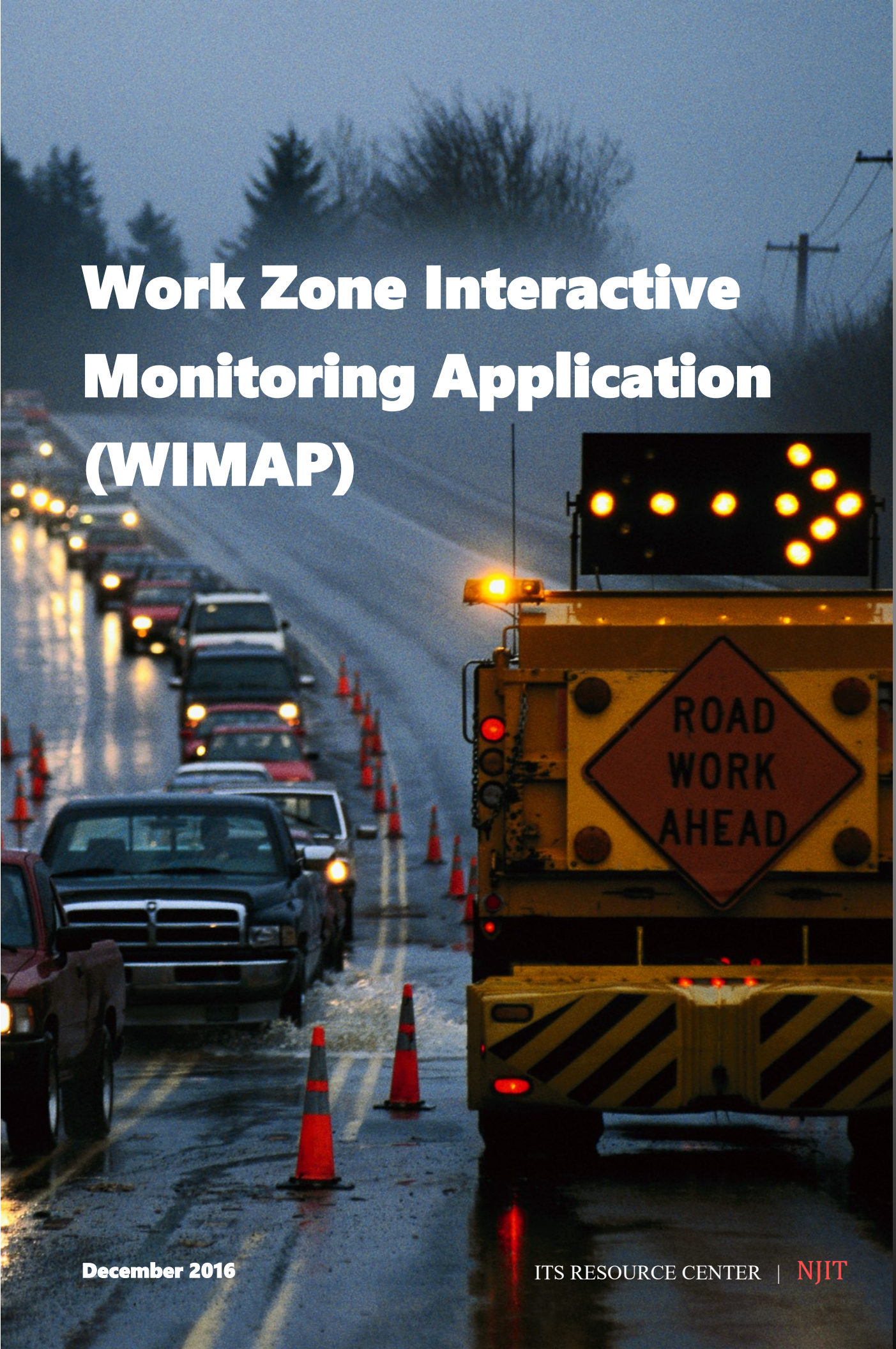
Work Zone Interactive Monitoring Application (WIMAP)



