T&E COMMITTEE #3
December 7, 2015

MEMORANDUM

December 3, 2015

TO: Transportation, Infrastructure, Energy and Environment (T&E) Committee

FROM: Glenn Orlin, Deputy Council Administrator

SUBJECT: Planning for Adaptive Signal Control Technology (ASCT)

During the spring of 2014 the T&E Committee recommended—and the Council ultimately approved—$480,000 above the Executive's Recommended FY15 Operating Budget to conduct a study to develop a state-of-the-art signal system that would automatically adapt to changing traffic conditions in real time. That study was estimated to take 16 months to complete. The Department of Transportation (DOT) engaged Jacobs Engineering to evaluate the feasibility of implementing Adaptive Signal Control Technology (ASCT), and that work is now complete. The consultant contract produced several technical reports; an Executive Summary encapsulating the basic conclusions is attached (©1-5).

The objective is ASCT is to better maximize flow through an intersection to the point where it is much closer to the intersection's theoretical capacity. National studies indicate that ASCT systems can improve travel time by 10-15% over conventional signal control timing. The improvement would be experienced when an intersection is operating close to capacity, such as at Level of Service E. However, if an intersection is operating at well over capacity—well into the Level of Service F range—ASCT is likely to have little or no effect.

The report recommends testing two particular ASCT commercial products: Siemens' SCOOT and Kimley Horn's Kadence. As recommended by Jacobs, the next step would be to test them as part of a pilot on **Montrose Road/Montrose Parkway** between I-270 and Rockville Pike in North Bethesda (©6), at a cost of about $1 million. Assuming a successful pilot, Jacobs suggests rolling out ASCT in four other areas, at a total cost of about $9 million:

Democracy Boulevard: actually, the entire Rock Spring Park/Montgomery Mall area (©7);
Shady Grove Road between Key West Avenue and Oakmont Avenue (©8);
Frederick Road/Hungerford Drive (MD 355) between Richard Montgomery Drive/Dodge Street and South Westland Drive, north of I-370 (©9); and
The Wheaton Triangle: the Wheaton CBD plus University Boulevard west of the CBD (©10).

Jacobs reports that 9 traffic engineers, operators, and technicians will be needed to staff ASCT, at an annual cost of about $570,000. In addition, each installation will incur operating expenses for maintenance and warrantee support, replacement of hardware, etc. Therefore, the Montrose Road/Parkway pilot segment would require an additional $120,000 for operating expenses, for a total of $690,000. When ASCT is implemented in the Democracy Boulevard area, the annual recurring cost would be raised by about $100,000, to $790,000. The chart on ©2 shows the estimated incremental annual recurring cost for each segment added.

Jacobs suggested seven other zones as the next highest priority:

Old Georgetown Road (MD 187) between Beech Avenue (south of I-495) and Rockville Pike (MD 355) in White Flint;
Georgia Avenue (MD 97) between Norbeck Road (MD 28) to Olney-Laytonsville Road (MD 108);
Seven Locks Road between Montrose Road and River Road (MD 190);
Randolph Road between Georgia Avenue (MD 97) and US 29;
Olney-Laytonsville Road (MD 108) between Bowie Mill Road and Doctor Bird Road;
Darnestown Road "East" between Muddy Branch Road and Glen Mill Road; and
Darnestown Road "West" between Riffleford Road and Main Street (the Quince Orchard area)

The County Executive, of course, has not yet made a recommendation; he will have that opportunity either as part of the upcoming Capital Improvements Program or Operating Budget.

Acting DOT Director Al Roshdieh and Acting Chief of Traffic Engineering and Operations Fred Lees will introduce the subject. Dieterich VanDillen of Jacobs Engineering will conduct the briefing.

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Montgomery County, Maryland
Adaptive Signal Control Technology

Executive Summary

Jacobs Engineering
Jeffrey Randall, PE, PTOE
Diederick VanDillen, PMP

October 16, 2015

Introduction

The County has expressed interest in exploring Adaptive Signal Control Technology (ASCT) as a means to more effectively manage traffic. Adaptive control is a form of traffic signal operation in which phase times of a signal system are continuously adjusted to optimize an objective function (progression, throughput, stops, delays, operating cost, emissions, etc.).

In April 2014 Jacobs Engineering developed a white paper on ASCT describing what it is, its history, background, potential benefits, and implementation related issues. In July 2014 the County decided to pursue the preliminary engineering steps necessary to plan, evaluate and ultimately deploy ASCT in the County. This paper is a summary of the resulting engineering effort and recommendations for ASCT deployment.

