

USAGE OF THE REGIONAL INTEGRATED TRANSPORTATION INFORMATION SYSTEM (RITIS)

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TPB Technical Committee
March 2, 2018



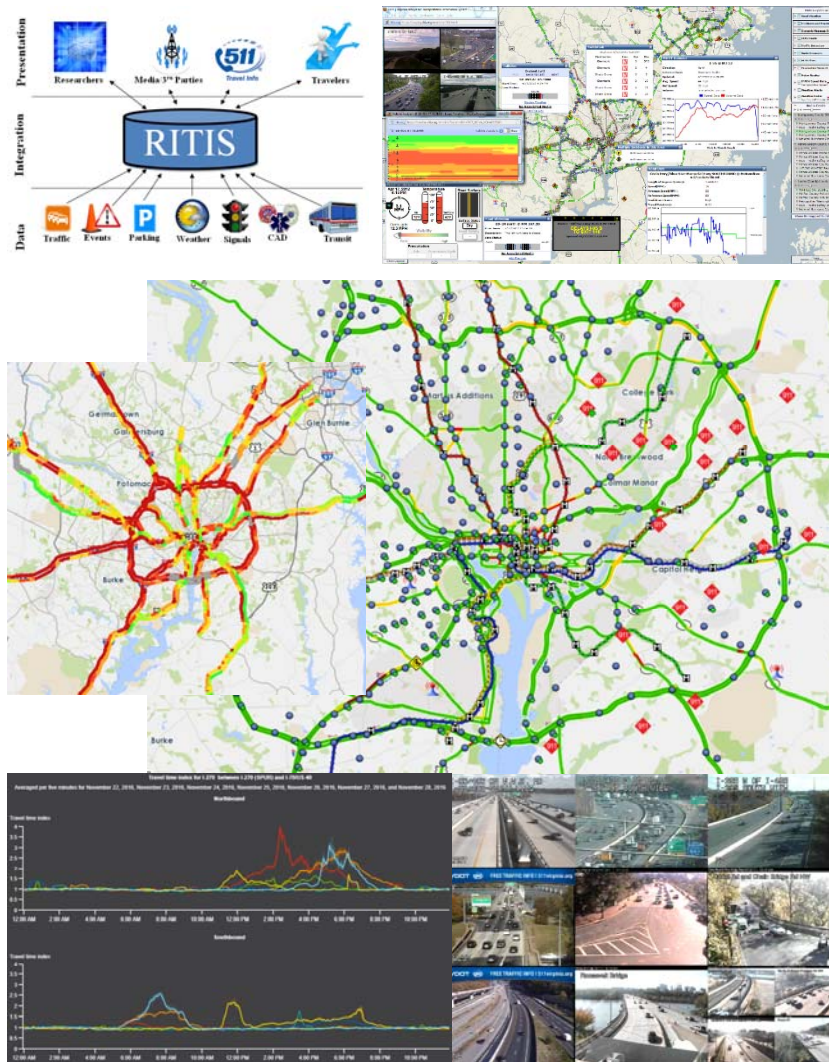
National Capital Region
Transportation Planning Board

Agenda Item #9

Introduction

- This slide deck builds upon the background information on the Regional Integrated Transportation Information System (RITIS) provided in advance of today's TPB Technical Committee briefing
- Today's focus will be on vital uses of RITIS in the region – not the “theoretical” of what RITIS is capable of doing, but the “actual” of critical RITIS use cases in the region

- Developed at the University of Maryland's Center for Advanced Transportation Technology Laboratory (2006)
 - Compiles real-time (near real-time) traffic and transit data from agencies around the nation
 - Consolidates the data into a common format
 - Archives the data for performance measures and visual analytics
 - Enables the data to be shared with agencies, researchers, the media, and the public
 - Additional data sets welcomed
- Gives users a **common operating picture** of a region's transportation network
 - Puts MATOC staff in a position of identifying actions/responses that would be helpful when transportation incidents occur in the NCR
- MATOC Staff provide RITIS Training on behalf of the University of Maryland Center for Advanced Transportation Technology Lab (UMD CATT Lab)
 - Training focuses on the operational application of RITIS



- **MATOC's core system to monitor roadway conditions** in and around the National Capital Region
- **Limited to public sector agencies**
- Approximately **8,000 RITIS users** from around the nation representing various disciplines
- Gives users a **common operating picture** of a region's transportation network
- **New:** 911 CAD and Waze integration, more CCTV coverage, improved data visualizations
- **RITIS Training Available**
 - Monthly Webinars offered my MATOC Staff
 - www.matoc.org/training

Major Features of RITIS

System Status & Decision Support	Communication
Incident List (Overview screen of incidents for a selected Region of Interest with buttons to more features/functions)	Event Chatroom & File Sharing (Chat with an unlimited number of users to collaborate & exchange related files on events)
Traffic Map (View, search and filter DMS, detectors, cameras, probe speed data, and more)	Address Book (Create detailed address books, search and view available contact information for agencies/individuals)
Incident Overview (Click on event & incident icons for details on type, location, detour plans, lane status, chats, and more)	Planning & After Action Review
Incident Timeline (View responder notifications/arrival times, lane closures, traffic queues, clearance times, and more)	Event Query Tool (Search, summarize, categorize and visualize archived event data for problem ID/project evaluation)
DOT/Public Safety Fleet Management (Track and monitor vehicle fleets, stream video from patrol vehicles, view in-vehicle equipment status)	Detector Data Explorer (View traffic detector system health, explore detector inventory, profile and export data to other tools)
Real-Time Weather (View real-time and predicted weather radar, ground weather, forecasts and weather alerts)	Data Archive Portal (Access data files for a variety of categories: DMS, detector, events, volume and speed data and more)
Traffic Cameras/Radio Feeds (Create a personal media wall of streaming videos; listen to police, fire, rescue, air traffic control nationally)	Personal Traffic Alerts
Public Transit (Display rail lines, stations, AVL and arrivals; display bus routes, stops and vehicle data)	Personal Traffic Alerts (Create incident or speed subscriptions on a travel route to be instantly alerted via text/email)
Evacuation Support	Training
Evacuation (Plan, build scenarios & manage evacuations using data layers for hospitals, staging, evac. routes, etc.)	Monthly Training Webinars (Increase your productivity and tool skills through regular online training)
Traveler Information	Collaboration & Virtual Meetings
TrafficView (Live traffic on the I-95 Corridor Coalition’s website; view congestion, events, DMS, CCTV, etc.)	RITIS Meeting (Virtual meeting platform for collaborative decision-making in a situational awareness environment)

Source: Michael Pack, University of Maryland CATT

Some Drivers of RITIS Features' Development and Evolution

- MATOC operations staff, MATOC Steering Committee, and subcommittees
- Urban Area Security Initiative (UASI) and public safety / emergency preparedness needs
- DDOT/MDOT/VDOT/WMATA input
- USDOT/federal initiatives (e.g., NPMRDS 2)
- New features commissioned by other states from the I-95 Corridor Coalition or across the country
 - Features whose development was paid for by various sponsors have become available to the wider range of RITIS users

RITIS Cost Drivers

DATA & Systems Integration

- Integration/reintegration/changes
- 24/7 Feed Maintenance & Monitoring
- Base Map Data Licensing
- Agency Data/Information Requests

HARDWARE

- Storage Costs
- Power & Networking
- Hardware Maintenance / Refresh

SOFTWARE

- Software Maintenance (DB admin/bugs/server patching/etc.)
- Cloud Services
- Software Enhancements

ADMIN/User Support

- Account Administration
- Helpdesk support
- Special Requests
 - > “Can you help me with... Can you explain why... My executive is about to give a press briefing on X, can you provide a graphic that shows Y? Can you run a report for me?” Etc.