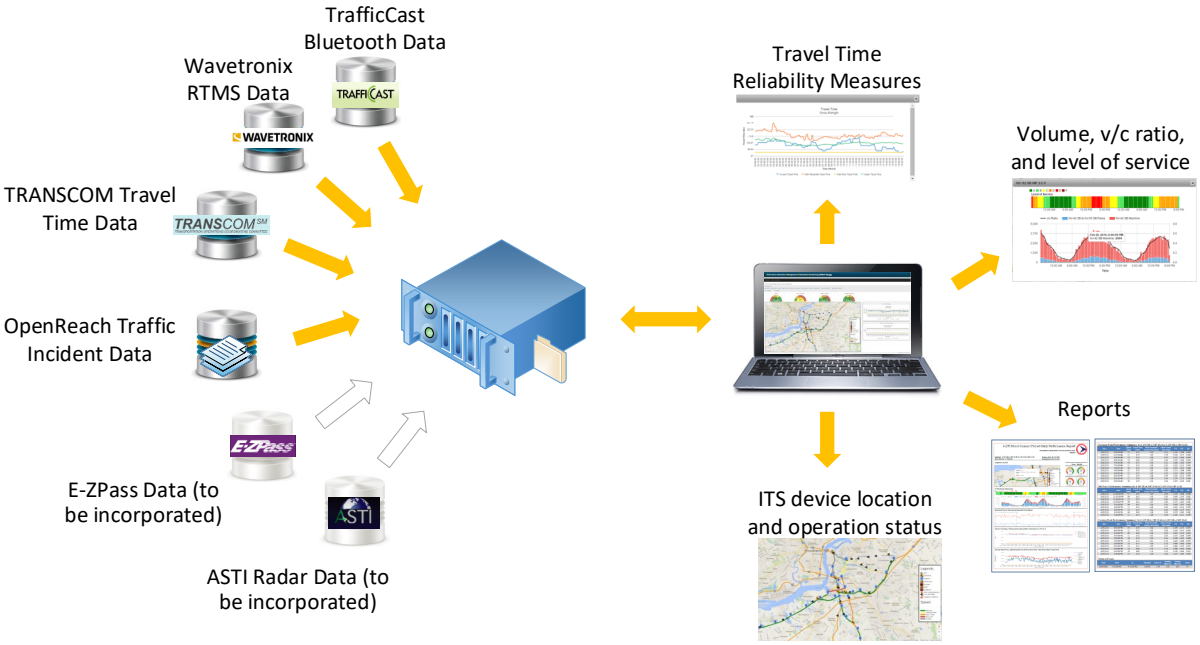
WIMAP QUICK START GUIDE

December 2016

ITS RESOURCE CENTER | NJIT

WIMAP Development

The New Jersey Department of Transportation (NJDOT) recently initiated the I-295 Direct Connection Project, a major highway interchange reconfiguration project for I-295/I-76/NJ-42 in Camden County. The construction project commenced in March 2013 and it was expected to complete in 2021. For the duration of the project, lane closures (both short-term and long-term) and traffic diversion are necessary and expected. With the anticipation of the potentially significant impact of the lane closures on the already saturated network, a web-based performance measure system, namely Work Zone Interactive Monitoring Application (WIMAP), was proposed. WIMAP is being developed by the Intelligent Transportation System Resource Center (ITSRC) of New Jersey Institute of Technology (NJIT) in research partnership with NJDOT.



WIMAP System Architecture

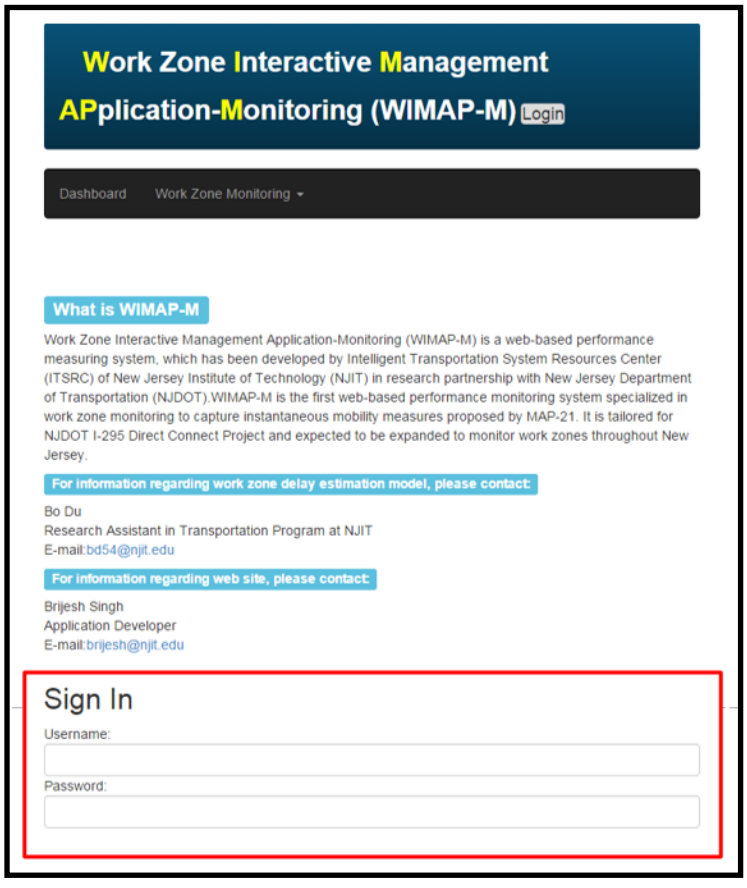
System Requirement

WIMAP is web-based and free of installation. Most internet browsers support WIMAP, including:

- Google Chrome
- Microsoft Internet Explorer
- Mozilla Firefox
- Apple Safari.

Login Instructions

The URL for WIMAP is: http://transprod04.njit.edu/WZMApplication/



WIMAP Sign-in Page

Currently, there are 2 types of credentials: the agency credential and the public credential.

