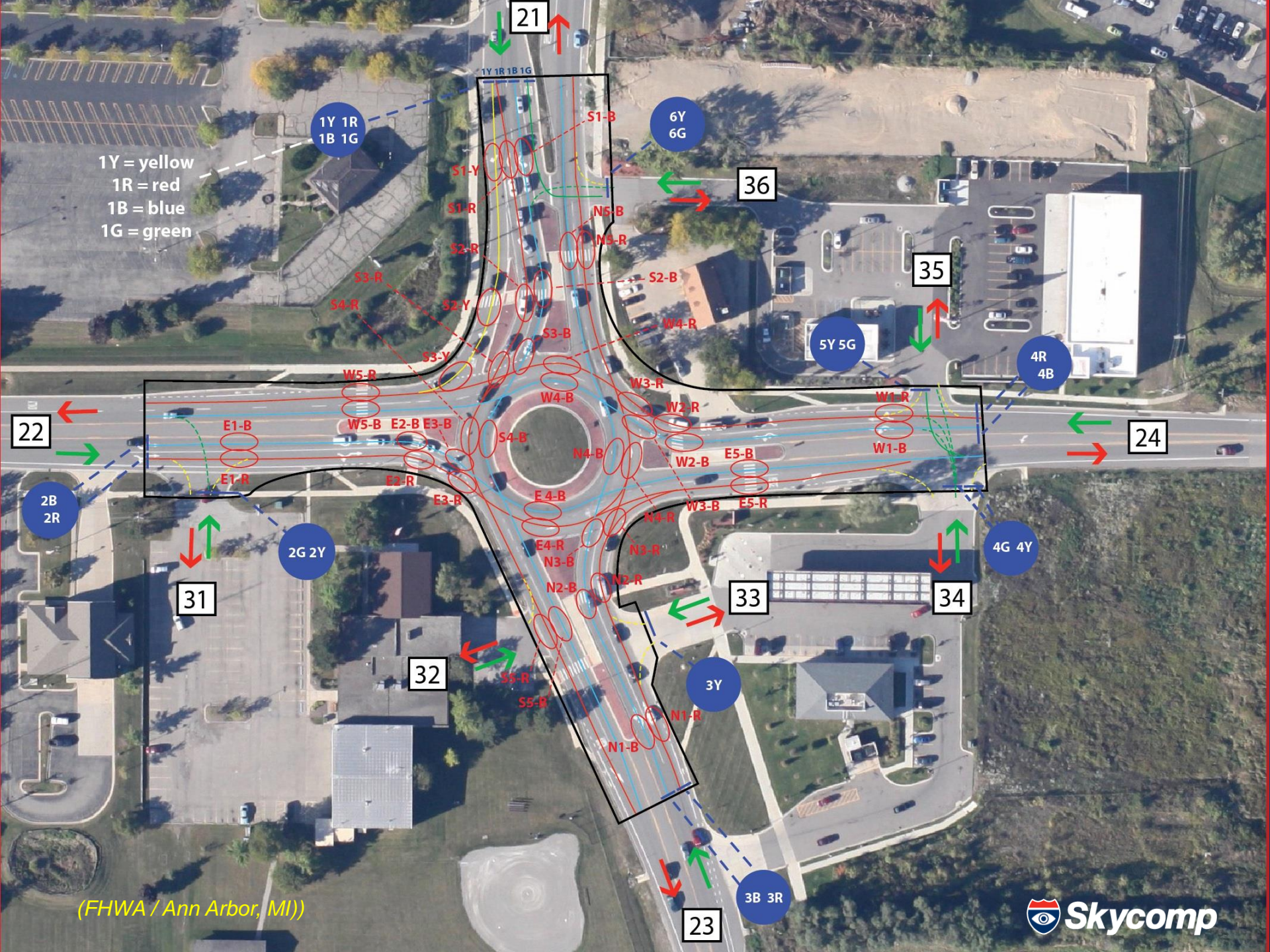
SOUTHBOUND

When the rules change to allow drone flights over people (near future), what traffic flow survey types make sense?

- 1.
- 2.
3. Granular vehicle trajectory research (DDI's, NGSIM).



1Y = yellow
1R = red
1B = blue
1G = green



(FHWA / Ann Arbor, MI)

When the rules change to allow drone flights over people (near future), what traffic flow survey types make sense?

- 1.
- 2.
- 3.
4. Pedestrian and bicycle movements.

PHOTOBOARD WITH OVERLAY - VERSION 1.0 (MORNING)

Pedestrian / Bicycle / Motor Vehicle O-D Survey

Inman Square, Cambridge MA

May 20, 2015; Period: 7:00 a.m to 9:00 a.m.



When the rules change to allow drone flights over people (near future), what traffic flow survey types make sense?

- 1.
- 2.
- 3.
- 4.
5. Work zone / daily inspection & documentation of MOT



Shea Stadium / Citi Field (NY Mets)

What could we do if we were suddenly and magically permitted to fly up high where we could see for miles?

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2. Understand and validate big data sets (e.g. probe O-D).

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1. Improved vehicle trajectory research (bigger areas).
2. Understand and validate big data sets (e.g. probe O-D).
3. Calibrate and validate complex microsimulation models by capturing ALL flow metrics at once (numbers will lock together).

Metrics possible, *and all captured together:*

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1. Travel time profiles between any two points.

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4. True O-D (with route options) between any points of interest.

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5. Freeway densities and LOS.

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6. Intersection LOS and signal cycle failures.

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(All by general vehicle class – auto, truck, tractor-trailer, bus)

Well, we decided not to wait around for permission...

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In 2012 Skycomp began to develop the market
for all of these applications, legally, by using...

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MANNED DRONES

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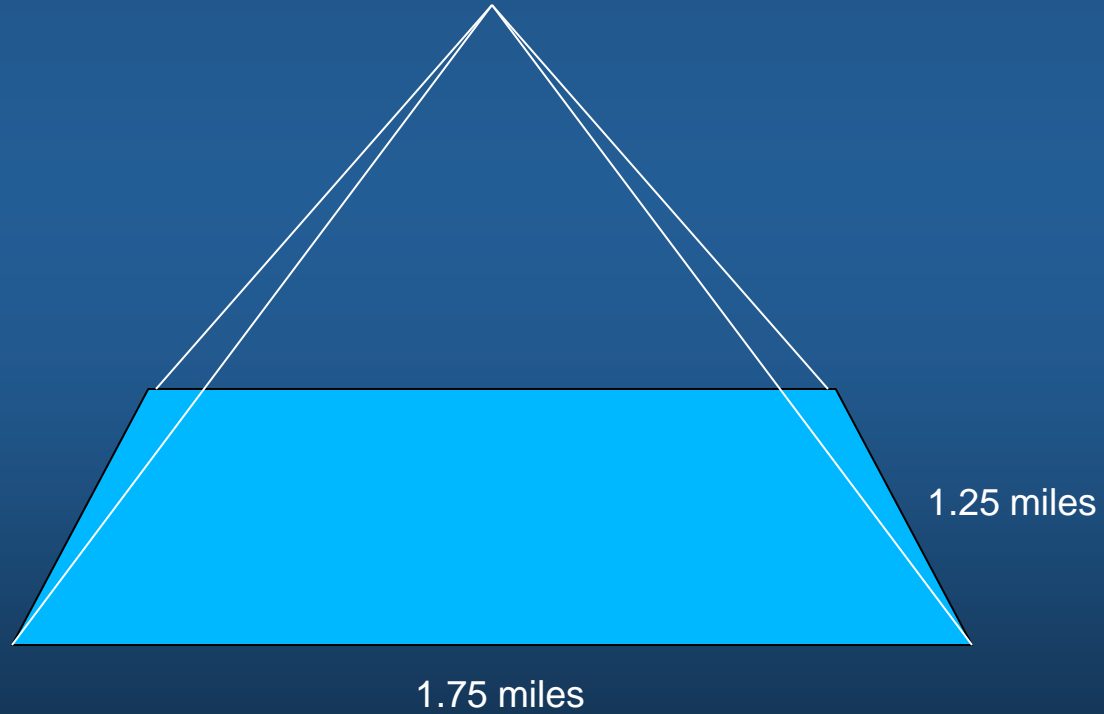
MANNED DRONES

(a.k.a. helicopters hovering in place at high altitudes)