COORDINATION

- Significant event coordination
- Event response

MISC

- User Training & Support
- Agency System Training
- Upgrades as defined by the user community

Source: Michael Pack, University of Maryland CATT



RITIS Support

- Users enjoy the benefits of RITIS because of annual financial support from participating states across the country, notably here including DDOT, MDOT, and VDOT
 - Behind-the-scenes data exchanges between RITIS and other systems may mean that users of those systems do not even know they are utilizing RITIS
- We are grateful for the support of our state DOTs both for RITIS overall and for “full” vehicle probe data roadway network coverage
- There are ongoing discussions among the states, the MATOC Steering Committee, and the University of Maryland on RITIS costs, value, and support
 - Documentation of RITIS use cases such as covered today can help inform discussions of future support



RITIS Use Case: MATOC



MATOC's Situational Awareness Mission

Input



Traffic Cameras



Media Broadcasts

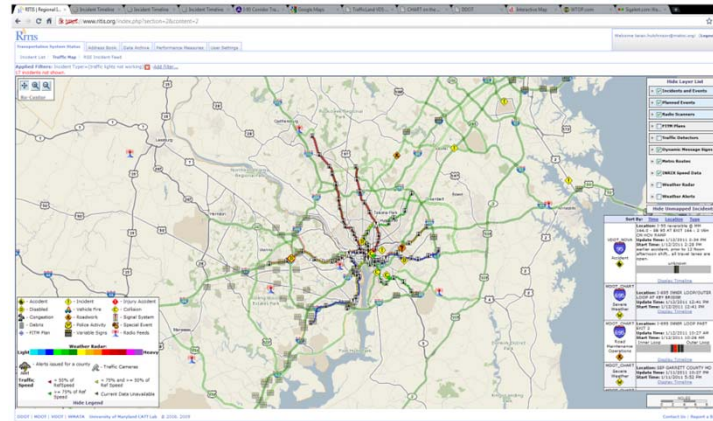


Scanners
(Public Safety / Media /
Agency/Traffic Spotters)

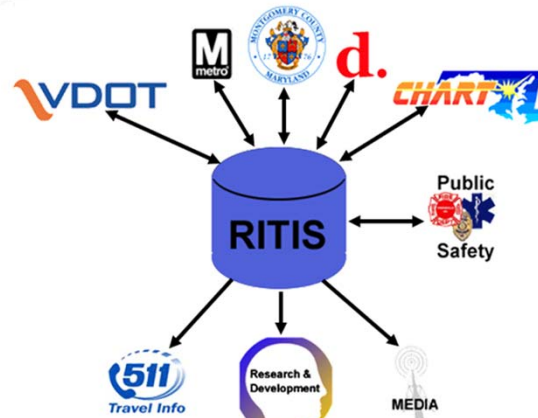


Incoming Messaging
Feeds
(Agency / Media /
Social Media)

Fusion



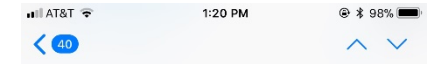
RITIS - Regional Integrated Transportation
Information System



MATOC Staff
Monitoring



Notifications



MATOC Alert: Crash. I-95 NB before
VA-289. Ffx Co, VA.
November 22, 2017 at 7:33 PM

MATOC can be reached by email at operations@matoc.org

For your situational awareness;

Incident: Crash (Reportedly involving overturned
vehicle)

Location: I-95 NB before VA-289. Fairfax County,
VA.

**All northbound lanes are blocked. Delays
begin past Lorton Road, approximately 4
miles.**

RITIS Timeline: [https://timeline.ritis.org/timeline/?
incidentId=VDOT_INNO25217543-11222017](https://timeline.ritis.org/timeline/?incidentId=VDOT_INNO25217543-11222017)

MATOC Operations
[301-614-3703](tel:301-614-3703)

Sent by MATOC Staff via MATOC Alerts notification system



MATOC's Use of RITIS: Connecting the DOTs

1) Water Main Break (Road & Rails Closed)

2) Special Event (Increased Traffic)

3) Unusual Delays

4) DMS Support

Major Accident in MD at Ex. 19 Expect Delays

Major Crash! (Interstate Closed)

Fatalities Involved
I-95 INNER LOOP/OUTER LOOP AT EXIT 19 US 50
-Fatalities Involved: 50
Started: 8/1/2014 8:51 AM
Updated: 8/1/2014 11:15 AM
6 Responders on the Scene
Inner Loop Outer Loop
Description: RAMP FROM US50 WEST TO THE OUTER LOOP A CLOSED AND TRAFFIC IS BEING DIVERTED TO THE RAMP TO THE NEW CARROLLTON METRO STATION
O/L (NB) delays begin past exit 11, near D'Arcy Rd. I/L (SB) del

Collision (Fatality) @ I-95 INNER LOOP/OUTER LOOP AT EXIT 19 US 50 - Event Timeline - Google Chrome
https://timeline.ritis.org/timeline/?incidentId=MDOT_CHART_e100fc4e638d04db0053fa2ec4235c0a
I-95 INNER LOOP/OUTER LOOP AT EXIT 19 US 50
Collision (Fatality)
Time: August 1, 2014 8:41:00 AM
Distance: 15.5 miles upstream
Speed: 40 - 50 mph
Incident on I-495

RITIS Real-Time Map and List

Transportation System Status

Incident List | Traffic Map | Incident Overview | Traffic Cameras | RSS Feed | WZPMA | RITIS Meeting

Showing: 1-100 of 239

Location	Type	Lane Status
Montgomery County, MD I-495 INNER LOOP PRIOR TO EXIT 28A MD 650 NEW HAMPSHIRE AVE	Inner Loop	Outer Loop
Alexandria City, VA I-95 north @ MM 178.100	South	North
Arlington County, VA I-395 north @ MM 9.700	South	North
Fairfax County, MD I-495 north @ MM 42.300	South	North
Montgomery County, MD CABIN JOHN PKWY SOUTH AT I-495	South	North
Fairfax County, VA I-495S south @ MM 44.000	South	North
Prince Georges County, MD PRINCE GEORGE'S COUNTY: I-95 SOUTH/NORTH FROM (GV - 119) -	South	North
Prince Georges County, MD 4812 COLLEGE AVE		
Prince Georges County, MD MOUNT OAK RD / MITCHELLVILLE RD		
Fairfax County, VA I-66 west @ MM 60.000	West	East
Prince Georges County, MD 12305 TILBURY LN		
Fairfax County, VA I-95 south @ MM 175.000	South	North
Prince Georges County, MD INDIAN HEAD HWY SB / WILSON BRIDGE DR		
Alexandria City, VA I-395S south @ MM 2.500	South	North
Montgomery County, MD MD 355 SOUTH FROM ELM ST TO BETHESDA AVE	South	North
Prince Georges County, MD I-95 INNER LOOP FROM SUITLAND PKWY TO AUTH RD	Inner Loop	Outer Loop
Prince Georges County, MD 4812 SILVER HILL RD SB		
Alexandria City, VA I-395S south @ MM 5.300	South	North
Prince Georges County, MD 5200 BLK INDIAN HEAD HWY NB		

Map Labels: Glen Echo, McLean, Annandale, Burke, Cheltenham, Capitol Heights, North Brentwood, Colmar Manor, College Park, Potomac River Park.

Scale: 0 1 2 3 4 MILES

Search: RITIS - CATT Lab, Demo Demo, Robert Wojack, RITIS - City of Charlotte, Mohamed Kaddoumi, RITIS - DC HSEMA, Alexandria Tepper, Jose Wood, Megan Hewitt, Zuxuan Deng, RITIS - FDOT, Aquiles Alfaro, RITIS - FDOT Contractors, Carlos Francis, Dan D'Antonio, RITIS - Lehman Center for T..., Angela Kitai, RITIS - Pennsylvania Nation..., Shawn Wentz, RITIS - Rhode Island DOT.

All conversations on RITIS Chat are logged.

The screenshot displays the RITIS Transportation System Status interface. The main map shows a collision (fatality) on I-495 near Exit 28A MD 650. An incident pop-up provides details: "I-495 INNER LOOP PRIOR TO EXIT 28A MD 650 NEW HAMPSHIRE AVE (EB)", "Montgomery County, Maryland", "Started: 11/28/2017 3:39 PM", and "Updated: 11/28/2017 3:55 PM". It lists responders: State Police, Fireboard, and SHA Office OC. A "Nearby FITM Plans" section lists I-495/495 Exit 28 to Exit 29, Exit 29 to Exit 30, and Exit 27 to Exit 28. A "Media" section includes an "Add File/Link" button. A "Join Incident Chat Room" link is also present.