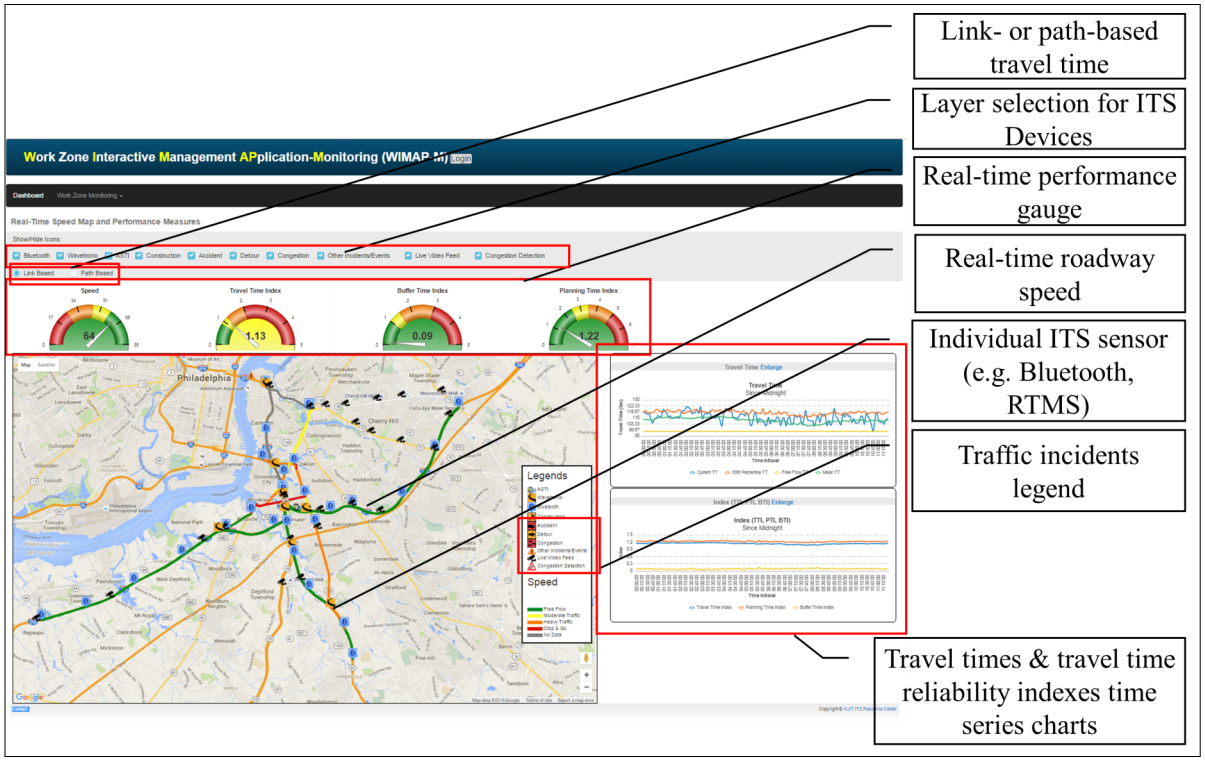
Public Credential: This type of credentials can be generated by the general public and it is free of charge. However, public credential access is limited for certain content (e.g. no mass data downloading privilege).

Agency Credential: This type of credentials allows access to historical data, report generator, and downloadable contents. However, only the system administrator can grant agency credential access.

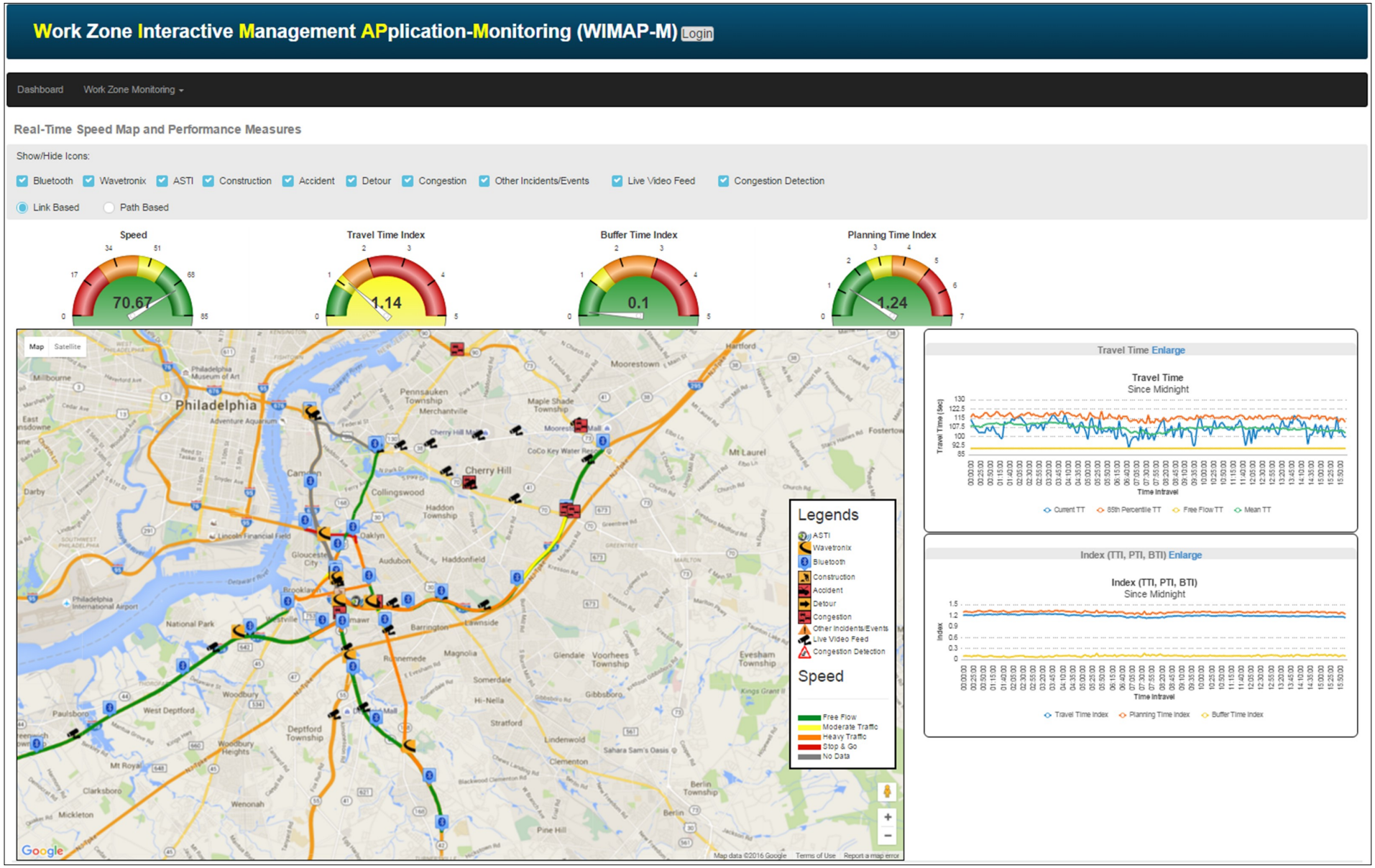
Application Overview

A snapshot of the WIMAP dashboard is shown below with the major components highlighted. This intuitive web-based interface serves as a data portal and allows users to retrieve and display real-time traffic information.