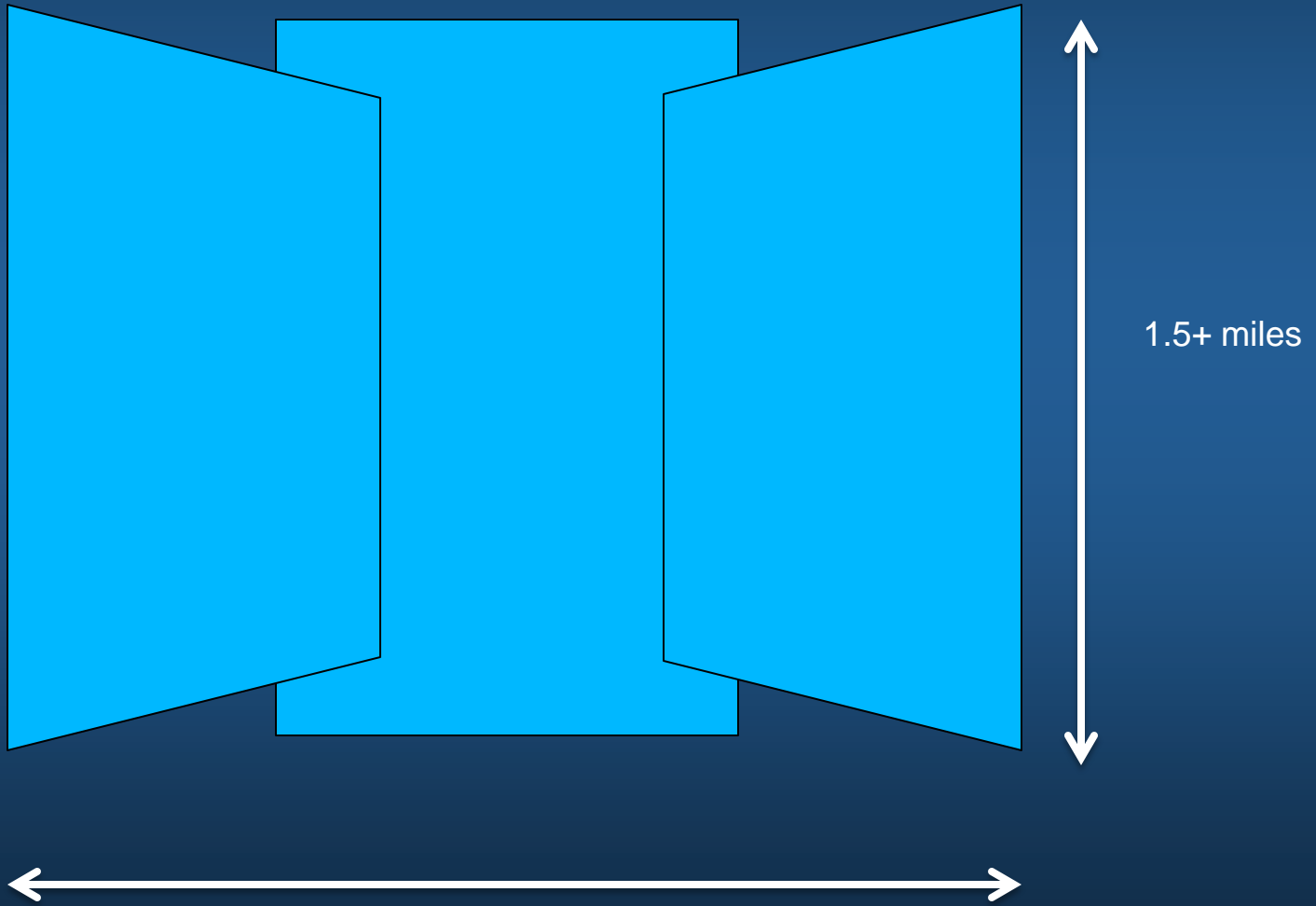


(Robinson R-44)

1-camera configuration
(from one mile high)

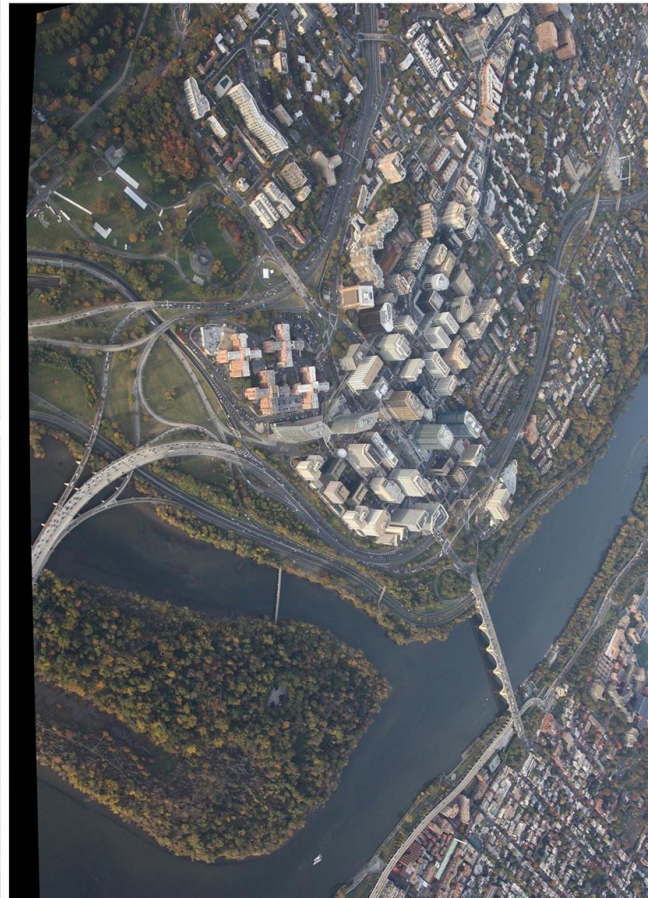


3-camera
(area) configuration



3.5+ miles

1.5+ miles





(MWC0G)



EXAMPLE SET 1

Trust Big Data...

but verify!

I-95 APPROACH CORRIDOR TO GWB SPAN



Fort Lee

5669 ft

Google earth

(TLAP survey conducted for PANY&NJ)

ACCESS POINTS (ORIGINS) TO GWB SPAN



Fort Lee

Google earth

(TLAP survey conducted for PANY&NJ)



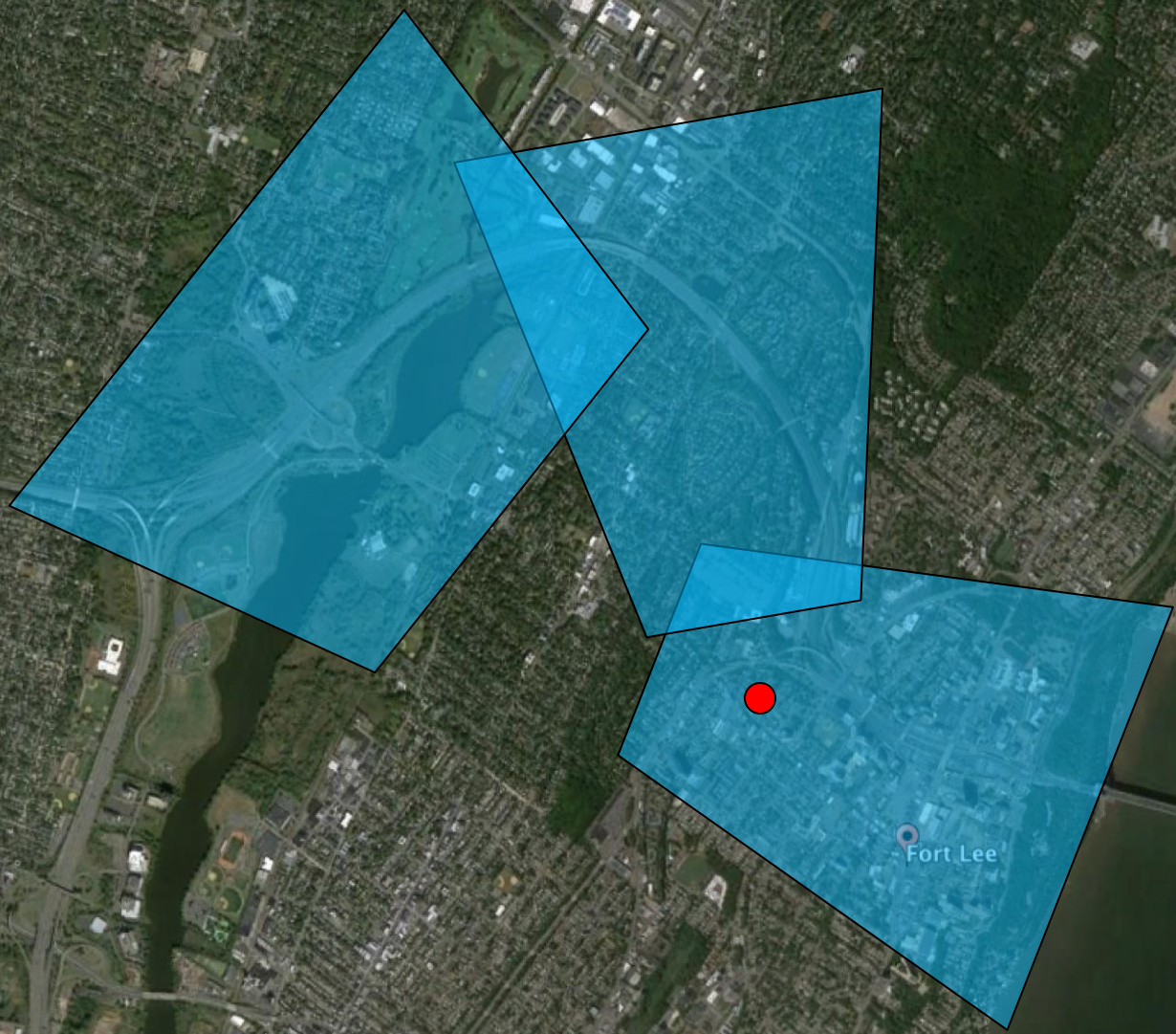
HOVER POSITION AND CAMERA #1 COVERAGE ZONE



Fort Lee

Google earth

ALL THREE CAMERA COVERAGE ZONES



5669 ft

Fort Lee

Google earth

Tour Guide 1995

Imagery Date: 9/6/2015 lat 40.863461° lon -73.973886° elev. 241 ft eye alt 24384 ft

(TLAP survey conducted for PANY&NJ)

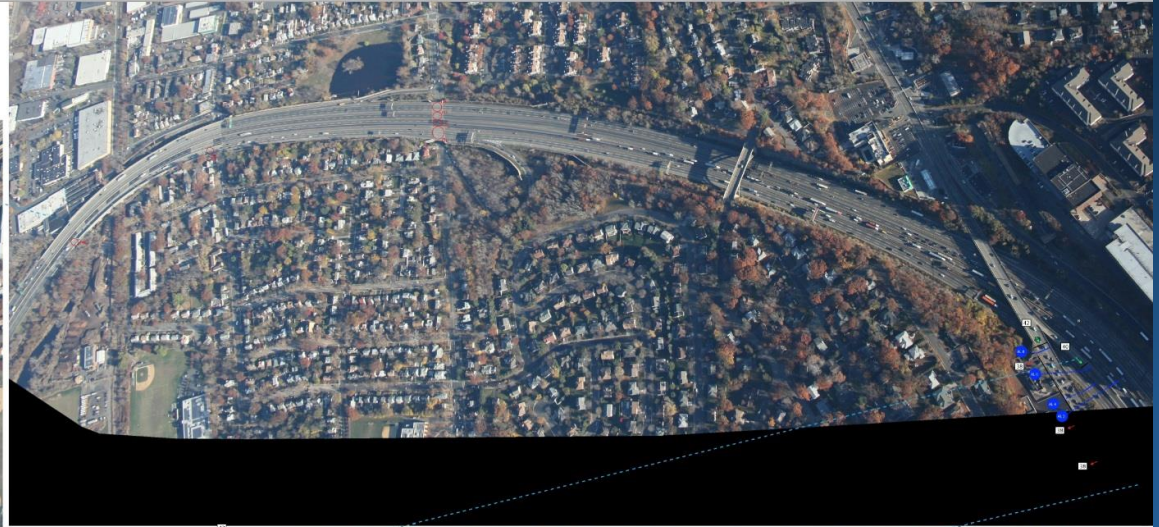


SINGLE PHOTO BOARD, AT ONE INSTANT OF TIME

PHOTOBOARD WITH OVERLAY
NJ approaches to the George Washington Bridge / Version 1.0
November 19, 2014; Period: 7:00 to 9:00 a.m.