The event timeline on the left shows a "Collision (Fatality)" at 3:39:03 PM on November 28, 2017. It lists "CHART Unit 9309 SG00626" and "CHART Unit 9301 SG01017". A "CCTV" window shows a camera view from "CAM-067 A" at "I-495 & New Hampshire Ave (MD 650)".

The interface includes a navigation menu (Incident List, Traffic Map, Incident Overview, Traffic Cameras, RSS Feed, WZPMA, RITIS Meeting), a user profile (Welcome Daivamani Sivasailam!), and a list of users on the right side.

The screenshot displays the TrafficView web application interface. At the top, the title "TrafficView" is followed by navigation links: "Live Traffic", "My Routes", and "Camera List". On the right side, there are "Login" and "Register" buttons. The main area is a map of the Washington D.C. region, showing major highways and various traffic incidents marked with icons. Three incident pop-up windows are visible:

- Collision:** Incident 1 of 2, BACK TO LIST, NEXT. MD 355 SOUTH AT SHADY GROVE RD. Started 34 minutes ago.
- Disabled Vehicle:** Incident 1 of 5, BACK TO LIST, NEXT. I-95 SOUTH PRIOR TO BALTIMORE AVE. Started 58 minutes ago.
- Collision:** This incident has been closed. I-66W west @ MM 67.800. Started 2 hours, 1 minute ago.

On the right side of the map, there is a "Layers" panel with the following options:

- Accidents and Events (Legend)
- Severity (Low / Medium / High)
- Overhead Signs
- Traffic Cameras
- Comparative Speed
- Weather Radar
- Weather Alerts (Legend)

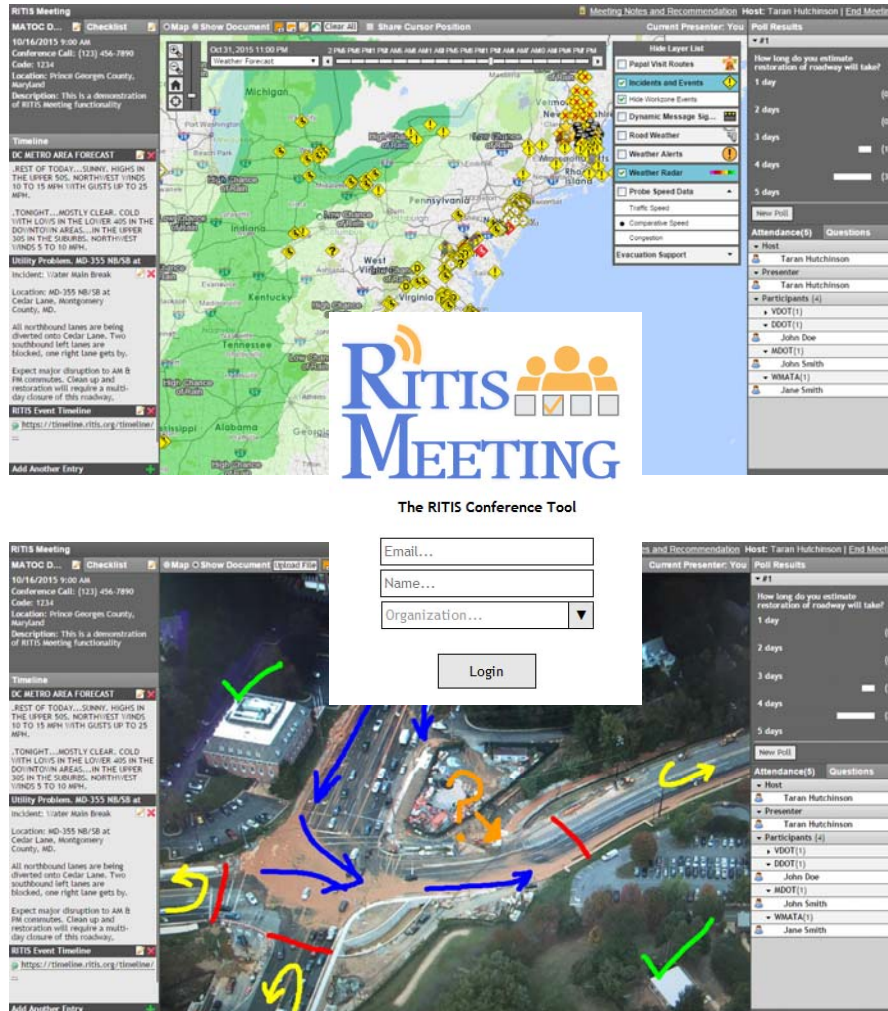
At the bottom right, there are four camera feed thumbnails:

- I-495 N OF AMER LEGION
- I-85/485 ON U.U.B. MD

At the bottom left, there is a scale bar and "Copyright 2015". At the bottom right, there are links for "Help | Contact Us | Our Partners | Developer Tools".

RITIS Meeting

“Collaborative Decision Tool”



The screenshot displays the RITIS Meeting web application interface. It features a central map showing a road network with various incident markers. On the left, there is a sidebar with a 'Timeline' section containing a 'DC METRO AREA FORECAST' and a 'Utility Problem: MD-355 NB/5B at Cedar Lane, Montgomery County, MD.' Below the map, there is a 'RITIS Event Timeline' section. On the right, there is a 'Poll Results' section with a question: 'How long do you estimate restoration of roadway will take?' with options for 1, 2, 3, 4, and 5 days. Below the poll, there is an 'Attendance' list showing participants like Taran Hutchinson, John Doe, and Jane Smith. At the bottom of the screenshot, there is a login form with fields for 'Email...', 'Name...', and 'Organization...', and a 'Login' button.

The RITIS Conference Tool

- Available to RITIS users
- **Simple** web meeting function that allows for:
 - Faster call/meeting management
 - Multiple-presenter functionality
 - Interactive mapping, share documents and images, drawing functions
 - Shared view of an event or incident
 - Document meeting minutes
 - Open and transparent decision-making (e.g., real-time polling)
 - Participants receive a PDF meeting summary at the end of the session
- Works on all internet browsers
 - **No plugins required**
 - Supports up to 300 participants per session

RITIS Use Case: Smart Scale



RITIS as an Information Source for Smart Scale

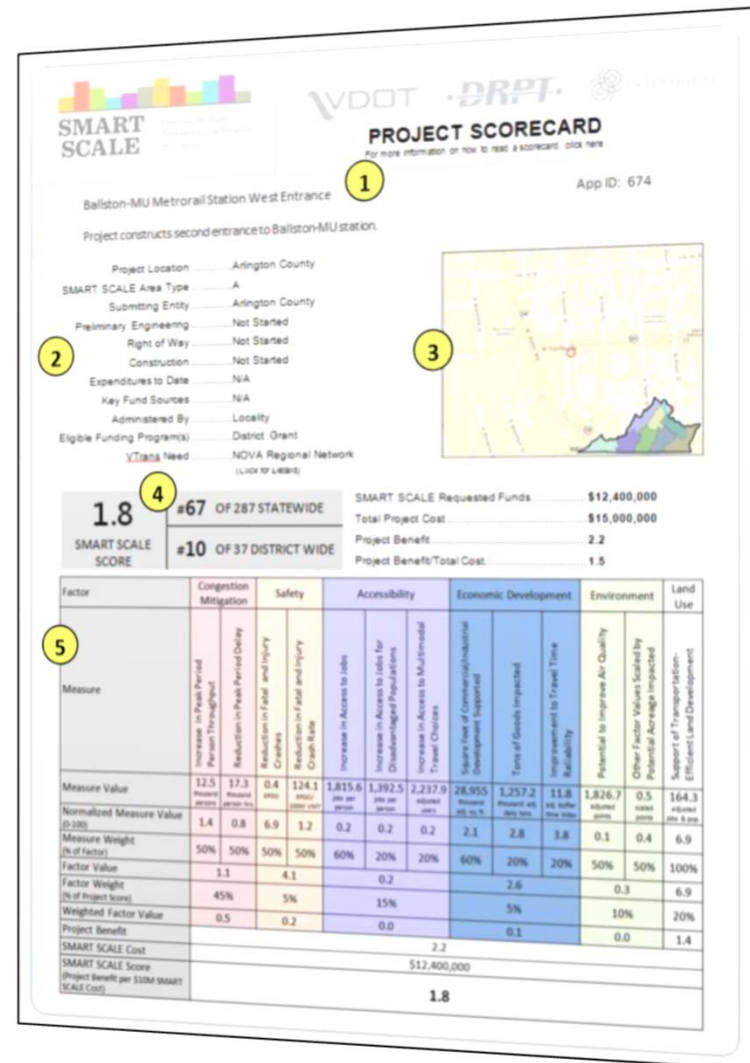
- Smart Scale is a Virginia program to score and select potential projects based on an objective, outcome-based process
- Data and analysis are critical to Smart Scale applications
- RITIS commonly used for Smart Scale for:
 - Travel time reliability information
 - Peak hour/peak period data conversions
 - “Hot spot” identification