Users can select the instrumented roadway segment of interest. Upon selection, all of the available performance measures are displayed. For information purposes, a dashboard screenshot with higher resolution is shown on the next page.



WIMAP Dashboard Overview



WIMAP Dashboard

Database Overview

WIMAP has been gathering traffic data on a real-time basis. Advanced 4G LTE communication has been established between each individual RTMS and the database server hosted in ITSRC of NJIT. For the Bluetooth sensor data, Open research data, and Plan4Safey data, WIMAP has been directly collecting real-time data feeds from the respective server as well.

Users are able to access the database via the WIMAP web application which is hosted on a application server in ITSRC.

Collection Time	Pair ID	Route Info	Direction	Speed	Travel Time	Last Match Time
11/11/2013 12:25:13 AM	11210	Route 295 MP 15.28 to Route 295 MP 17.24	N	65	109	11/11/2013 12:20:53 AM
11/11/2013 12:25:13 AM	11211	Route 295 MP 17.24 to Route 295 MP 15.28	S	64	111	11/11/2013 12:18:14 AM
11/11/2013 12:25:13 AM	11212	Route 295 MP 17.24 to Route 295 MP 19.28	N	58	126	11/11/2013 12:20:11 AM
11/11/2013 12:25:13 AM	11213	Route 295 MP 19.28 to Route 295 MP 17.24	S	63	116	11/11/2013 12:15:41 AM

Sample of TrafficCast Bluetooth Sensor Data

Check In Time	Lane Counts	Lane ID	Direc-tion	Speed (mph)	Volume (veh/hr)	Occupancy (% of time)	Speed 85th (mph)
2/4/2014 8:05:20 PM UT	6	1	S	66.07	15	7.9	70
		2	S	70.15	26	12.4	75
		3	S	74.14	26	12.4	75
		4	S	80.70	21	6.5	83
		5	S	73.43	23	6.5	78
		6	S	68.09	17	7.1	85

Sample of Remote Traffic Microwave Senor Data

Link ID	Connection Time	Average Speed (mph)	Travel Time (second)
5361734	2014-02-04 14:56:29	108	203
5361734	2014-02-04 14:56:25	37	355
4329502	2014-02-04 14:56:30	92	91

Sample of Transmit Data

Contents	OpenReach	Plan4Safety
Data Source	STMC* & TOC' South	NJDOT Crash Records
Incident Starting time	√	√
Incident Ending time	√	X
Event Description	√	X
Interstate, US, and State Hwy	√	√
Local Roads	X	√
Other Incidents (except Crash)	√	X
No. of Lane closed	√	X
Mile Post from and to	√	X

Sample of Traffic Event Data (OpenReach & Plan4Safety)

WIMAP Performance Measures

Performance Measure

With the data collected, a variety of performance measure could be computed in WIMAP. WIMAP groups performance measures into three categories

- Mobility performance measures
- Travel time reliability performance measures
- Safety performance measures

Performance Measure	Definition
Mobility Performance Measure	• Spot Average Speed: real-time speed at RTMS location • Link Average Speed: real-time link average speed at BT-instrumented segment • 85th & 95th percentile Travel Time: the travel time at or below 85% (or 95%) of all samples of a data collector • Level of Service (LOS): LOS (as defined Highway Capacity Manual) measured at the RTMS Location • Occupancy: percentage of time vehicles are over a RTMS
Travel Time Reliability Performance Measure	• Travel time index (TTI): the mean travel time/ free-flow travel time • Planning time index (PTI): the 95th travel time/ mean travel time • Buffer time index (BTI): (the 95th percentile travel time – the mean travel time) / the mean travel time
Safety Performance Measure	• Number of crash • Crash records • Crash locations