Prepared by Skycomp in association with Robinson Aerial Surveys for the Port Authority of NY & NJ



(TLAP survey conducted for PANY&NJ)



OUTCOME OF TRAJECTORY TRACING

(% OF GWB EASTBOUND TRAFFIC)

I-80
13%

I-95
16%

Degraw
1%

US 46
9%

Fletcher
8%

NJ 4
18%

Palisades Pky
17%

Fort Lee
Main Plaza
ramps 17%

5669 ft

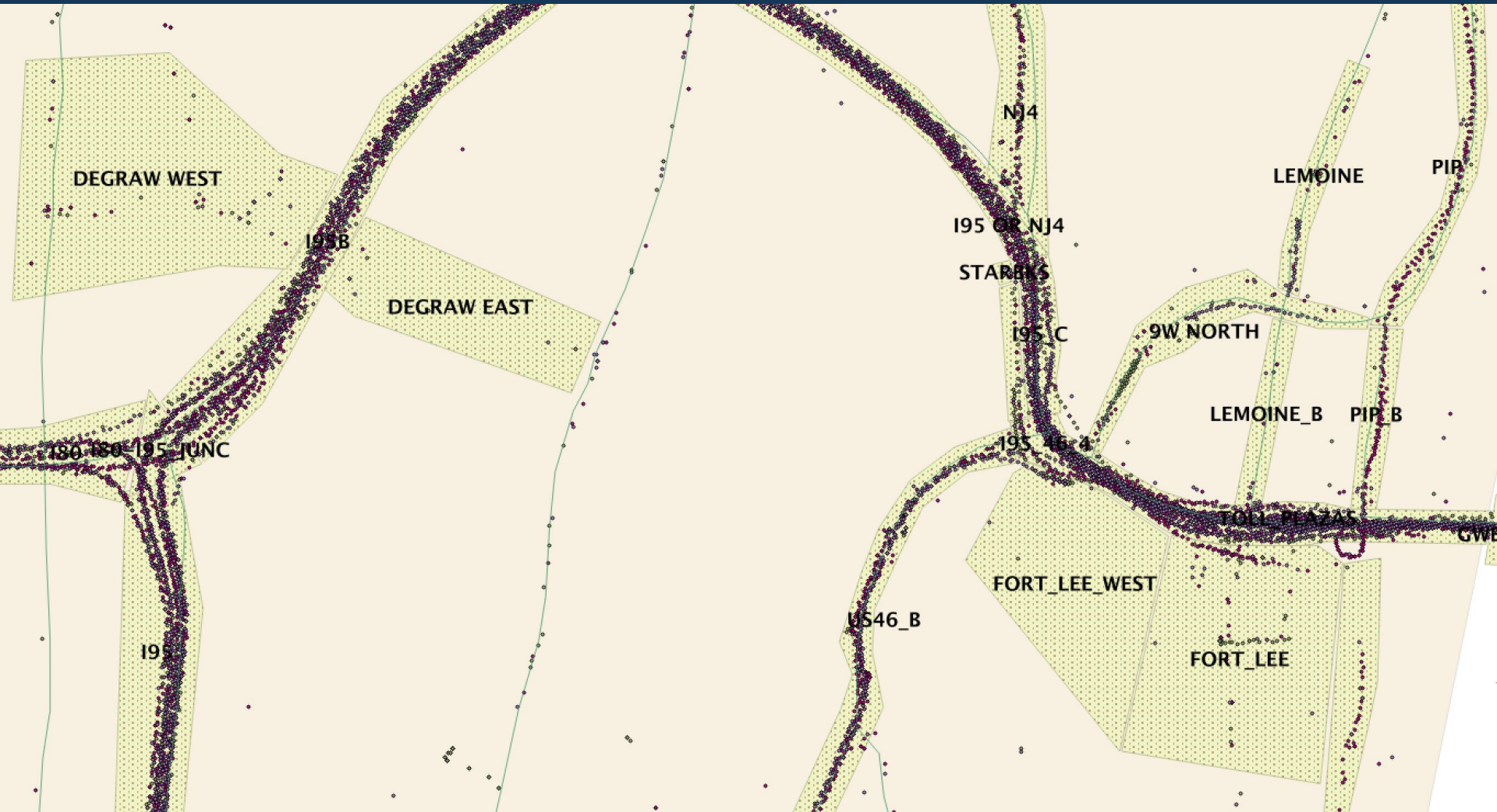
Google earth

Imagery Date: 9/6/2015 lat 40.863461° lon -73.973886° elev. 241 ft eye alt 24384 ft

(TLAP survey conducted for PANY&NJ)



EARLY DRAFT ZONES FOR PING SEQUENCING



(demo performed for PANY&NJ)

FINAL ZONES FOR PING SEQUENCING



(demo performed for PANY&NJ)

SAMPLE ZONE SEQUENCES OF SPECIFIC VEHICLES FROM NJ 4

NJ4 I95_4_NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_4_NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_4_NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_4_NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_4_NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_4_NJ4 I95_5_NJ4 I95_6_46 SPAN
NJ4 I95_4_NJ4 I95_5_NJ4 I95_7_9W I95_5_NJ4 I95_6_46 I95_7_9W I95_8 SPAN
NJ4 I95_4_NJ4 I95_6_46 I95_7_9W I95_8 SPAN
NJ4 I95_4_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_4_NJ4 I95_8 I95_6_46 I95_7_9W I95_8 SPAN
NJ4 I95_4_NJ4 SPAN
NJ4 I95_5_NJ4 I95_6_46 I95_7_9W I95_8 SPAN
NJ4 I95_5_NJ4 I95_6_46 I95_7_9W I95_8 SPAN
NJ4 I95_5_NJ4 I95_6_46 I95_7_9W I95_8 SPAN
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NJ4 I95_5_NJ4 I95_6_46 I95_8 I95_6_46 I95_7_9W I95_8 SPAN
NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_5_NJ4 I95_6_46 I95_8 SPAN
NJ4 I95_5_NJ4 I95_6_46 TOLL I95_7_9W SPAN

REVIEW: TLAP-ONLY ORIGIN PERCENTAGES

APPROACH	TLAP
PALISADES PKY	17.0%
MAIN PLAZA RAMPS	17.0%
FLETCHER / 9W	8.0%
US 46	9.0%
NJ 4	18.0%
DEGRAW AVE	1.0%
I-80	13.0%
I-95	16.0%

TLAP data derived from survey on Nov. 19, 2014, 7:00 to 9:00 a.m.

(Typical day; no incidents; normal toll plaza volumes)

TLAP VS. INRIX “TRIPS” ORIGIN PERCENTAGES

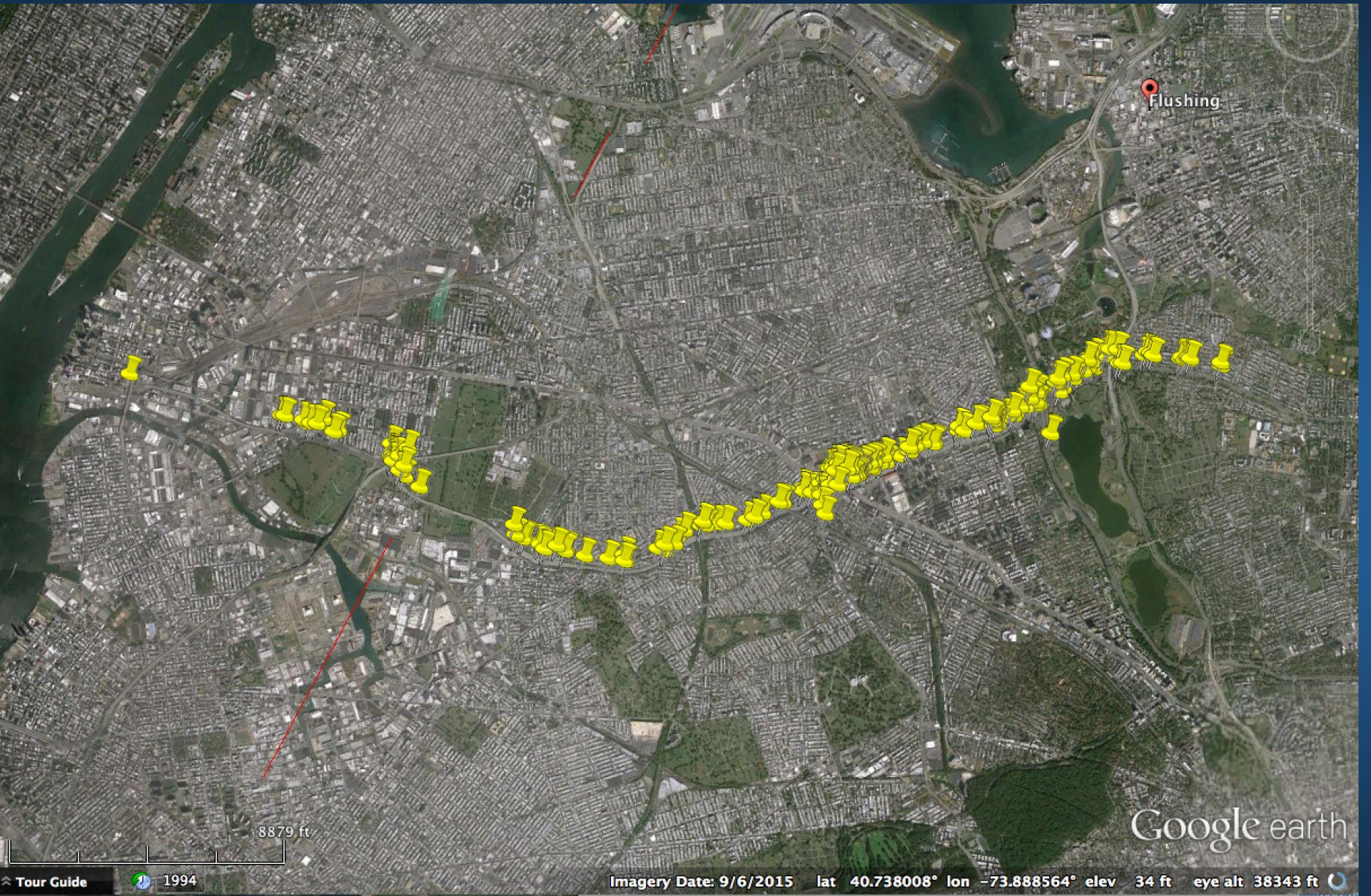
APPROACH	TLAP	INRIX
PALISADES PKY	17.0%	16.4%
MAIN PLAZA RAMPS	17.0%	20.1%
FLETCHER / 9W	8.0%	6.4%
US 46	9.0%	8.1%
NJ 4	18.0%	19.5%
DEGRAW AVE	1.0%	0.8%
I-80	13.0%	11.6%
I-95	16.0%	17.3%