Project Located in Typology	Congestion Mitigation		Safety		Accessibility		Environment		Economic Development		Land Use		
	Category A												
		Increase in Daily Person Throughput	Increase in Person Hour Delay	Reduction in Fatal and Injury Rate	Reduction in Fatal and Injury Rate	Increase in Access to Disadvantaged Populations	Improved Access to Multimodal Choices (Users Benefit Value)	Air Quality (Total Benefit Value)	Acres of Natural/Cultural Resources Potentially Impacted	Economic Development Support (Sq. ft.)	Intermodal Access Improvements (Tons Benefit Value)	Travel Time Reliability Improvement	Transportation Efficient Land Use
	0.3	0.2	0	2.5	1.4	46.4	4.3						
	20%	50%	50%	60%	20%	100%							
	0.1	0.1	0	1.5	0.3	9.3	4.3						
		14	6	0.6				0.1		11.1		4.3	
								10%		5%		20%	
		0							0.6			0.9	



Smart Scale Project Scorecards

- Smart Scale “Project Scorecards” summarize potential post-project conditions



RITIS Citation in Smart Scale Manual

SMART SCALE Technical Guide



ED.3 Travel Time Reliability

Definition: Change in travel time reliability attributed to the project.

Data Source(s)

- Latest five complete years of crashes from VDOT Roadway Network System (RNS) GIS data maintained by Traffic Engineering Division.
- Buffer index (BI) from University of Maryland Regional Integrated Transportation Information System (RITIS).
- Weather information from VDOT VA Traffic database.
- AASHTO *Highway Safety Manual (HSM)*, 2010.

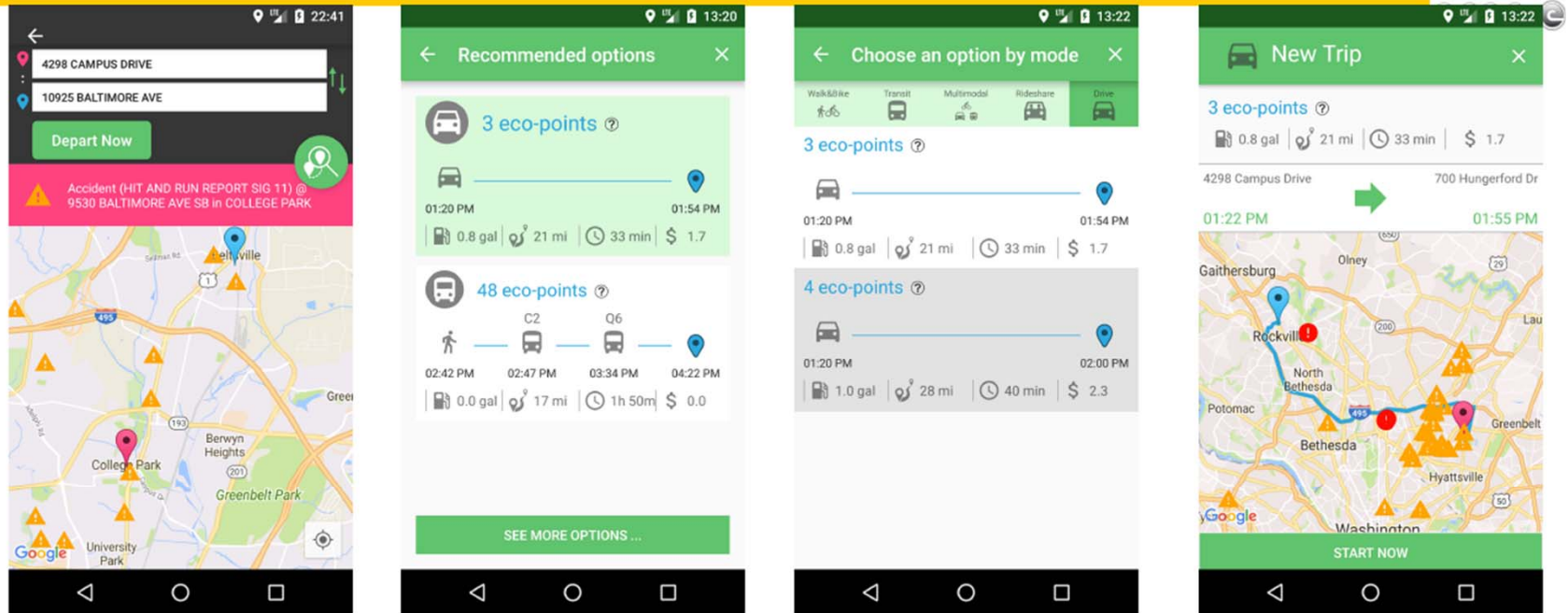


RITIS Use Case: Commuter Connections



RITIS Use in Flextime Apps

Plan a Trip



- ✓ **Flexible Departure Time**
- ✓ **Alternative Modes Options**
- ✓ **Earn Points**
- ✓ **Reserve Future Trips**
- ✓ **Dynamic Route Options**
- ✓ **Accident & Weather Alerts**



National Transportation Center @Maryland || www.ntc.umd.edu || www.ipretii.umd.edu

Source: Lei Zhang, University of Maryland



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RITIS Use Case: Congestion Management Process



CMP Analysis Before Availability of Vehicle Probe Data Through RITIS

Arterial Floating Car Travel Time Study

Table 10: Schedule and Routes of the Arterial Travel Time Study

State	FY 2000 FY 2003 FY 2006 FY 2009		FY 2001 FY 2004 FY 2007 FY 2010		FY 2002 FY 2005 FY 2008 FY 2011		Total
	Routes	Miles	Routes	Miles	Routes	Miles	
MD	MD 355	15.3	MD 4	11.5	MD 97	9.5	155.5
	MD 117	6.8	MD 586	5.4	MD 5	11.9	
	MD 198	5.0	MD 450	12.8	MD 28	9.0	
	MD 197	14.7	MD 144	4.2	MD 193	4.2	
	US 1*	13.4	Indian Head Hwy*	11.0	Randolph Road	9.1	
	MD 193*	4.6			Colesville Rd/US29*	7.1	
		59.8		44.9		50.8	
VA	US 50	23.0	VA 234	22.6	Fairfax County Pkwy	19.7	222.7
	US 15	12.5	VA 28	17.0	US 1	18.8	
	VA 123	27.7	VA 120	8.1	US 29 Seg 1,2&3	21.0	
	Wilson Blvd*	4.9	VA 7	29.3	US 29 Seg 4*	11.1	
			VA 28*	7.0			
		68.1		84.0		70.6	
DC	Wisconsin Ave	4.1	Canal Rd	3.7	14th Street NW	1.0	59.4
	Pennsylvania Ave	1.1	7th St NW	3.4	16th Street NW	6.1	
	17th Street NW	0.7	Georgia Ave	3.3	Connecticut Ave	4.0	
	Independence Ave	1.9	Constitution Ave	2.4	K Street NW	4.2	
	I Street NW	0.8	Pennsylvania Ave	3.7	Military Road	2.5	
	H Street NW	0.6			Pennsylvania Ave NW	0.8	
	15th Street NW	0.7			L Street NW	1.1	
	16th Street NW**	6.1			South Dakota*	2.7	
	L Street NW**	1.2					
	Rhode Island Ave*	3.3					
		20.5		16.5		22.4	
Total		148.4		145.4		143.8	430.3