Major Features

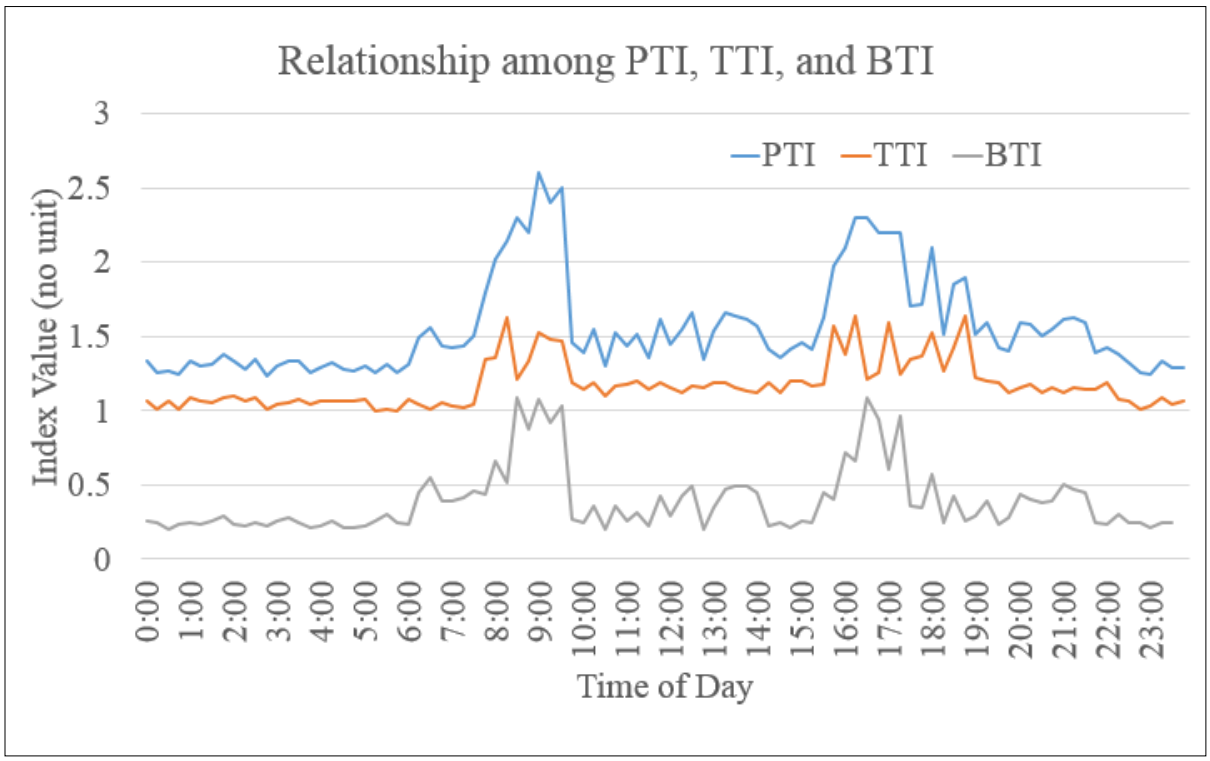
Function Group	WIMAP Features
Real-Time Traffic Performance Measures	• Link-based Travel Time Reliability Measures • Path-based Travel Time Reliability Measures • Location-based Performance Measures
Additional Monitoring Tools	• Level of Service Overview • Report Generator • Archived Data Geospatial Plotting • Real-time CCTV Camera Feed • Congestion Detection • Real-time ITS Device Status • Traffic Incident Alert

Link-based Travel Time Reliability Performance Measures

The link-based travel time is based on a single segment captured by two Bluetooth sensors at both ends of the link. The link-based travel time is obtained by matching: 1) the time stamps of each median access control (MAC) address of the Bluetooth-enabled mobile devices and 2) the Bluetooth sensors' locations and distances. Instant travel time, mean travel time, free flow travel time, and 85th percentile travel time (which is the 85th longest travel time ranking on an ascending order) can be computed.

In addition, the MAP-21-recommended travel time reliability indexes (i.e. travel time index (TTI), planning time index (PTI), and buffer time index (BTI) are able to be derived from the collected travel times. The relationship among these three indexes was demonstrated. The PTI measures the roadway-specific heaviest traffic days. By definition, it is the time a road user is required to allocate for the journey in order to have 95 out of 100 on–time arrivals. The TTI is the ratio between mean travel time and free flow travel time, which measures the deviation of current travel time to the historical mean travel time, while the BTI, as indicted visually, is the difference between the PTI and TTI. A roadway segment with a low BTI indicates high travel time reliability for road users. (i.e. a road user does not have to plan a

large amount of extra time in order to buffer potential delays caused by congestion.)



Path-based Travel Time Reliability Performance Measures

In view of the possible insufficient coverage of link-based travel time in certain monitoring applications (e.g. origin-destination monitoring), path-based travel time reliability is approximated based on the links that are constituting a path. Aforementioned travel times, as well as the 3 travel time reliability indexes, are made available.

Location-based Performance Measures

Unlike Bluetooth sensors, the RTMS measures the speed, volume, and lane occupancy of a point of roadway. Besides the basic traffic flow characteristics, the volume-to-capacity (v/c) ratio (measuring the level of saturation) and the level of service (LOS) could be calculated instantly by WIMAP. Details regarding the performance measure is discussed in the following parts of this manual.