INRIX data derived from 3 weeks, Mon-Fri only, Sept. 8-26, 2014, 6:30 to 9:30 a.m.

EXAMPLE SET 2

Capture many different metrics,
even from scattered sites,
all at the same time:

LIE MANAGED USE LANES STUDY (QUEENS, NY)



(Parsons Brinckerhoff / NYSDOT)

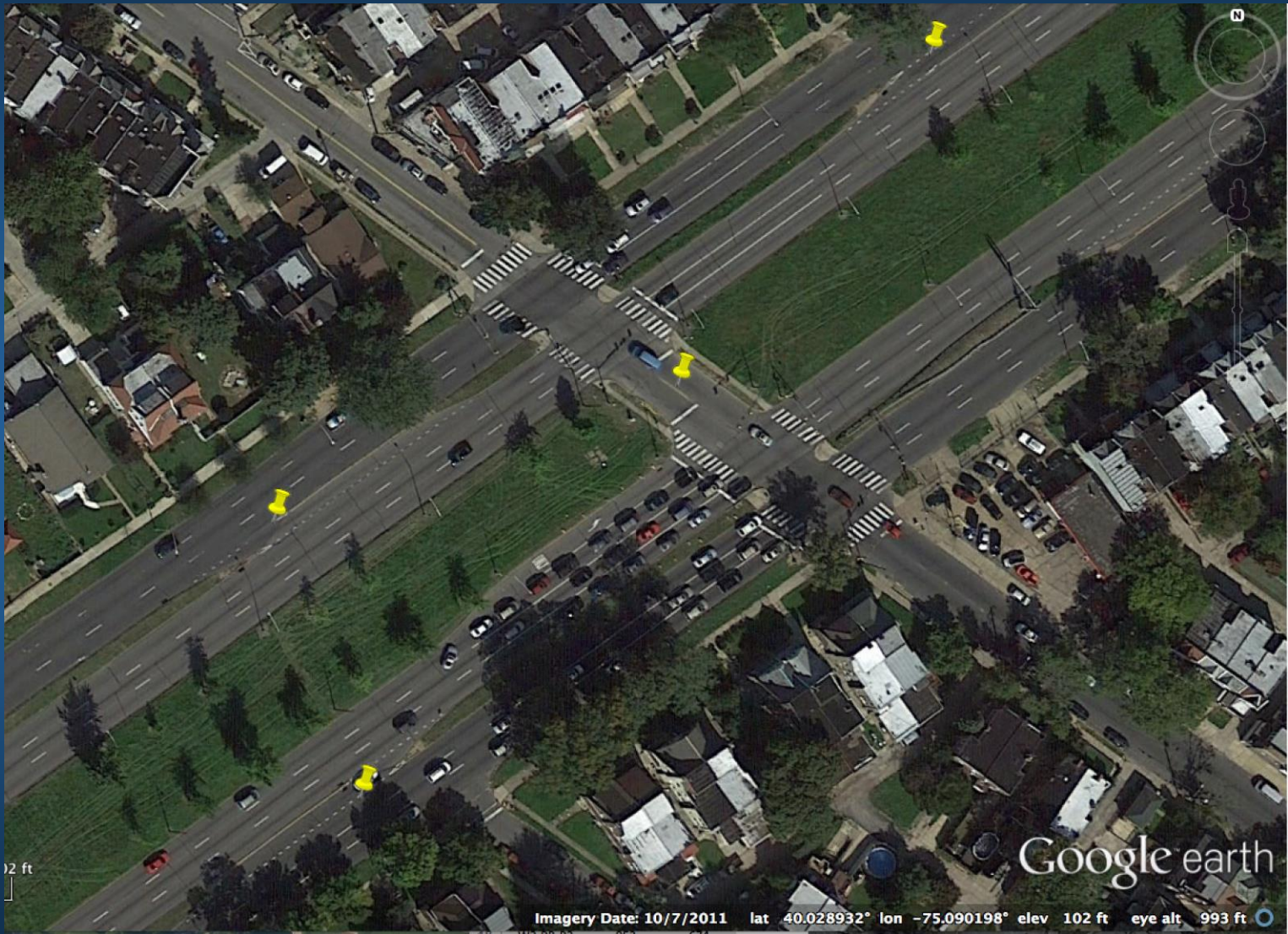
LIE MANAGED USE LANES STUDY (QUEENS, NY)



WISDOT PARAMICS MODEL, MADISON, WI



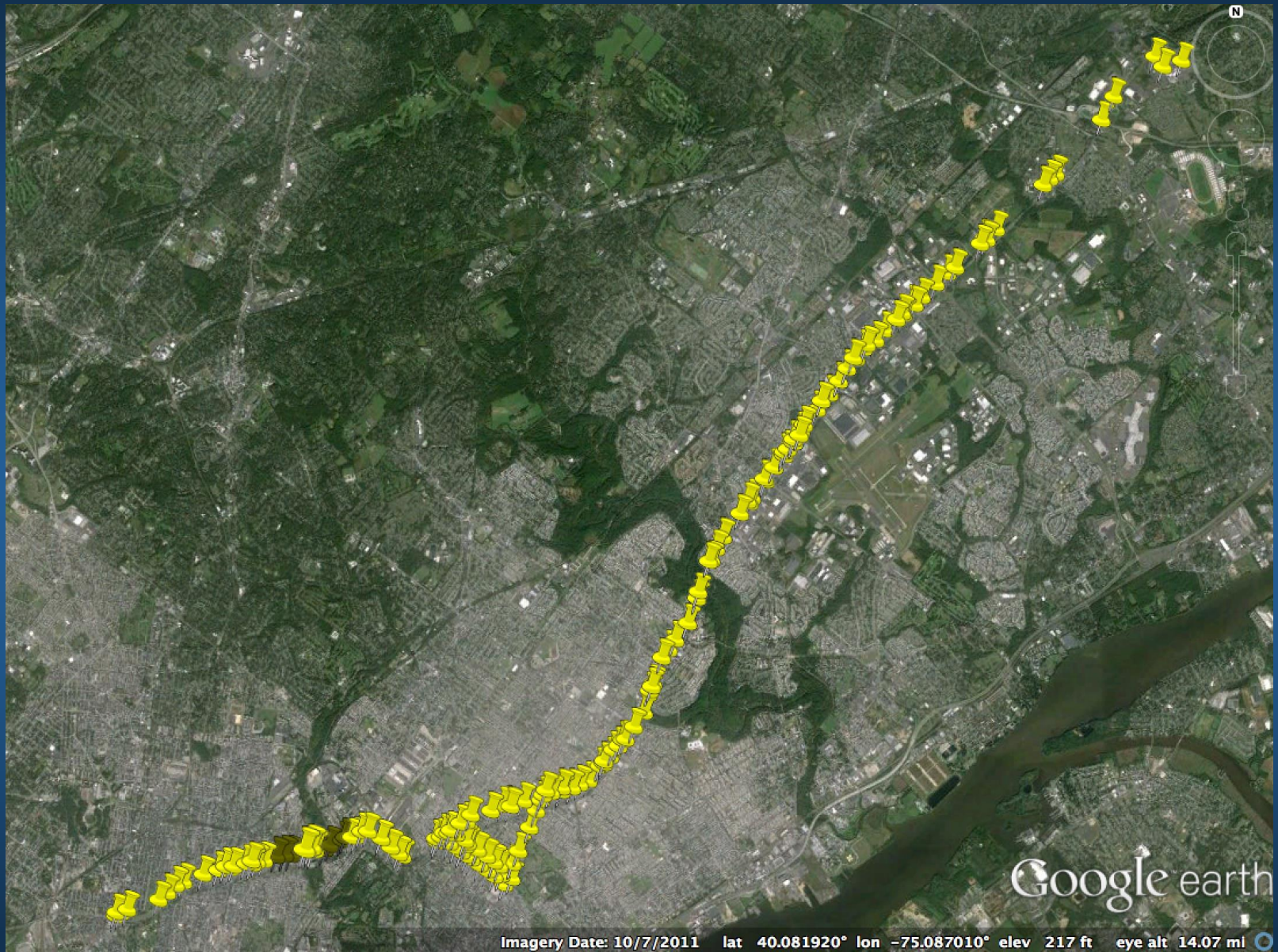
(model built by Strand Assoc.)