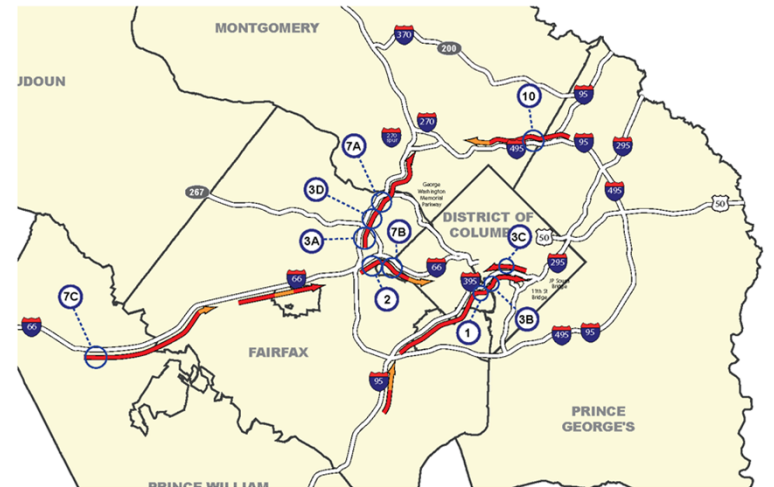
* New Routes studies since FY 2009 & constitute 65.1 miles.

** Due to construction these routes were shifted to a different year since FY 2006.

FREEWAY AERIAL PHOTOGRAPHY SURVEY

Criteria for the top ten congested locations are as follows:

- A location is defined as a congested freeway segment, by direction, between interchanges; this congested location is typically within a larger queue.
- Rankings for the top ten are based on the average hourly density value which corresponds to a speed (see table below).
- Construction-related congestion was not included in the rankings unless the location was historically congested in the absence of construction.
- Congestion caused by traffic signals was not included in the rankings.



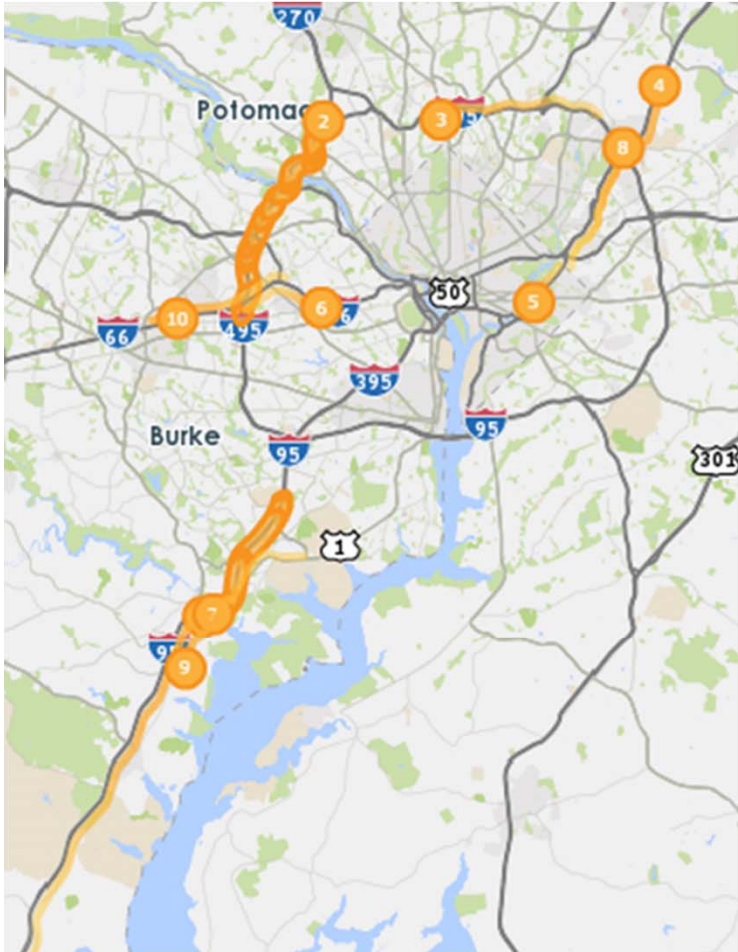
Top Ten Congested Segments on the Freeway System (2014)

Rank	Route	From	To	Density	Speed Range
1	NB I-395 (8:30-9:30 AM)	VA 27 (Washington Blvd)	VA 110 (Jefferson Davis Hwy)	150	5 MPH
2	EB I-66 (6:00-7:00 PM)	VA 7 (Leesburgh Pike)	VA 267	140	5 MPH
3A	Inner Loop I-495 (4:30-5:30 PM)	VA 123 (Chain Bridge Rd)	VA 267	120	5-10 MPH
3B	NB I-395 (8:30-9:30 AM)	VA 110 (Jefferson Davis Hwy)	George Washington Memorial Pkwy	120	5-10 MPH
3C	SB I-395 (5:00-6:00 PM)	4th St	12th St	120	5-10 MPH
3D	Inner Loop I-495 (4:30-5:30 PM)	VA 267	VA 193 (Georgetown Pike)	120	5-10 MPH
7A	Inner Loop I-495 (5:30-6:30 PM)	VA 193 (Georgetown Pike)	George Washington Memorial Pkwy	110	10-15 MPH
7B	EB I-66 (6:00-7:00 PM)	VA 267	Westmoreland St	110	10-15 MPH
7C	EB I-66 (6:00-7:00 AM)	VA 234 Bypass	VA 234 (Sudley Rd)	110	10-15 MPH
10	Outer Loop I-495 (7:00-8:00 AM)	MD 650 (New Hampshire Ave)	MD 193 (University Ave)	105	10-15 MPH

Note: Due to construction at the terminus of the Southeast Freeway, eastbound densities along this corridor were not included in the Top Ten list above.