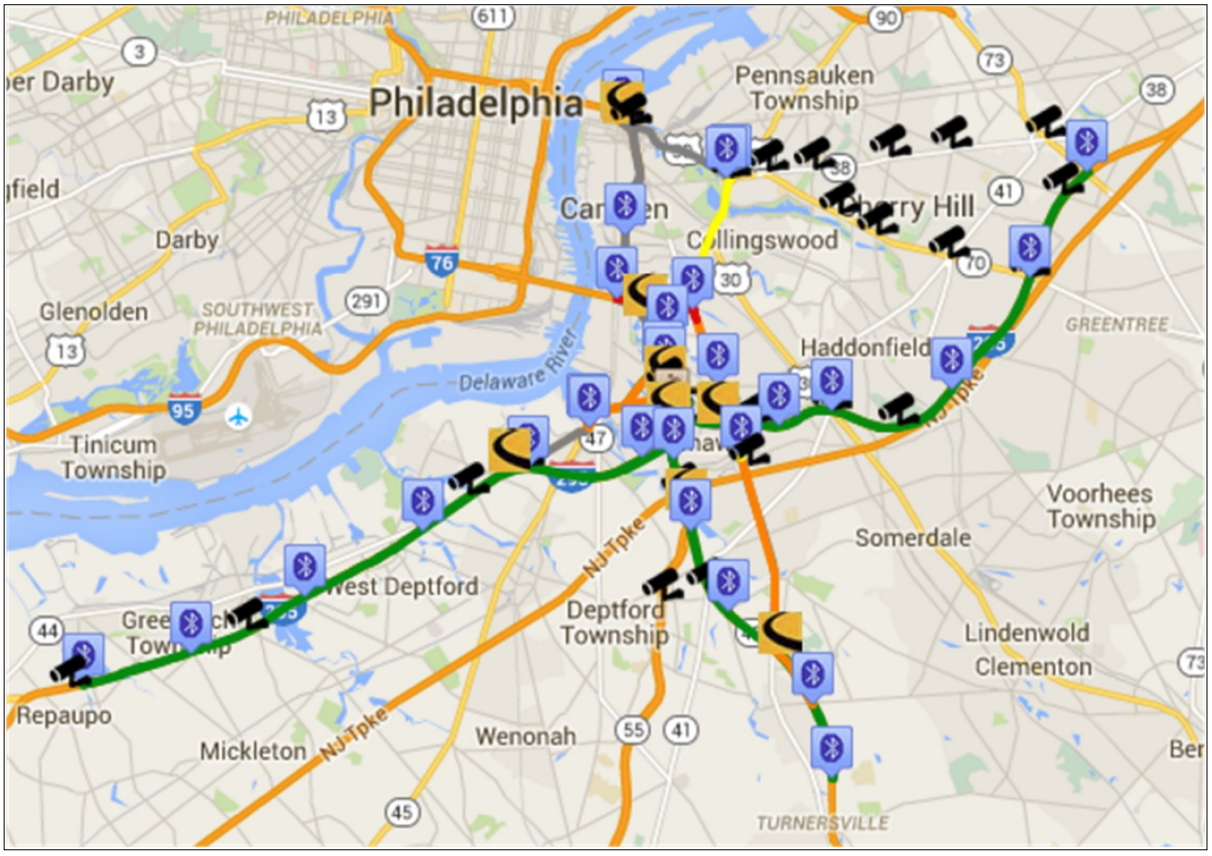
Sensor Deployment

Below are the current sensors (e. g. Bluetooth sensors, CCTVs, electronic toll readers). which are strategically deployed in the I-295 work zone area.

Sensor deployment is imperative in building a real-time monitoring system like WIMAP. During the planning stage of WIMAP, various types of sensors had been considered. The major factors for sensor selection include:

- Ease of deployment
- Detection coverage
- Data transmission in real time
- Sample size
- Track record.

RTMS, as one of the latest non-intrusive traffic detection technologies, is gaining increasing popularity among transportation agencies. RTMS are typically deployed on the overhead area (e.g. light pole) with microwaves intermittently sent out to capture traffic flow information. Using them as the backbone for real-time monitoring, WIMAP employs 10 remote RTMSs, as shown in the work zone area, and they provide:



WIMAP ITS Sensor Deployment

- Instantaneous traffic flow speed
- Volume information
- Lane occupancy.

In addition, other important performance measures can be subsequently derived:

- Volume-to-capacity (v/c) ratio
- Level of service (LOS).

The second type of sensor of choice is the Bluetooth sensor. Bluetooth has been recognized as a global standard protocol suitable for mid- to short-range wireless communications between two mobile devices (e.g. laptops, smartphones, or tablets). One of the unique features of Bluetooth is its ability to identify enabled devices by capturing their Media Access Control (MAC) addresses without data authentication procedures. In general, the MAC address matching rate of BlueTOAD in 2012 is approximately 4% of the daily traffic stream. With the ever-increasing connection capabilities of personal mobile devices, the market penetration rate of Bluetooth is expected to increase, yielding a larger and larger sample size for this technology.

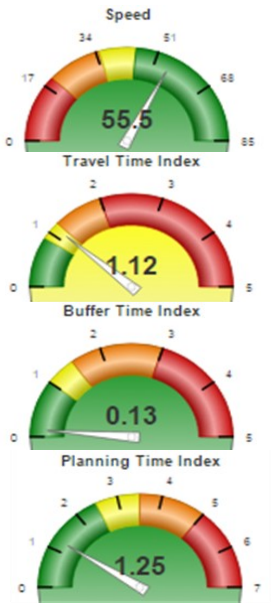
ITS Sensor Type	Data collected	Supporting Functionality	Advantages
Remote traffic microwave sensor (RTMS) (coverage 250ft)	• Traffic volume • Speed • Lane occupancy	• Traffic diversion effectiveness evaluation • Volume-to-capacity ratio • Level of service	• Not intrusive to traffic deployment • Insensitive to weather condition • Covers up to 22 lanes • Captures speed & flow accurately (vehicle-based detection)
Bluetooth sensor (coverage 300ft)	• Segment average travel time	• Link- & path-based travel times • Link- & path-based travel time reliability index	• Not intrusive to traffic deployment • Captures Bluetooth-enabled mobile device • Increasing market penetration
Electronic toll collection (ETC) tag reader (coverage 40ft)	• Segment average travel time	• Link-based travel times	• Not intrusive to traffic deployment • Passive RFID-based technology • More than 40% market penetration