Summary Recommendations

Proven commercial-off-the-shelf (COTS) ASCT solutions were investigated for use within the County Advanced Traffic Management System (ATMS) / Traffic Signal System (TSS) environment. Of the 14 systems evaluated only two (2), Siemens SCOOT (Split, Cycle, Offset Optimization Technique) and Kimley-Horn (KHA) Kadence, offered the best compatibility with the County's current traffic control infrastructure environment while providing the needed capability. These two systems were then evaluated against the desired ASCT operational and performance requirements. Both systems scored high enough to be recommended for further evaluation as part of a Phase 1 (Pilot) deployment where they can be tested in actual field conditions. The Phase 1 Pilot will help determine the following:

- Operational verification of each system. While SCOOT is a mature system that has been widely deployed, the County's use of the Econolite ASC/3 state-supplied traffic signal controller requires use of specialized field interface hardware to adapt the controller to the SCOOT environment. This interface hardware is still under development/testing with a planned availability in early 2016. The Kadence system is a relatively new product with only a few small installations. Testing will help validate operational compatibility with the County environment.

- Comparison of measured operational benefits vs. cost of each system to help determine final solution. While SCOOT appears to be the more capable system, it may also be the more costly solution primarily due to detection requirements, and its ease of understandability and usability needs further evaluation. Kadence complies with North American traffic control terminology and standards; however, its optimization performance and ability to handle complex roadway network configurations needs closer examination. Testing will allow actual data collection and analysis, while also evaluating subtleties of usability.
- Evaluate different vehicle detection technologies and layouts against the needs and performance of each system. The added vehicle detection required to support ASCT is estimated to account for over 60% of the total installation cost. SCOOT has more stringent detection performance requirements which could result in higher costs. Maryland State Highway Administration (MDSHA) policy of using non-intrusive (no in pavement) vehicle detection also has the potential of driving this cost higher. Testing and evaluating different technologies will help ensure that the appropriate ASCT and detector technology solution is being considered for subsequent deployments.

As many as 300 intersections along the County's 200 miles of critical roadway have been initially identified for possible application of ASCT at a total estimated cost of $28.3M. Further expansion up to and including support for all County intersections may be possible depending upon results of the initial deployments. An initial phased deployment schedule as shown below is recommended. The Phase 1 pilot would be used to validate the performance benefits and select the system and all supporting elements going forward. A revised cost estimate and deployment plan would also be developed with results from Phase 1 testing. Phases 2-5 were selected and prioritized based on providing ever increasing traffic operational challenges.

Corridor	Install Cost[1]	Annual Recurring Cost[2]
Montrose Rd./Pkwy. (Pilot)	$ 1,000,000	$ 690,000
Democracy Blvd.	$ 2,200,000	$ 100,000
Shady Grove Rd.	$ 2,100,000	$ 90,000
MD 355 Frederick Rd.	$ 2,600,000	$ 70,000
Wheaton Triangle	$ 2,100,000	$ 80,000

(1) The estimated install cost including ASCT hardware & software, detection, CCTV and travel time hardware.

(2) This column shows the incremental annual recurring cost for each ASCT segment, including all additional County staffing costs.

ASCT is certainly not a "set it and forget it" technology. Additional staffing will be required to sustain an increased level of traffic signal management and operations performance. The following staffing increases are recommended.

- Traffic Engineer (2 additional) - The traffic engineer is expected to experience an increased workload due to ASCT monitoring, periodic parameter adjustments, and performance evaluation and reporting. Although these are automated systems they still require close support to ensure operations reflect the established performance objectives.

- TMC Operator (2 additional) – TMC operation is expected to transition from passive system monitoring to one of active involvement in day-to-day operation of the ASCT while still managing non-ASCT signals.
- TMC Supervisor (1 additional) – The TMC currently operates with one supervisor. A need for a second supervisor is expected to accommodate increased TMC workloads and possible shift in operational hours under ASCT control.
- Signal Technician (4 additional) – Increase workloads are due to additional intersection detection and equipment. The quantity of detection will increase by about 50% and the SCOOT system would also add additional cabinet hardware requiring maintenance attention. Four (4) additional signal technicians are needed to bring staff levels up to Federal Highway Administration (FHWA) standards (1 person per 40 intersections).