Top 10 Bottlenecks Using RITIS



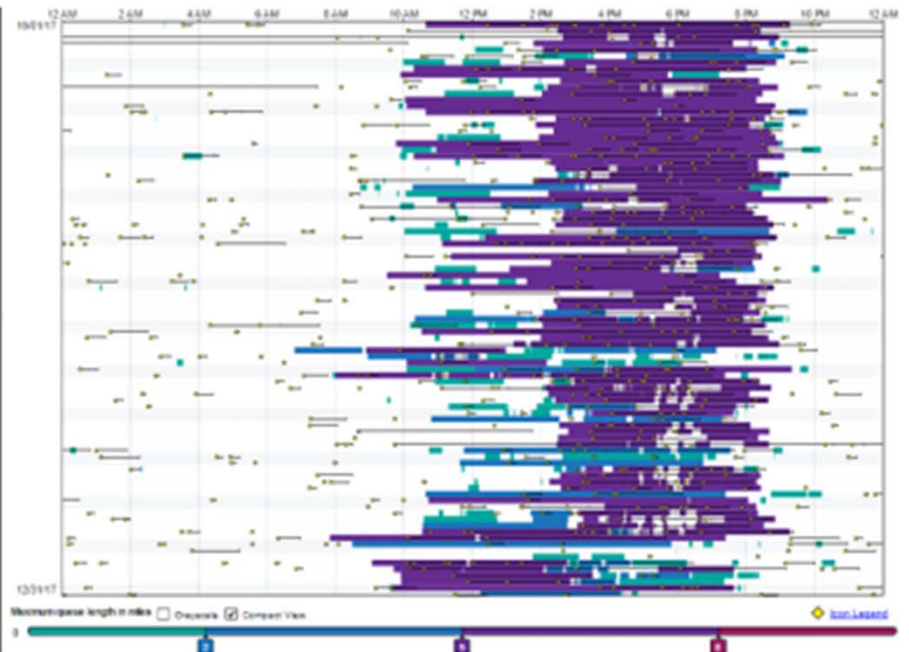
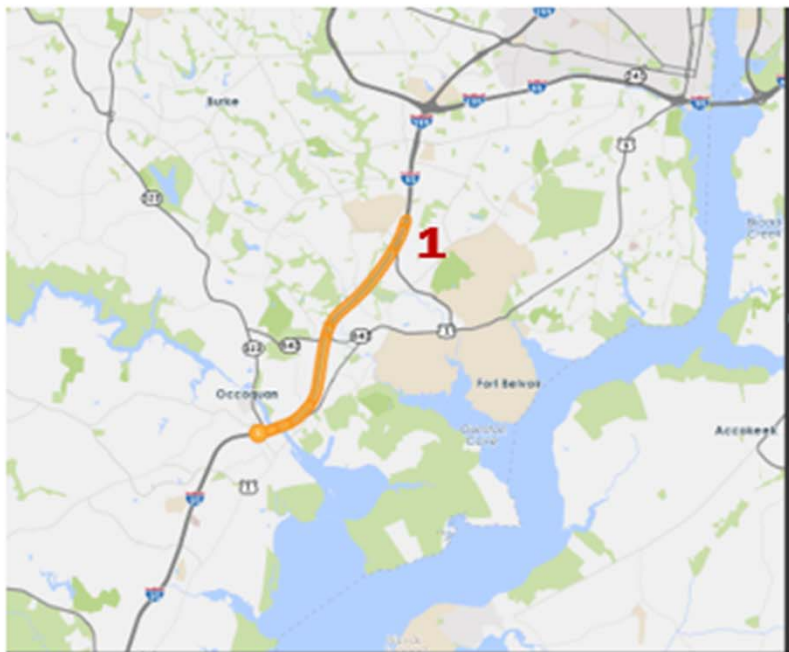
Rank (Last Quarter Rank)	Location	Average duration	Average max length (miles)	Total duration	Impact factor
1 (1)*	I-95 S @ VA-123/EXIT 160	7 h 24 m	3.95	28 d 10 h 18 m	145,274.09
2 (5)	I-495 CW @ I-270 SPUR	2 h 34 m	4.46	9 d 20 h 26 m	88,898.23
3 (6)	I-495 CCW @ MD-97/GEORGIA AVE/EXIT 31	4 h 22 m	2.67	16 d 18 h 04 m	82,678.58
4 (2)	MD-295 N @ POWDER MILL RD	5 h 58 m	2.81	22 d 22 h 13 m	73,249.20
5 (4)	DC-295 S @ CAPITOL ST	9 h 35 m	1.24	36 d 19 h 07 m	71,440.03
6 (8)	I-66 E @ SYCAMORE ST/EXIT 69	6 h 22 m	1.81	24 d 10 h 29 m	70,900.03
7 (3)	I-95 N @ VA-123/EXIT 160	3 h 25 m	3.32	13 d 02 h 42 m	68,786.91
8 (10)	MD-295 N @ I-495/I-95	4 h 07 m	3.14	15 d 20 h 21 m	66,618.89
9 (13)	US-1 S @ OPITZ BLVD	5 h 45 m	2.36	22 d 01 h 59 m	64,835.54
10 (12)	I-66 W @ VADEN DR/EXIT 62	4 h 22 m	1.67	16 d 18 h 05 m	60,747.47



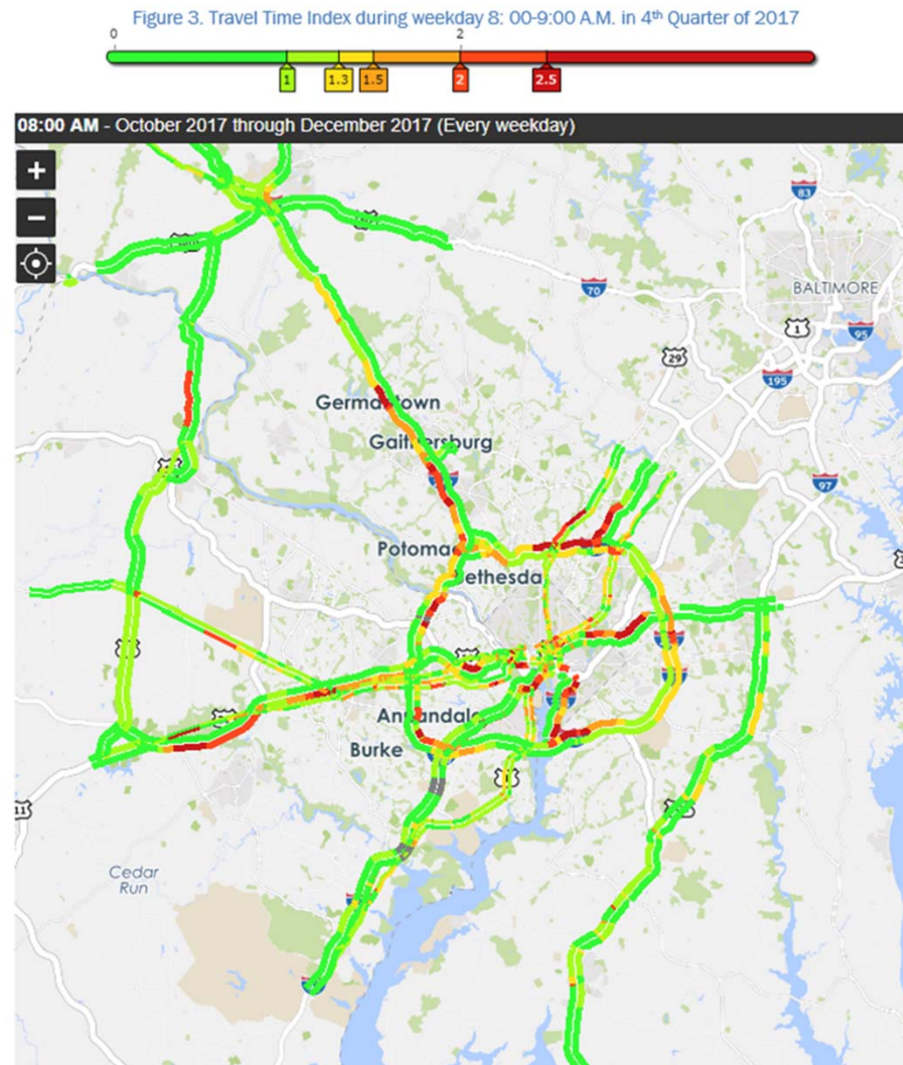
Details and Visualizations on Each Bottleneck

Rank	Location	Average duration	Average max length (miles)	Total duration	Impact factor*
1	I-95 S @ VA-123/EXIT 160	7 h 24 m	3.95	28 d 10 h 18 m	145,274.09

* The Impact Factor of a bottleneck is simply the product of the Average Duration (minutes), Average Max Length (miles) and the number of occurrences.