(HNTB / Urban Eng.)



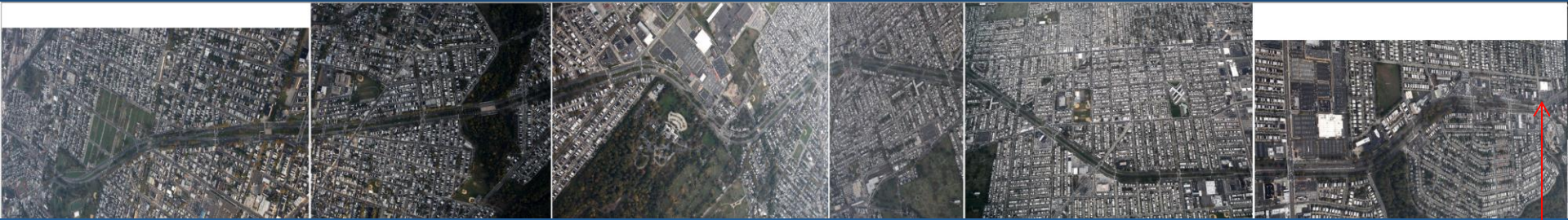
Roosevelt Blvd: 150 TMC's and slip ramp volumes



(HNTB / Urban Eng.)

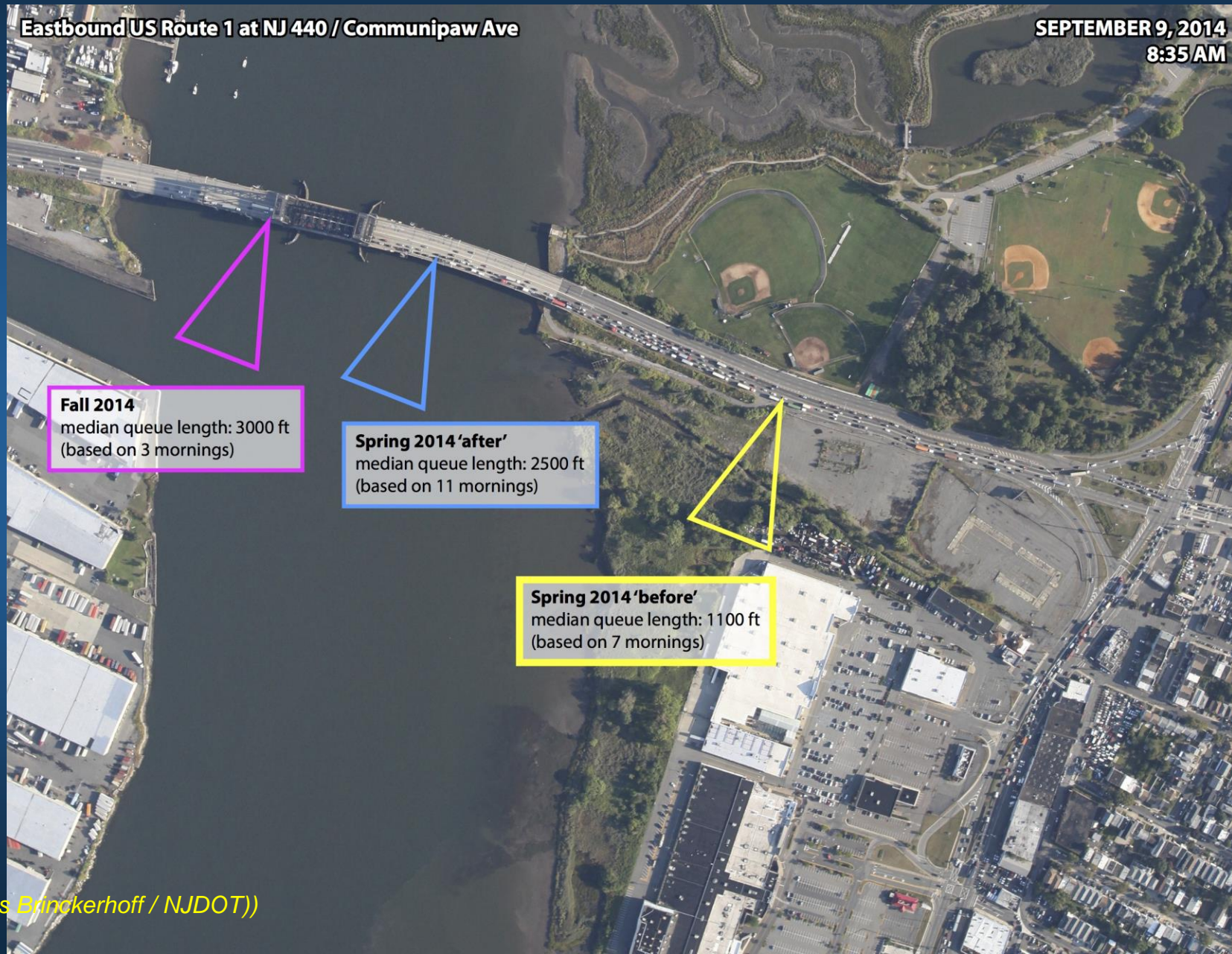
14 highway miles: four spaced, stationary helicopters;
overlapping photos every second for 90 minutes

(South end / N. Broad St)



(North end / Neshaminy Mall)

Sample time-lapse queue graphic (Jersey City, NJ)



BENEFITS

Pre-balanced metrics – many types at once – fit together

Get more later if needed

Verifiable

Produce visuals (videos)

Get real O-D patterns with route choices

Vehicle classes

Safety (minimal or no exposure of ground workers to traffic)

CONSTRAINTS

On-station duration 90-120 minutes (tag-team for longer periods)

Spatial and temporal coverages limited

Requires good visibility (must have back-up dates)

Still want to try a micro-drone survey?
(we might even be taking the plunge soon...)

FOR APPLICATIONS TECHNICALLY ALLOWED TODAY:

1. Get explicit permission from agency / client.
2. Get agency COA or commercial permit (333) from FAA.
3. Be sure your contractor has insurance & follows FAA rules (licensed pilot; not from moving vehicle; see-and-avoid, etc.).
4. Get property owner permission for operations base.
5. Do not operate directly over people.



Greg Jordan

jordan@skycomp.com

410-707-7479



(This day-by-day analysis isolates four days that were part of the 15 weekday average (NOV) on the right)

	Thu Nov 13	Wed Nov 12	Incident?		M-Thurs 4-day median INRIX	Excl. Tue 3-day median INRIX	15-day avg	15-day avg	1 typ. day
			Tue Nov 11	Mon Nov 10			NOV INRIX	SEPT INRIX	NOV 19 TLAP
PIP	21.4%	16.4%	22.4%	18.7%	19.9%	18.7%	19.1%	16.4%	17.0%
M WASH / CTR	21.1%	23.6%	13.3%	24.4%	21.6%	23.6%	21.4%	20.1%	17.0%
FLETCHER	6.3%	6.6%	4.9%	6.6%	6.2%	6.6%	6.9%	6.4%	8.0%
US 46	7.3%	6.8%	7.9%	8.5%	7.8%	7.3%	7.2%	8.1%	9.0%
NJ 4/STAR	18.2%	19.6%	18.2%	16.6%	18.2%	18.2%	18.0%	19.5%	18.0%
DEGRAW	1.1%	1.1%	0.3%	0.3%	0.8%	1.1%	0.6%	0.8%	1.0%
I80	9.5%	9.8%	12.7%	8.3%	9.3%	9.5%	9.8%	11.6%	13.0%
I95	15.2%	16.0%	20.2%	16.5%	16.2%	16.0%	16.9%	17.3%	16.0%
OTHER	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	

INRIX source:

Weekdays (M-F) for 3 weeks in Sept. 2014 (8th thru 26th)

Weekdays (M-F) for 3 weeks in Nov 2014 (3rd thru 21st)

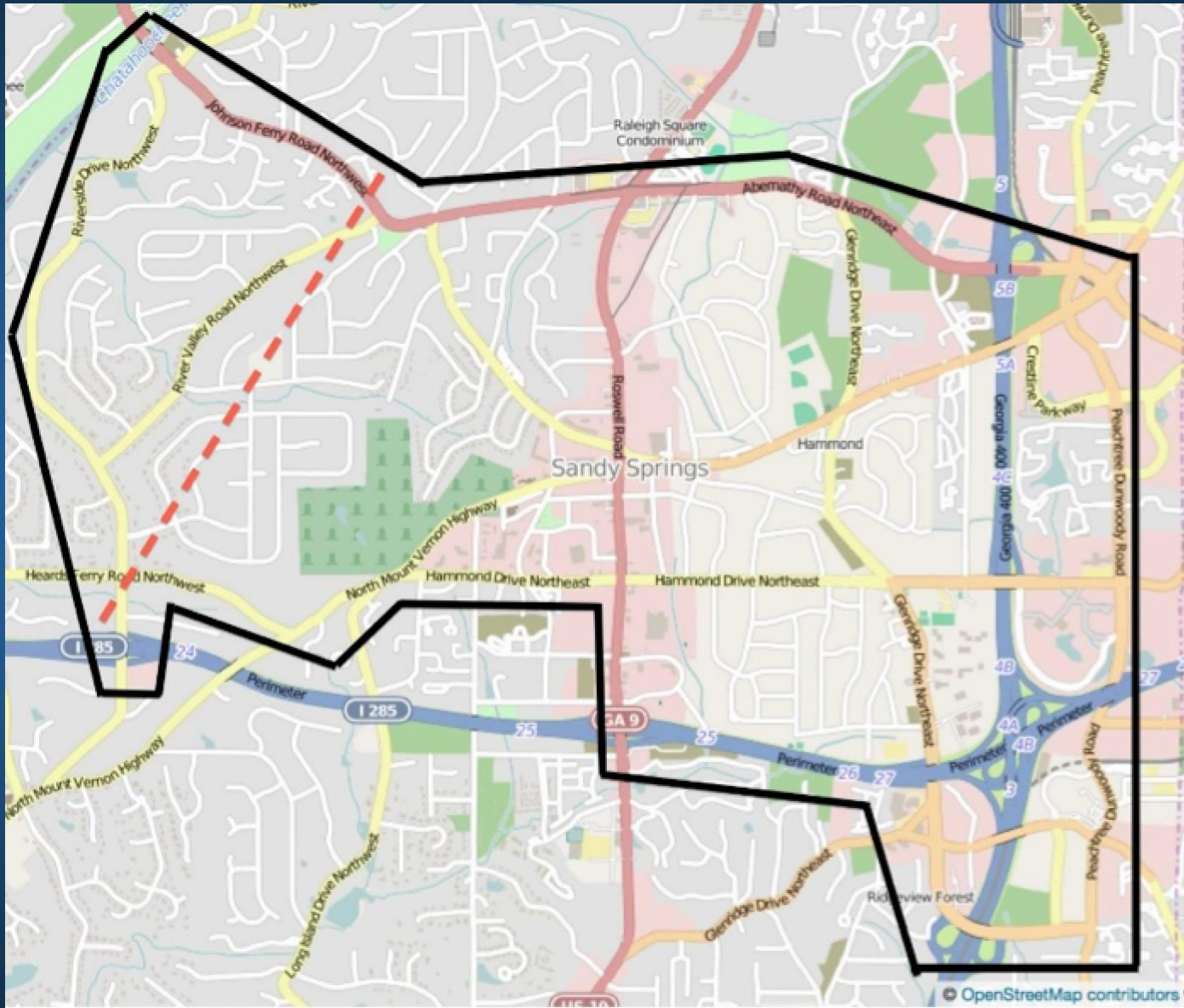
crossing GWB between 6:30 and 9:30 a.m.