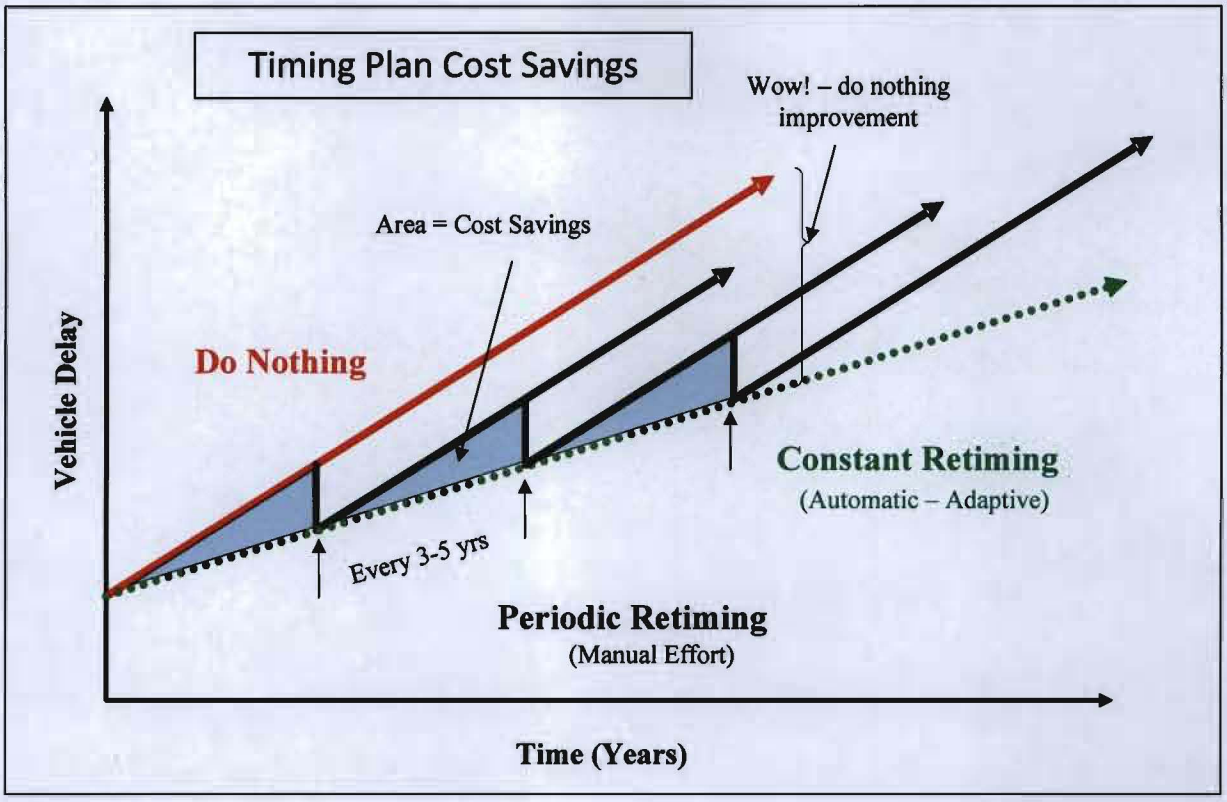
Background in Traffic Signal Control and ASCT

Adaptive control has been around since the 1970s, but its cost, complexity, and questionable benefits have historically limited its deployment to large scale city-wide installations, e.g. such as Los Angeles or Sydney Australia. However, in recent years, as a result of technical advances and efforts by the Federal Highway Administration (FHWA) to promote its use, more affordable systems have come on the market. All of the major signal control equipment manufacturers now offer some form of ASCT. These systems don't require municipalities to purchase the entire system as a package (i.e., computers, controllers, detectors, etc.) and they allow for incremental expansion. Further, adaptive systems can be installed on the County's existing controllers and use the existing communications infrastructure.

ASCT is not a panacea for all traffic control situations and is certainly not a "set it and forget it" technology. While it has demonstrated significant improvement in traffic flow efficiency and life-cycle cost improvements, it can't deliver what the arterials can't provide or constraints dictate. In other words, it will improve traffic in almost all conditions, but where demand exceeds the capacity of the arterial, its improvement, while there, will be limited. It has shown much benefit on the peak-period fringes – the one to two hours leading up to and following the peak period. Other considerations such as heavy pedestrian traffic and intersection geometric design may also constrain and limit its usefulness. A 2010 NCHRP synthesis report on Traffic Adaptive Control Systems State of the Practice indicated that adaptive systems can typically yield performance improvements of 10-15% over a well-maintained and timed conventional system. Performance improvements include reduced travel time, stops and delays; improved travel time reliability; improved average speeds, reduced fuel consumption and associated environmental impacts due to smoother traffic flow; and greater overall traffic throughput.