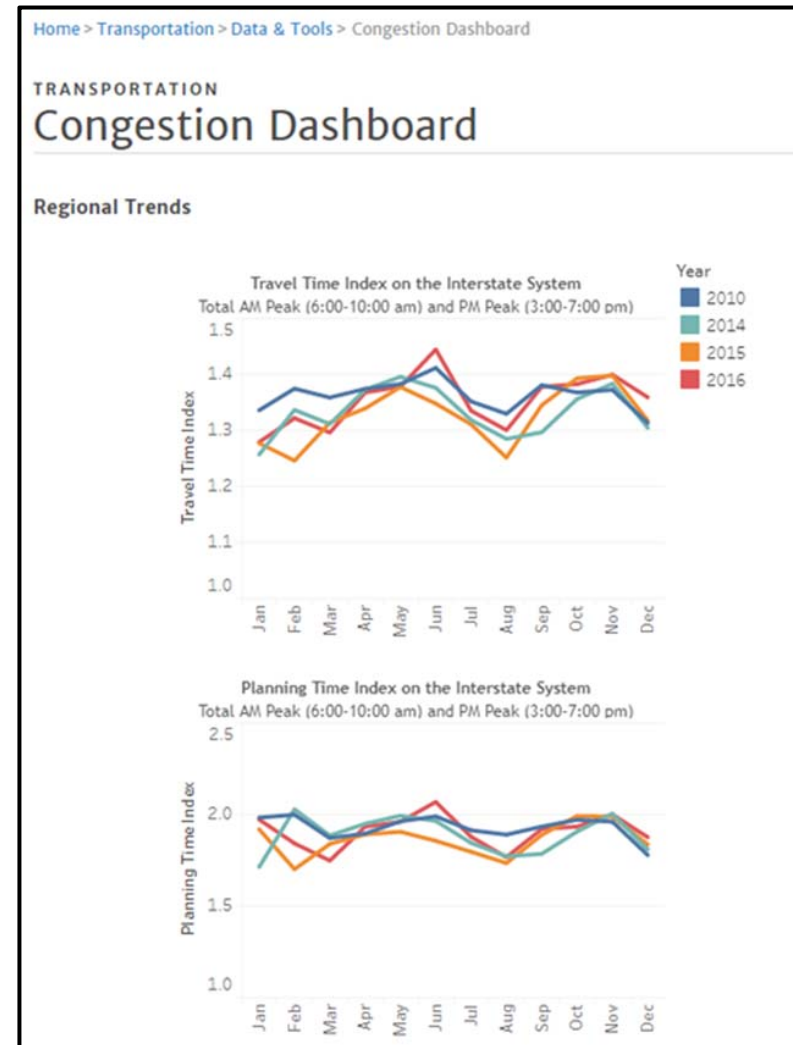


Flexible Mapping Capabilities

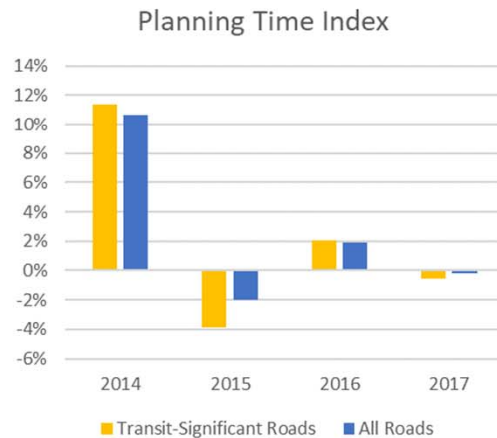
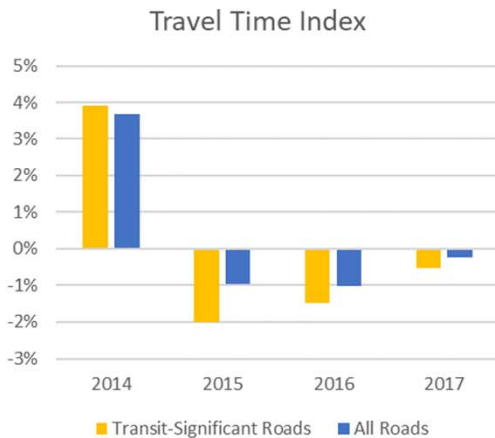
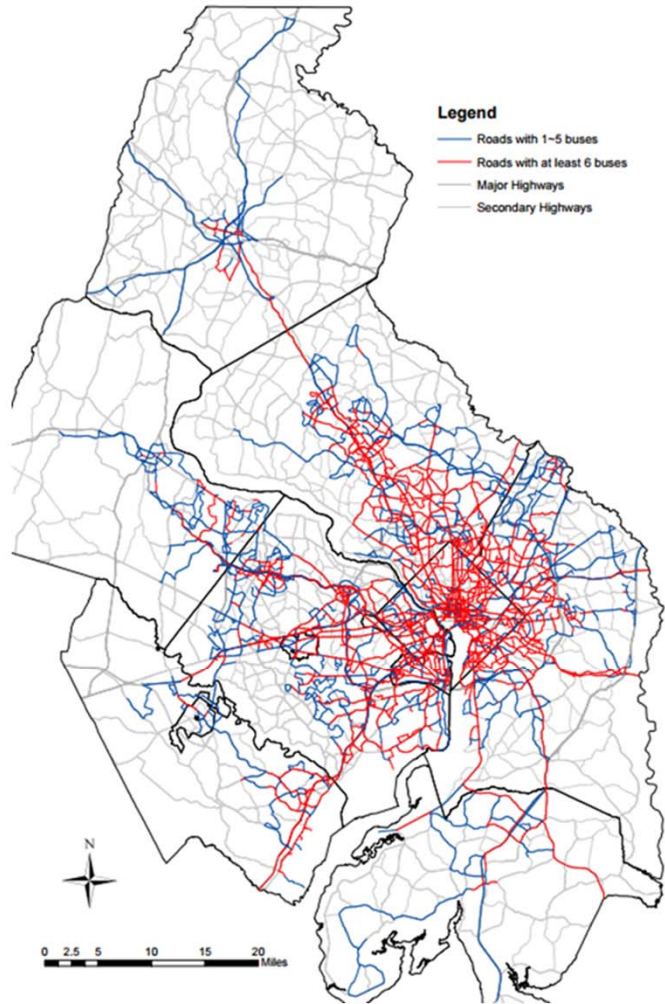
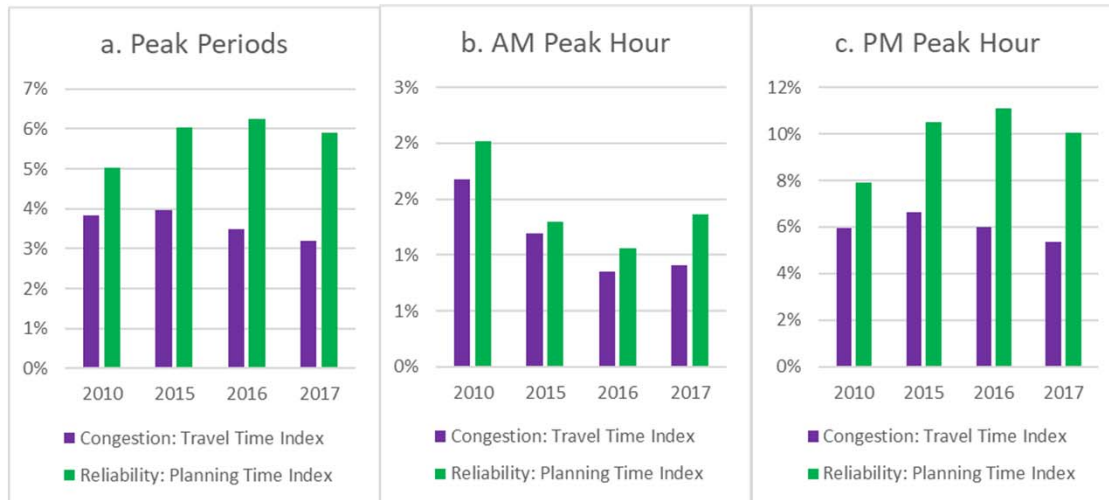


Congestion Dashboard

- Promptly available probe data enables creation of updateable dashboards
 - Interactive for users
- Currently quarterly
 - Previously triennially!
- See:
www.mwcog.org/congestion