TLAP source:

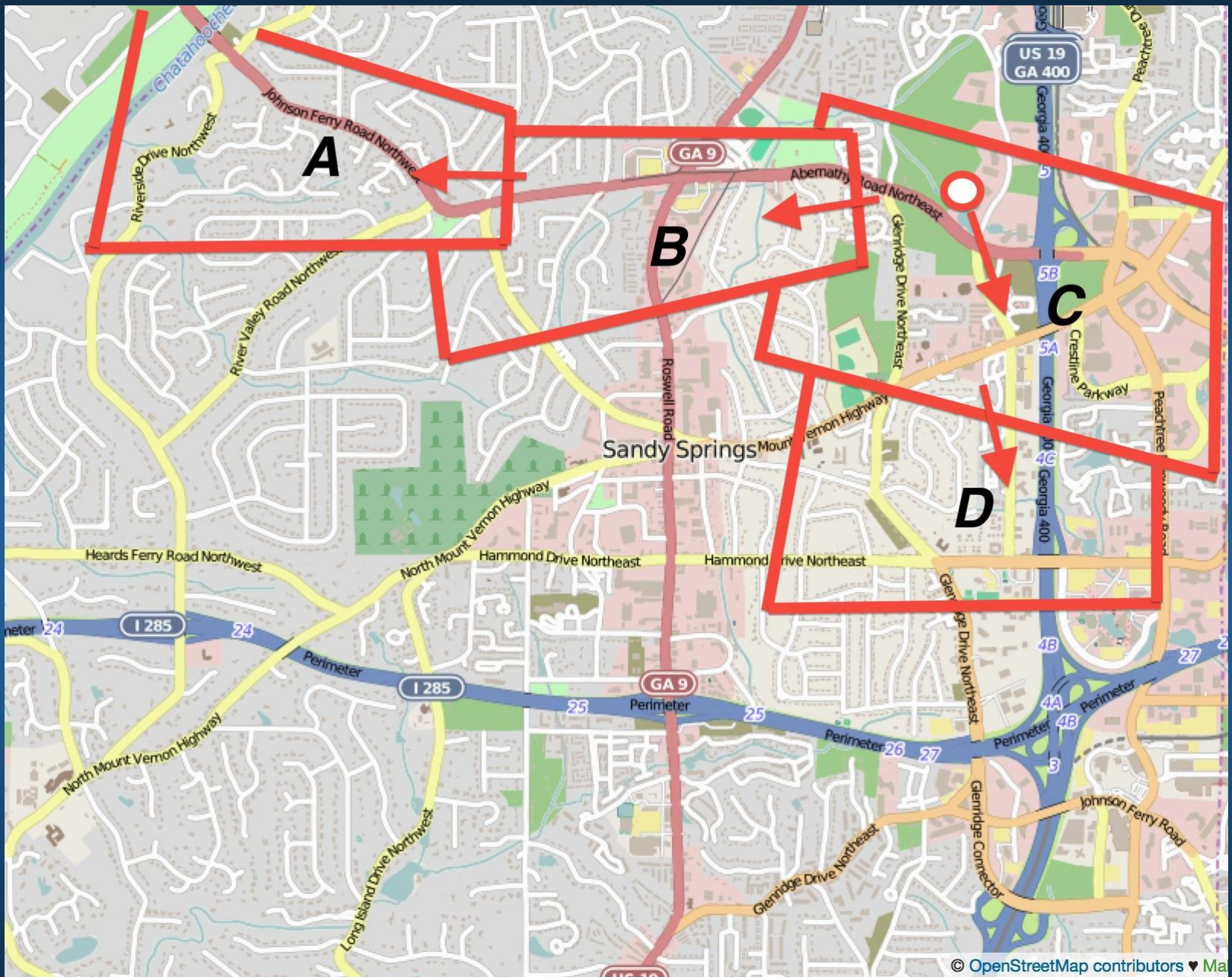
Nov. 19, 2014, 7-9 a.m.

(Analysis by Skycomp)

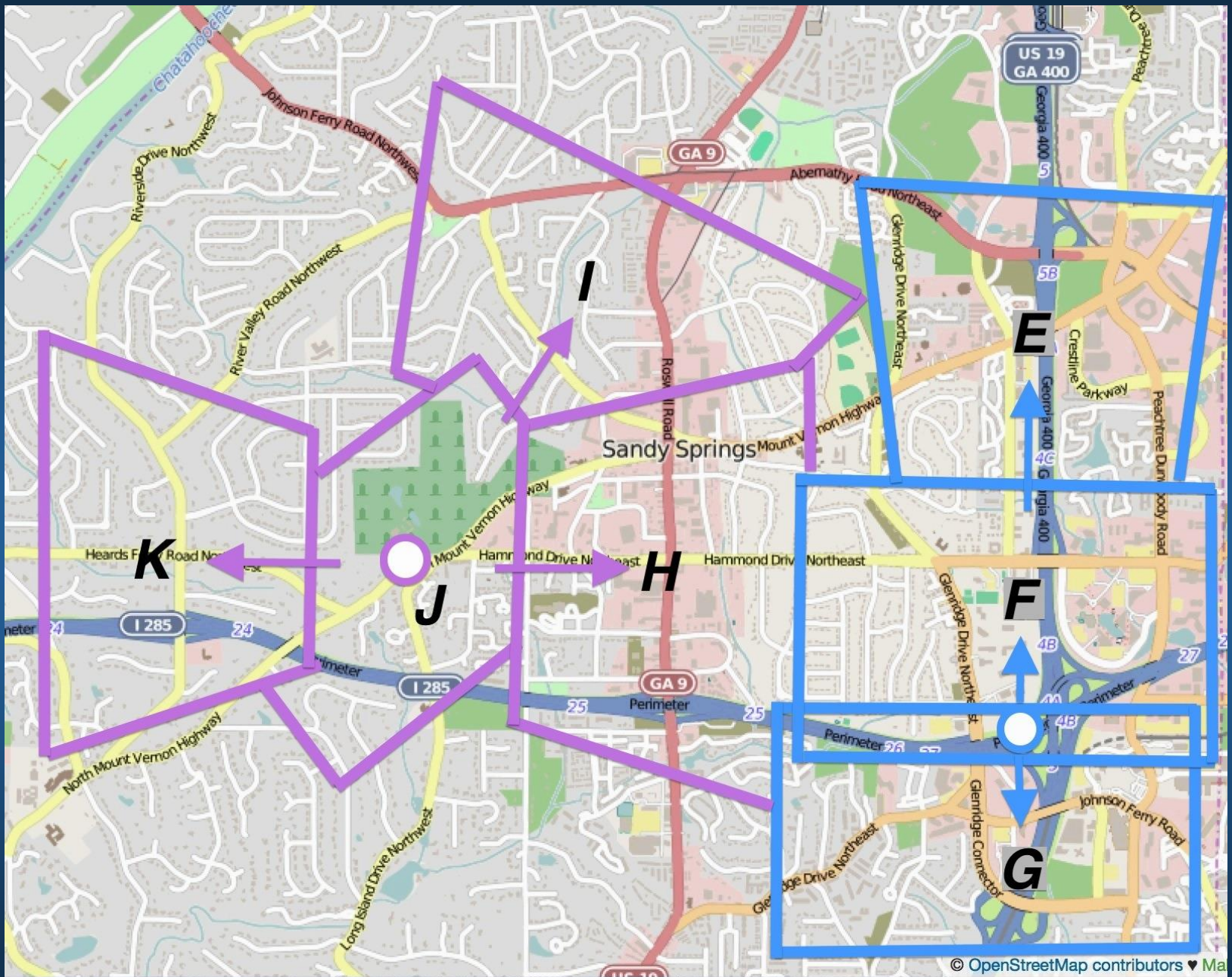
Needed: peak-period, city-wide travel time, queuing, delay, route and OD metrics