The variability and unpredictability of traffic demand on arterial systems often outpace the ability of an operating agency to update signal timings so that signalized intersections operate efficiently and do not cause congestion and delays to motorists and pedestrians. Traffic signal management has changed significantly from its early beginnings. The current state-of-practice for computerized traffic signal system control is to use fixed traffic signal timing plans to move traffic through a roadway network. These systems allow for coordinated traffic using timing plans that change during various, yet fixed, days of the week (DOW) and times of the day (TOD). Timing plans are manually developed using measured traffic volumes and observed traffic patterns at a given point in time. This is a labor intensive process that typically involves data collection, modeling and simulation, implementation and fine tuning. The timing plans age and become less effective as time moves on and as traffic patterns divert from the original design conditions. Timing plans should on average be revisited and adjusted every 3-5 years to account for this drift, but due to required cost and resources these plans often continue to be in

effect long past their useful life. These are the methods currently used by the County in managing its traffic signal network. The graph below illustrates the potential benefits and cost savings of adaptive operation in terms of vehicle delay. The cost savings benefit is a combination of reduced vehicle delay and savings from not having to constantly maintain traffic signal timing plans.

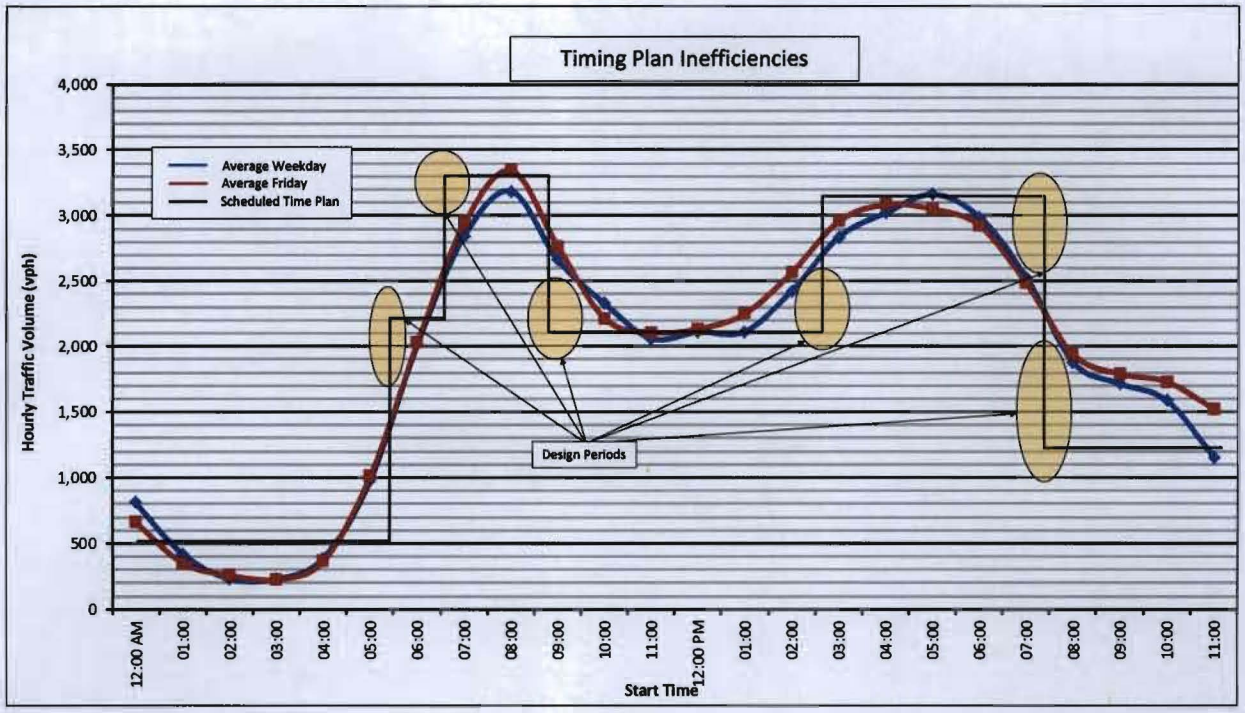


The adaptive methodology has to be robust and yet stable enough to be able to deal with a wide range of traffic conditions in different locations. The main benefits of adaptive signal control technology (ASCT) over conventional signal systems are that it can:

- Automatically adapt to unexpected changes in traffic conditions.
- Improve travel time reliability.
- Reduce congestion and fuel consumption.
- Prolong the effectiveness of traffic signal timing.
- Reduce the complaints that agencies receive in response to outdated signal timing.
- Eliminate the need to perform annual traffic counts and develop timing plans "off-line"
- Make traffic signal operations proactive by monitoring and responding to gaps in performance.