Deployed ITS Sensor Technical Summary

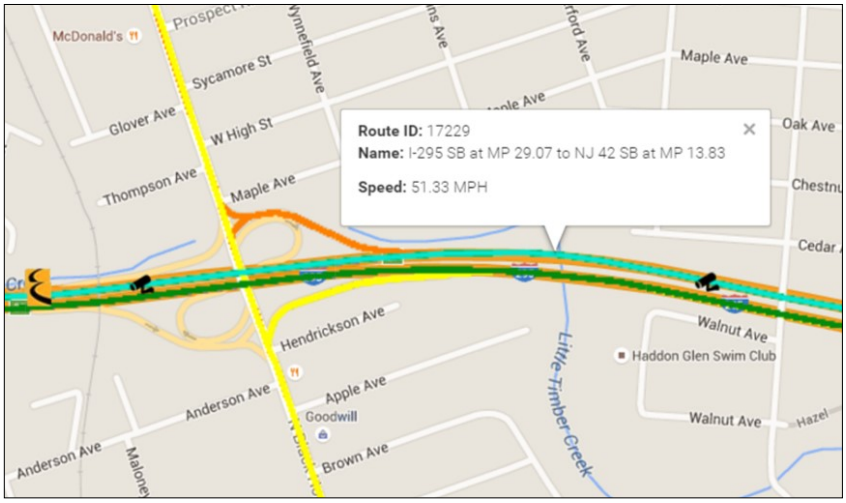
Travel Time Reliability

Link-based Travel Time Reliability

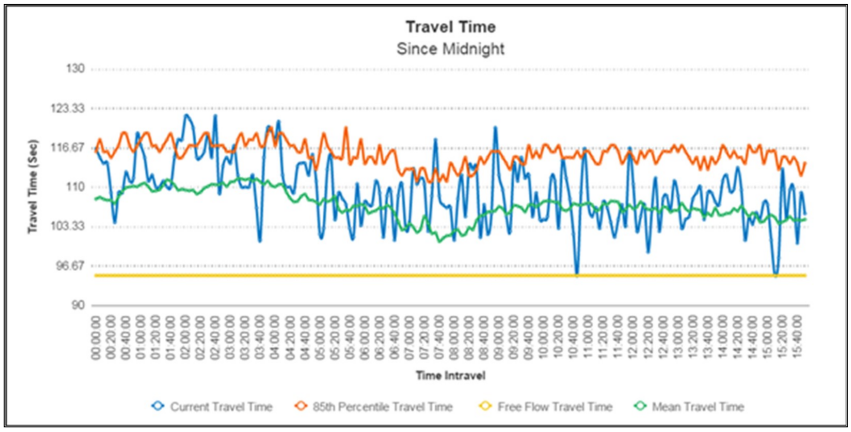
Under the link-based mode, users can move the mouse pointer to the roadway of interest. After clicking on it, road information will be shown on the screen. The time series plots on the right side will also refresh accordingly. The upper one displays the current travel time, 85th percentile travel time, free flow travel time and the mean travel time; while the lower chart shows travel time index, planning time index and buffer time index. Also, the four gauges on the upper side, which are real-time speed, travel time index, buffer time



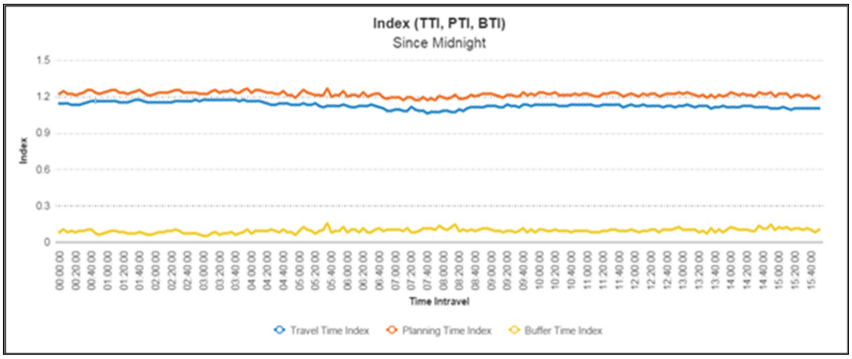
Performance Gauges



Highlighted Instrumented Roadway Segment



Time Series Plot of Travel Time



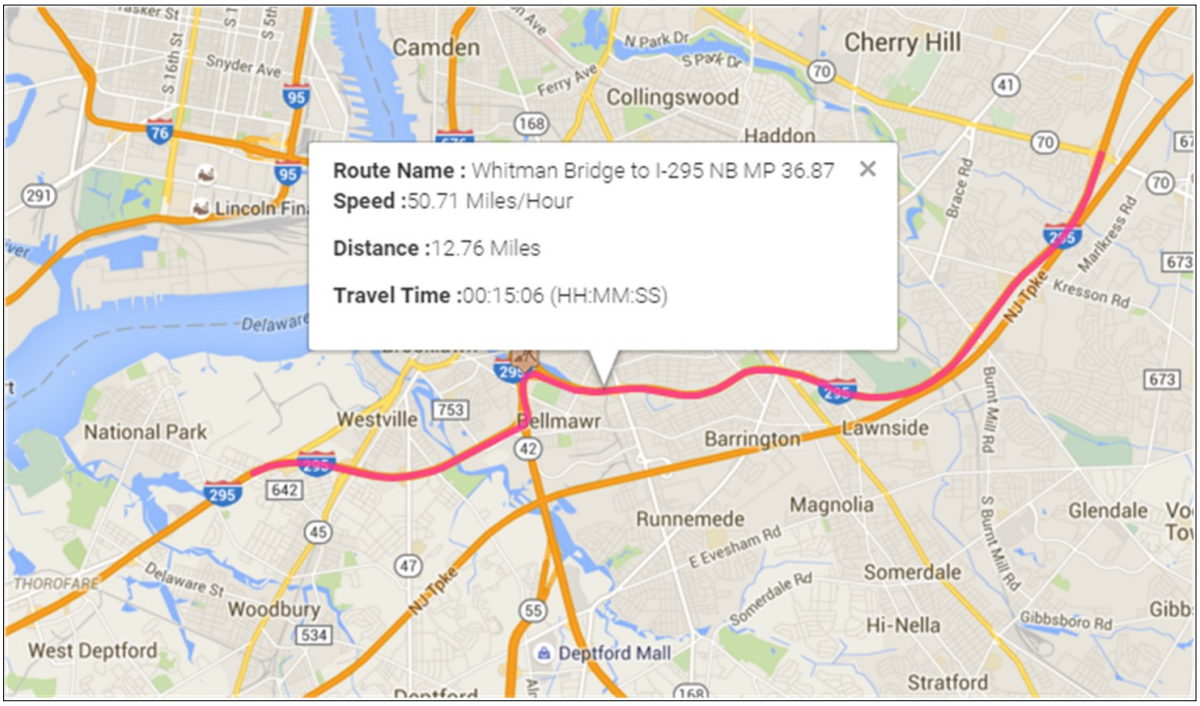
Time Series Plot of Travel Time Reliability Indexes