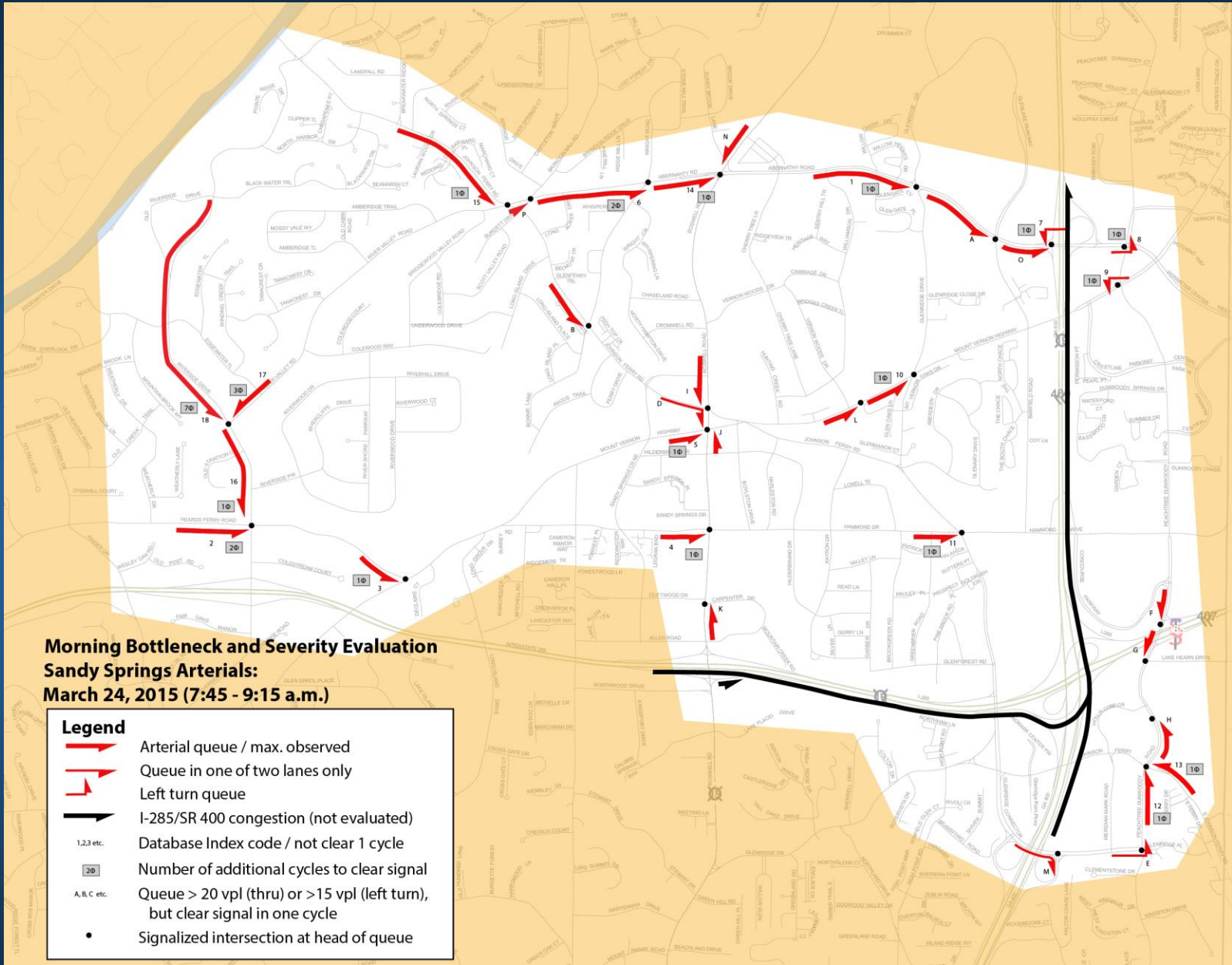
(Direct contract – City of Sandy Springs, GA)



(Direct contract – City of Sandy Springs, GA)








(Direct contract – City of Sandy Springs, GA)

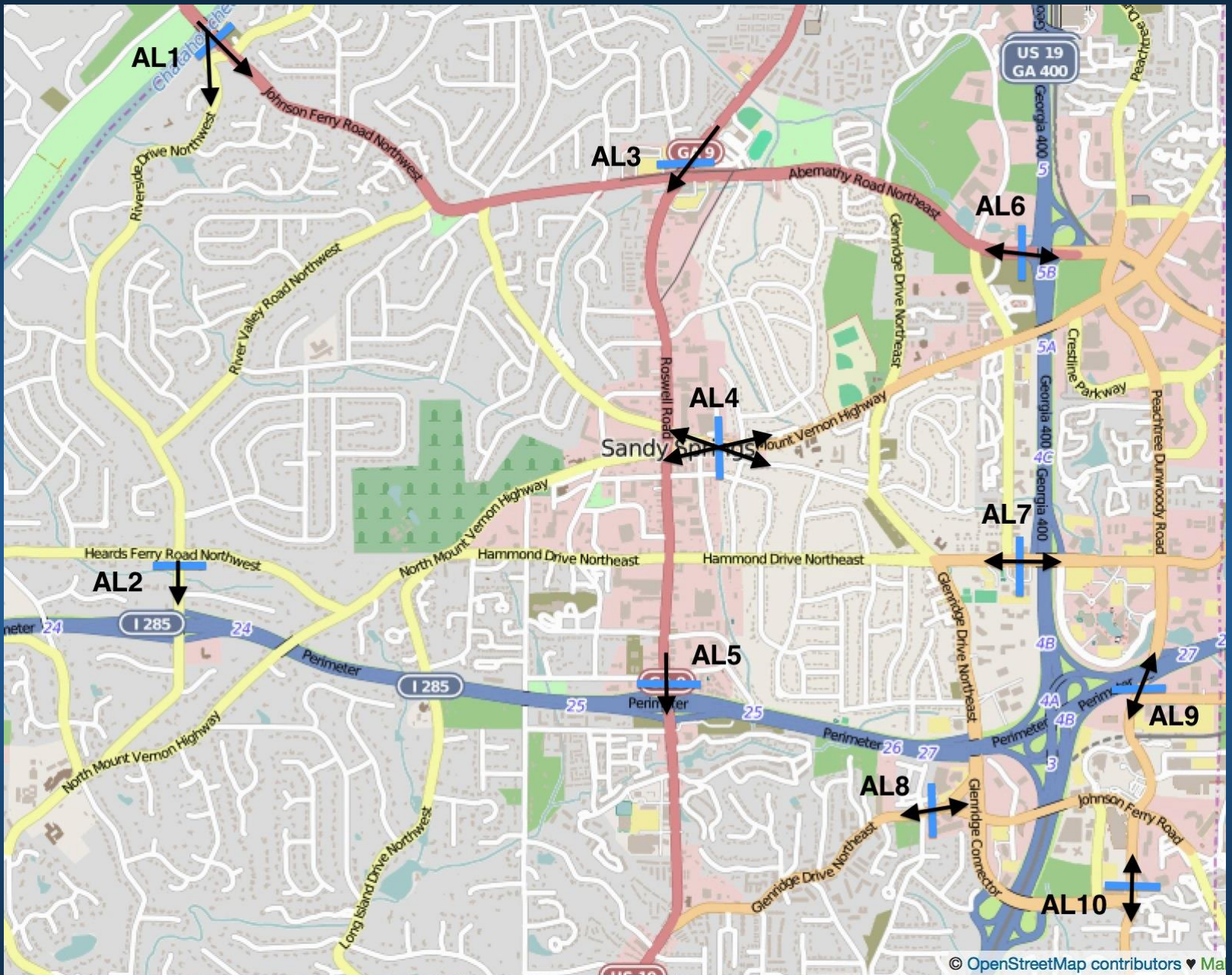


(Direct contract – City of Sandy Springs, GA)

**Evening Bottleneck and Severity Evaluation
Sandy Springs Arterials:
March 24, 2015 (4:45 - 6:15 p.m.)**

Legend

-  Arterial queue / max. observed
-  Queue in one of two lanes only
-  Left turn queue
-  I-285/SR 400 congestion (not evaluated)
- 1,2,3 etc. Database Index code / not clear 1 cycle
-  Number of additional cycles to clear signal
- A, B, C etc. Queue > 20 vpl (thru) or >15 vpl (left turn), but clear signal in one cycle
- Signalized intersection at head of queue