The graphic below illustrates the benefits of ASCT over conventional systems. Fixed timing plans are traditionally activated by DOW/TOD schedules that may not always align with actual

traffic demand (volume). It is these "shoulder" periods where ASCT can delay the onset of saturation (demand exceeds capacity) and allow a faster recover after traffic demand dissipates.



Project Process

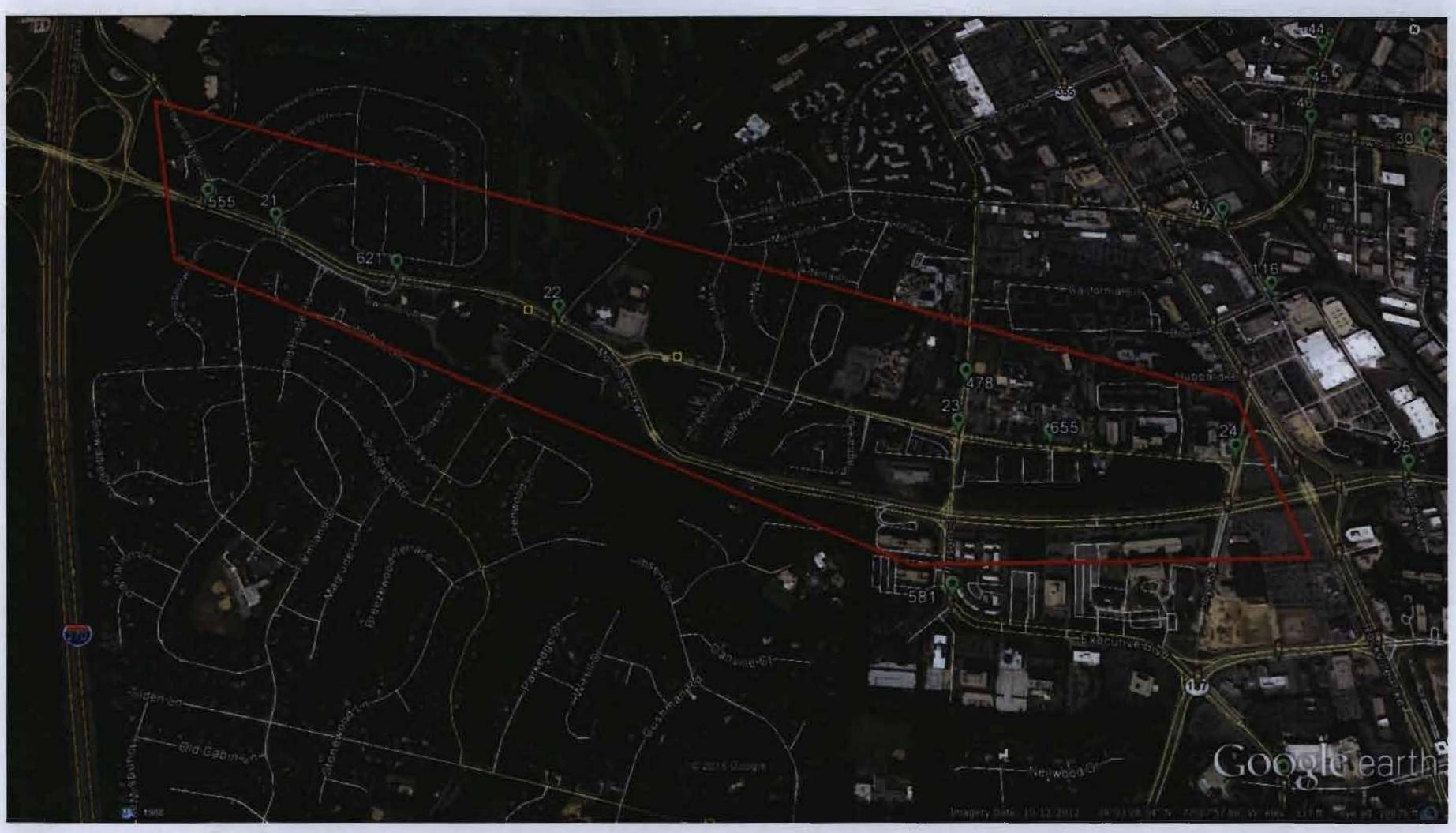
The County undertook an effort to examine the feasibility of implementing ASCT, and culminated with a five-year implementation plan for deployment. A systems engineering approach was followed as recommended by the USDOT and FHWA for Intelligent Transportation Systems and ASCT acquisitions. The systems engineering process reduces project risks and increases the likelihood that the implementation will meet the user's needs. Benefits include:

- improved stakeholder participation
- more adaptable, resilient systems
- verified functionality and reduce possibility of defects
- higher level of reuse from one project to the next, and
- better documentation

The feasibility was examined and documented in the following systems engineering reports:

- "Concept of Operations", Revision C, April 2015.
- "System Requirements", Revision B, April 2015.
- "Alternatives Analysis", Revision B, September 2015.
- "Central System Functional Requirements", Revision A, September 2015.
- "Implementation Plan", Revision A, September 2015.

1. MONTROSE RD / MONTROSE PKWY (I-270 to MD 355) (11 County Signals)



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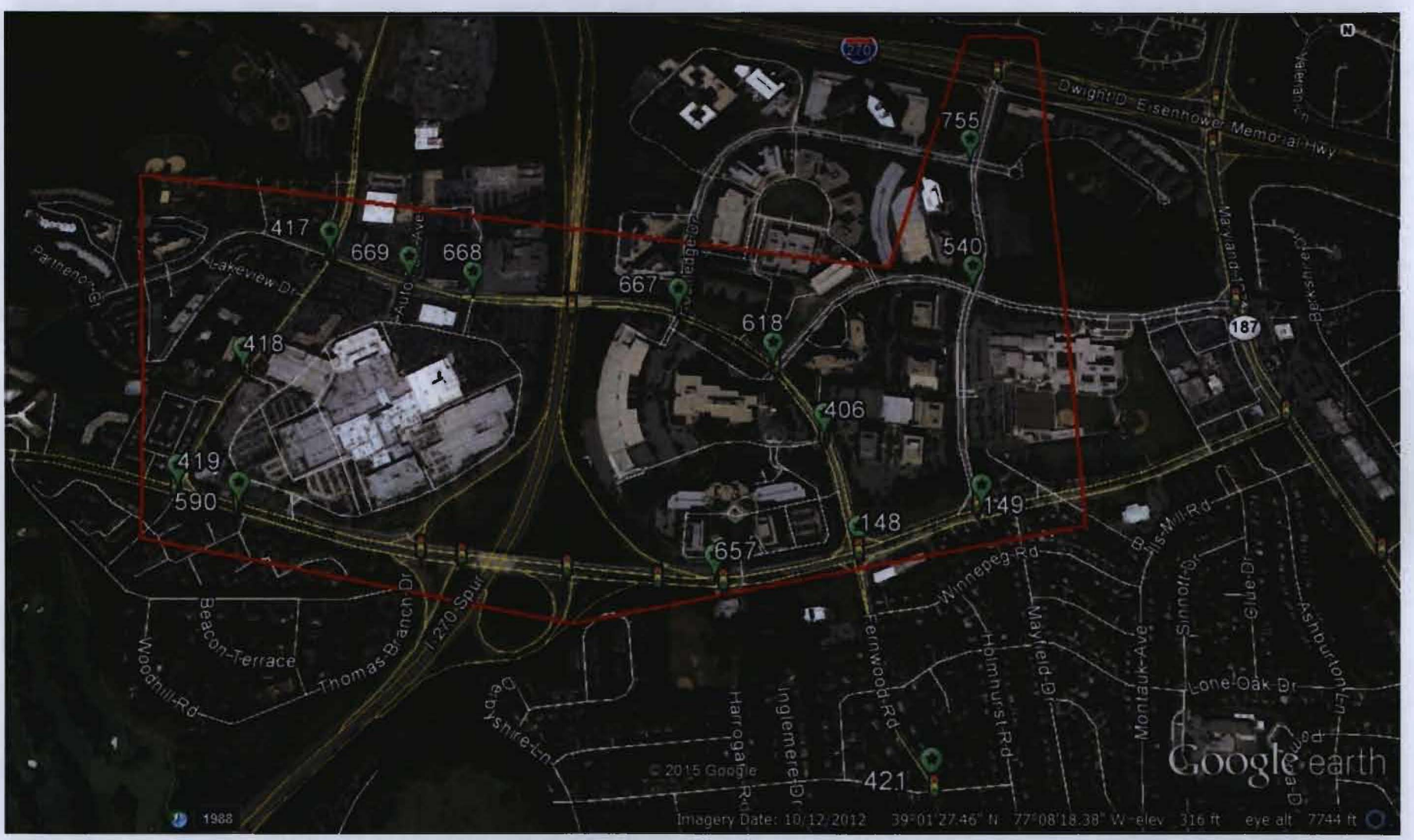
2. DEMOCRACY BLVD (MD 187 to WESTLAKE DR) (19 County/State Signals)