CMP Analysis of Transit-Significant Roads

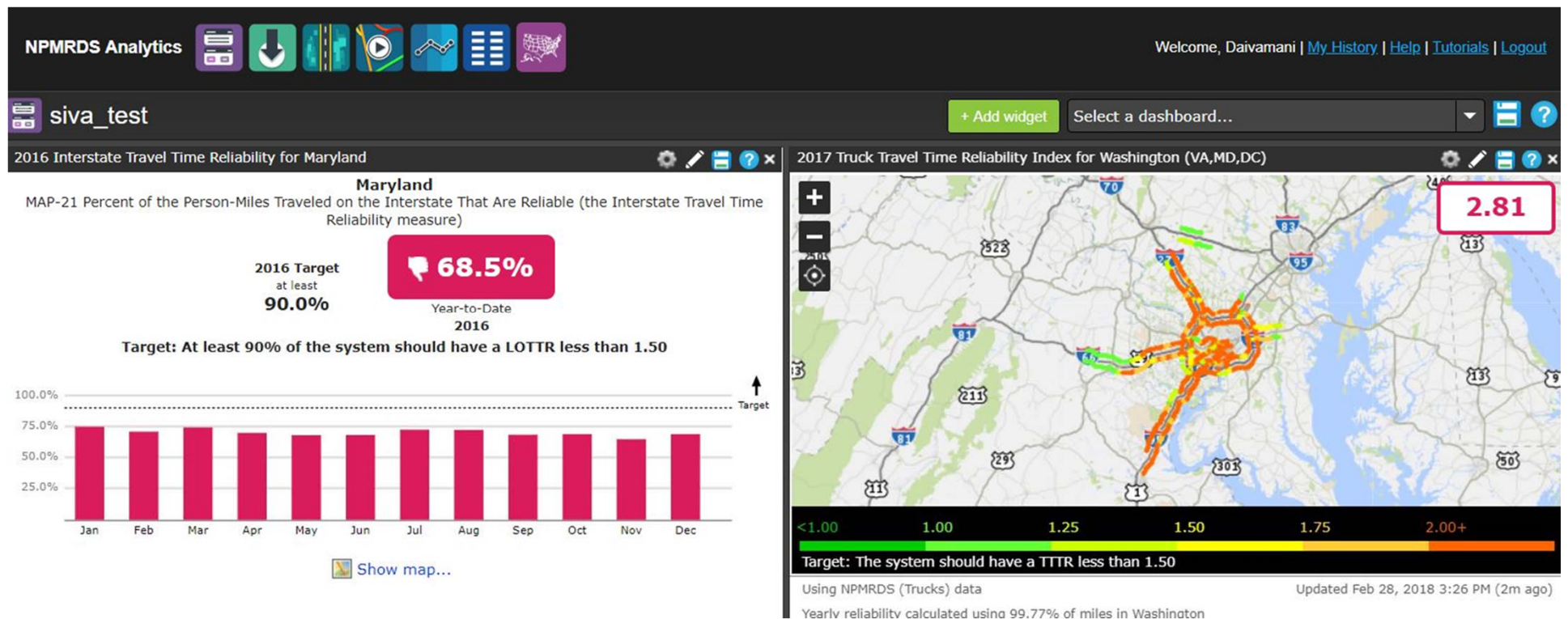


RITIS Use Case: Regional/Special Studies



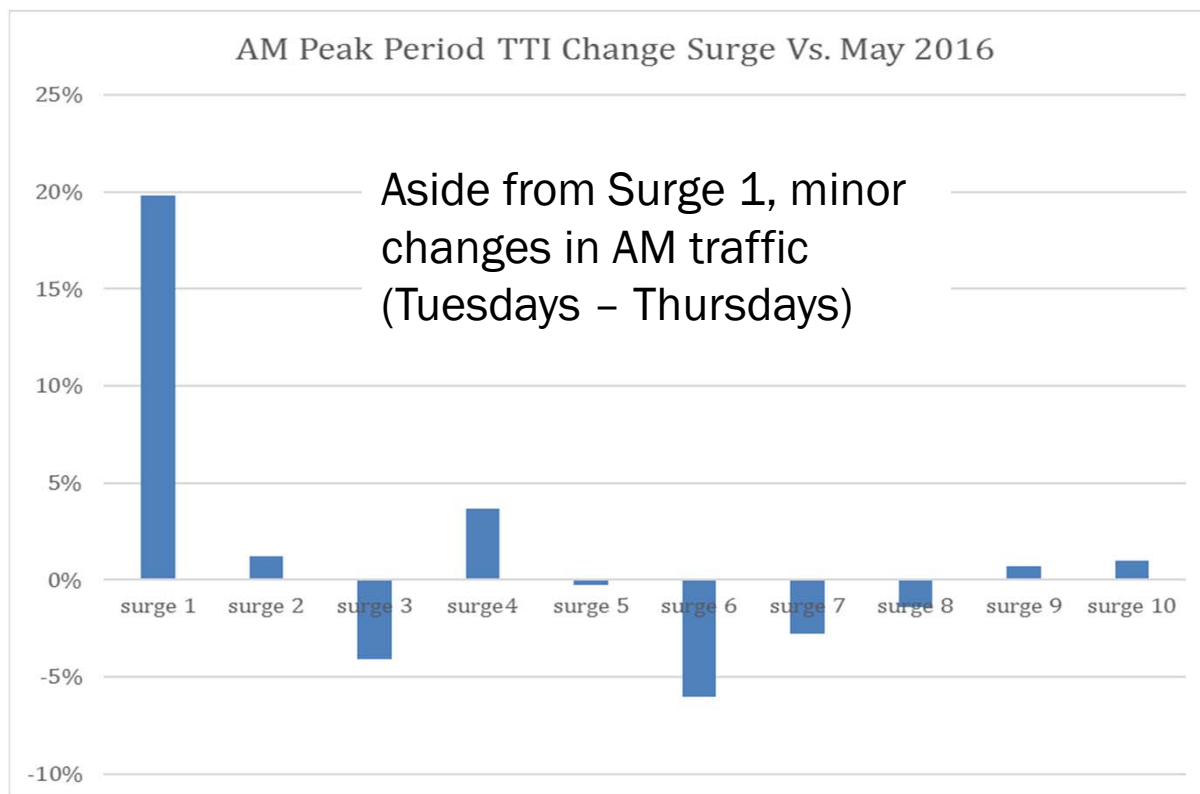
PBPP Analysis

- PBPP tools available through RITIS are more robust than NPMRDS default tools



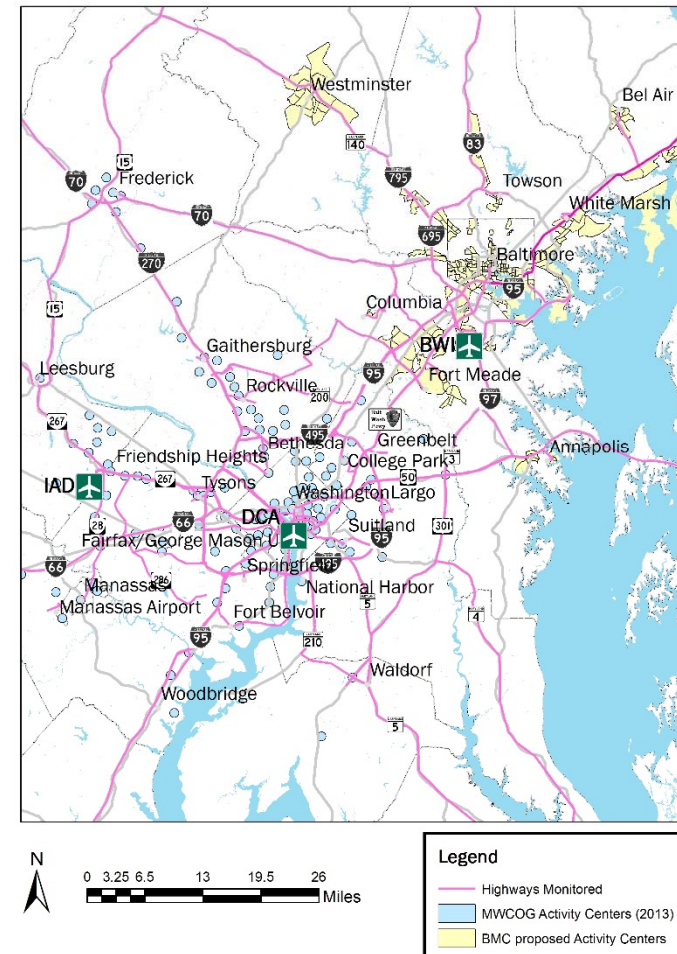
SafeTrack Congestion Analysis (2016/17)

- As part of a regional examination of the impacts of the WMATA SafeTrack surges, vehicle probe data were used to look at traffic congestion regionally and proximate to surge work areas



2015 Regional Airport Ground Access Study

- Computed mean speeds, average travel time, travel time index (TTI) and planning time index (PTI)
- For this recurring project, first time with a “big data” approach – millions of records processed
- Cost savings versus previous studies that used “floating car” methodology
- Ability to expand study due to availability of probe data (e.g., more origins, more time periods)



Outlook

- RITIS remains a critical system for the region's transportation planning and operations activities, especially through:
 - Breadth and coverage of data
 - Time and cost-saving tools
 - Data storage
 - “Invisible” data exchanges
 - Ties between operations experiences and planning activities

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