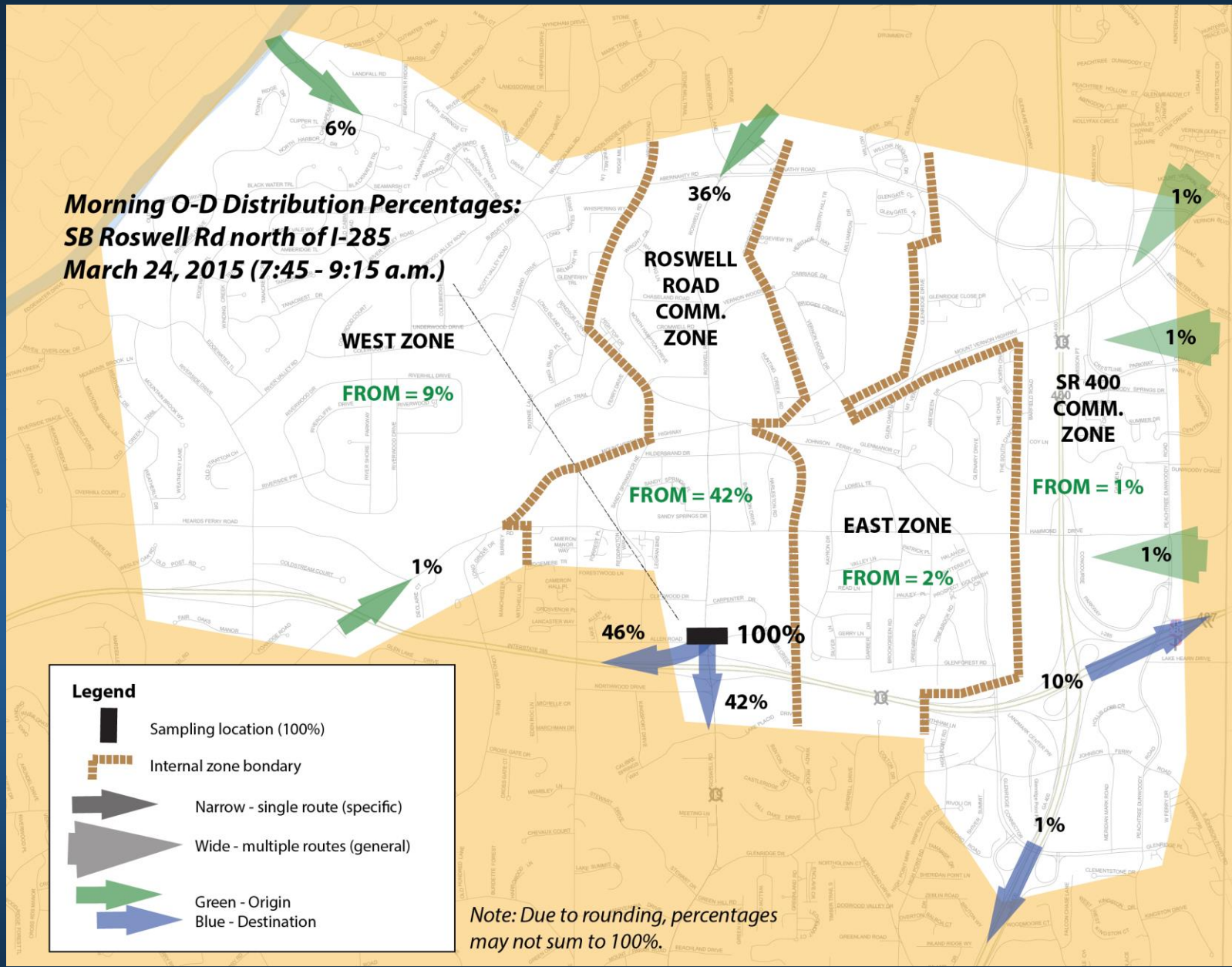


© OpenStreetMap contributors ♥ Ma

(Direct contract – City of Sandy Springs, GA)

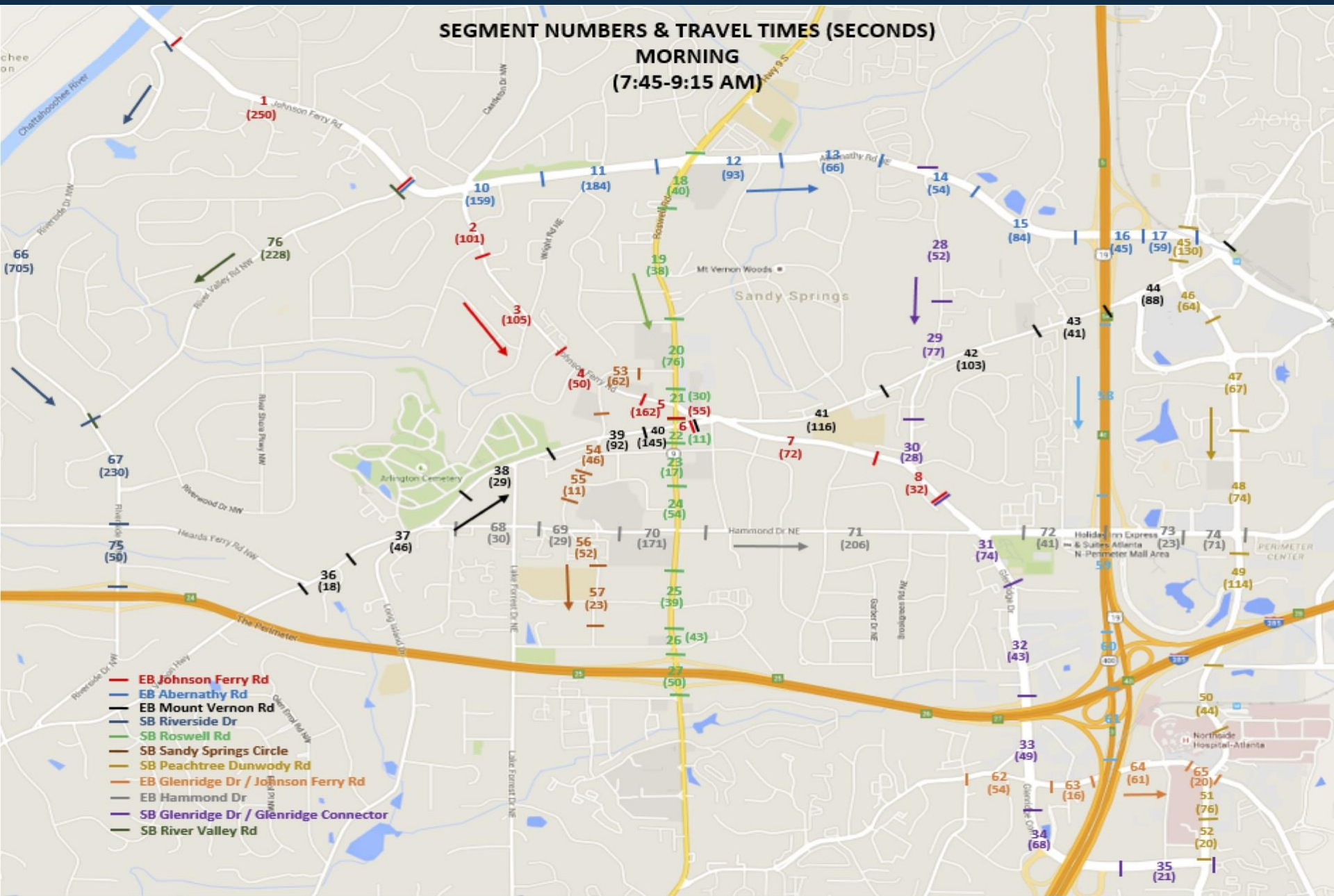


**Morning O-D Distribution Percentages:
SB Roswell Rd north of I-285
March 24, 2015 (7:45 - 9:15 a.m.)**



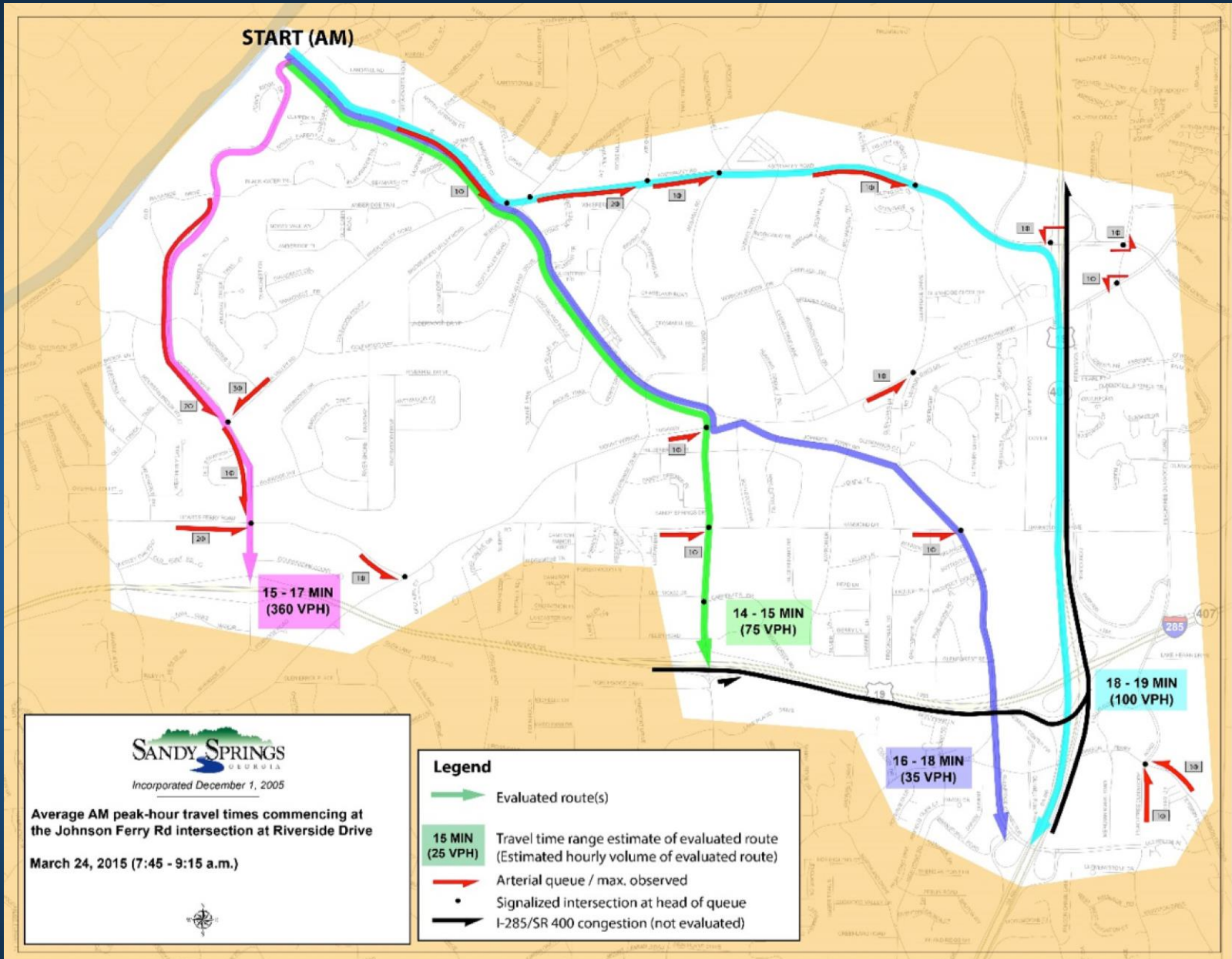
SEGMENT NUMBERS & TRAVEL TIMES (SECONDS)

MORNING (7:45-9:15 AM)



(Direct contract – City of Sandy Springs, GA)





(Direct contract – City of Sandy Springs, GA)