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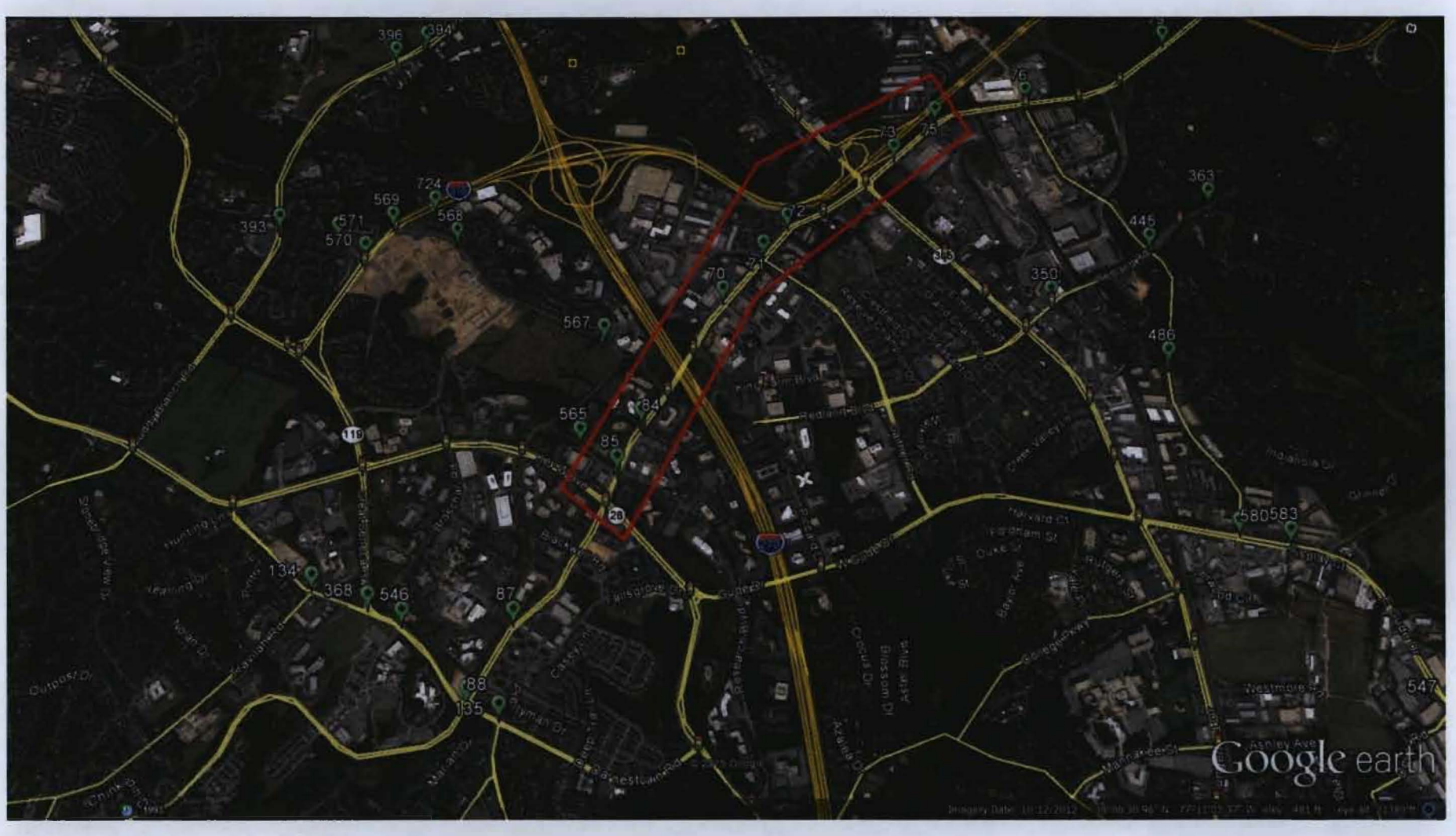
3. SHADY GROVE RD (MD 28 to Shady Grove Metro) (13 County/State Signals)



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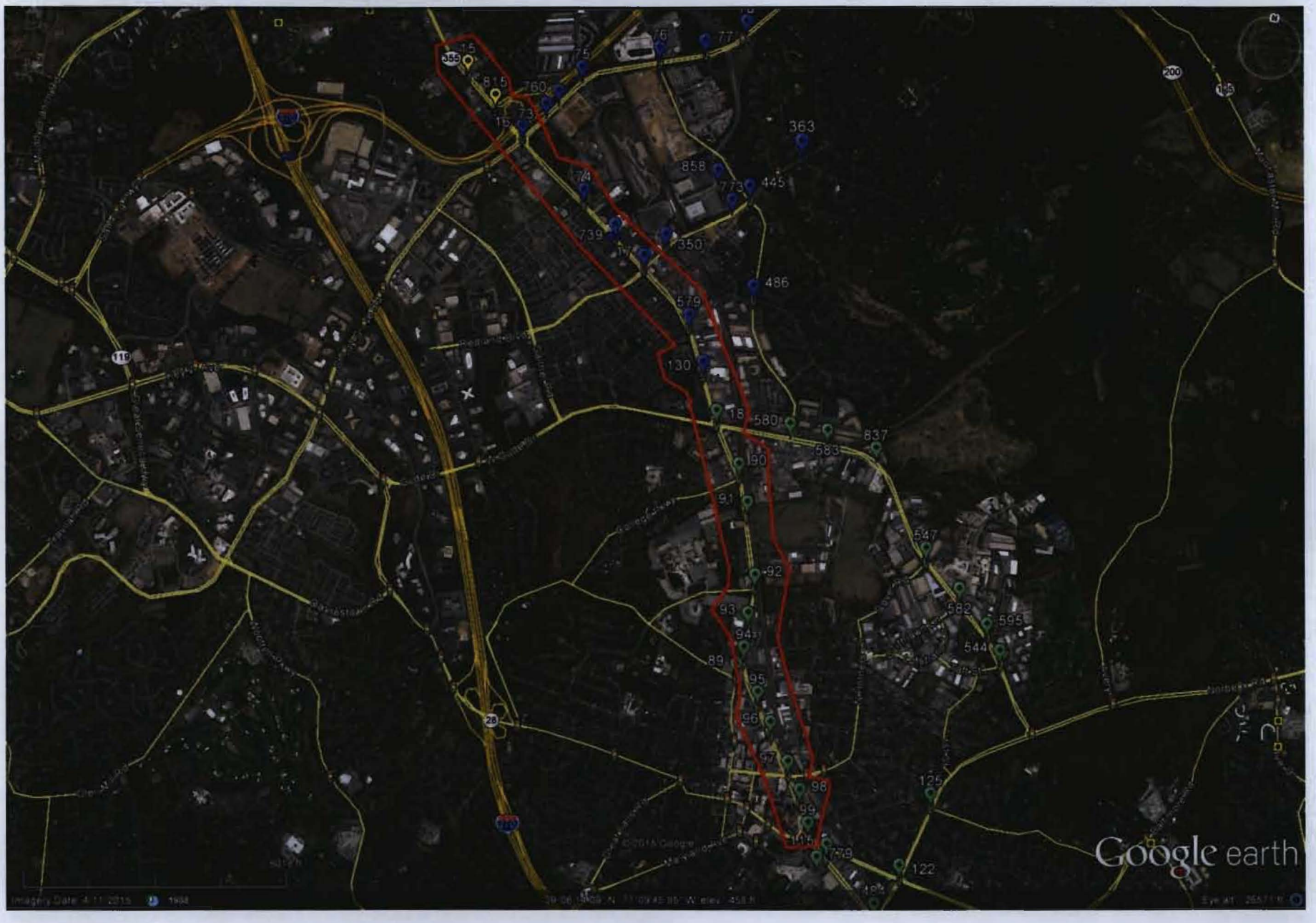
4. MD355 (SHADY GROVE RD to VEIRS MILL RD) (20 State Signals)



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5. WHEATON TRIANGLE (MD 97, 193, 586) (12 State Signals)

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