index and planning time index, all refresh at the same time, upon selection.

Path-based Travel Time Reliability

The path-based travel time reliability performance measures are also available in the dashboard, when selected. More granular information becomes available after WIMAP automatically zooms in on the path of interest.

With an approximation provided, the user can evaluate the overall path congestion. Origin-destination pairs in the greater work zone area have been determined based on historical traffic volume and geometric conditions. Each path (route) represents a major commuter route within the area. By comparing the "before" and "during" work zone travel times, the potential impact of the work zone could be estimated. For long-term lane shift or closure, the impact should be reflected even in the travel time reliability indexes. Moreover, with path-based travel time, combined with volume data obtained by RTMS, the change of origin-destination demand can be estimated to measure the change of traffic patterns.

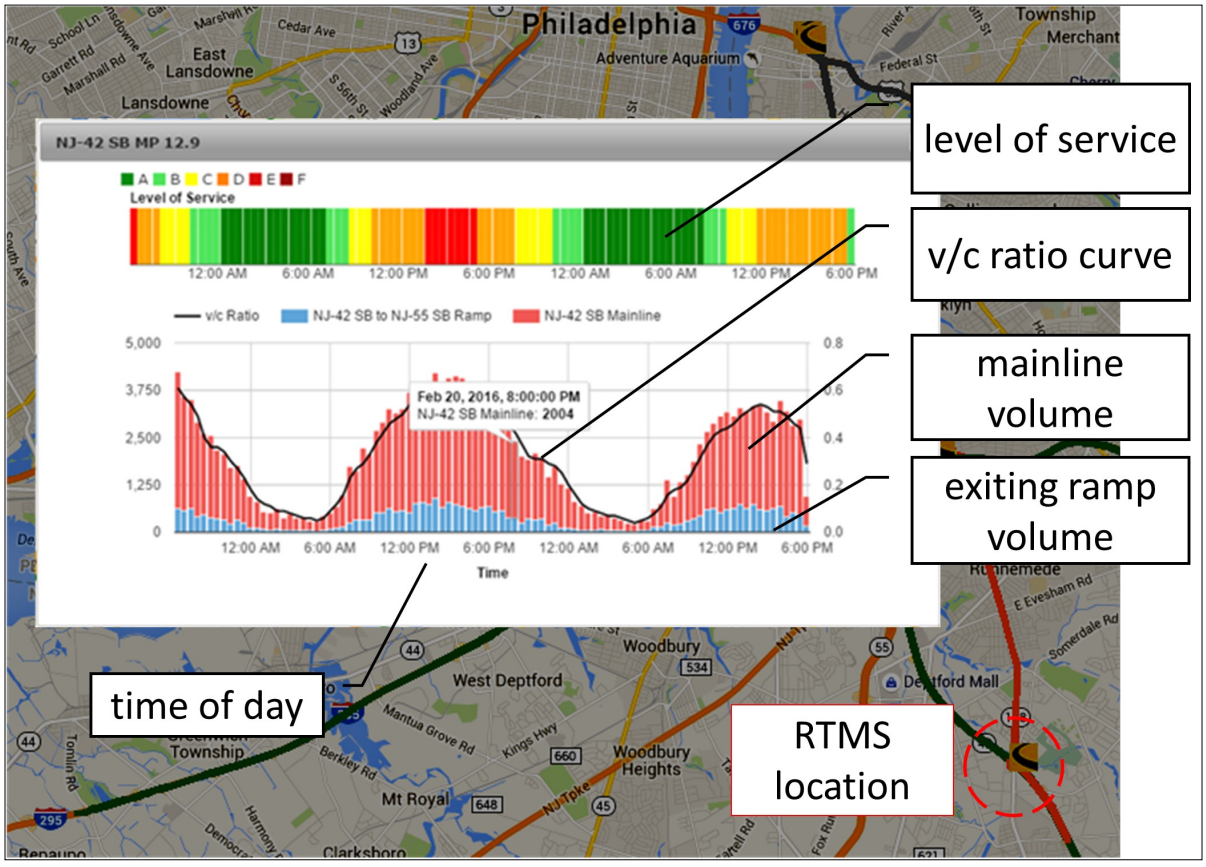


O-D Path of Interest (example)

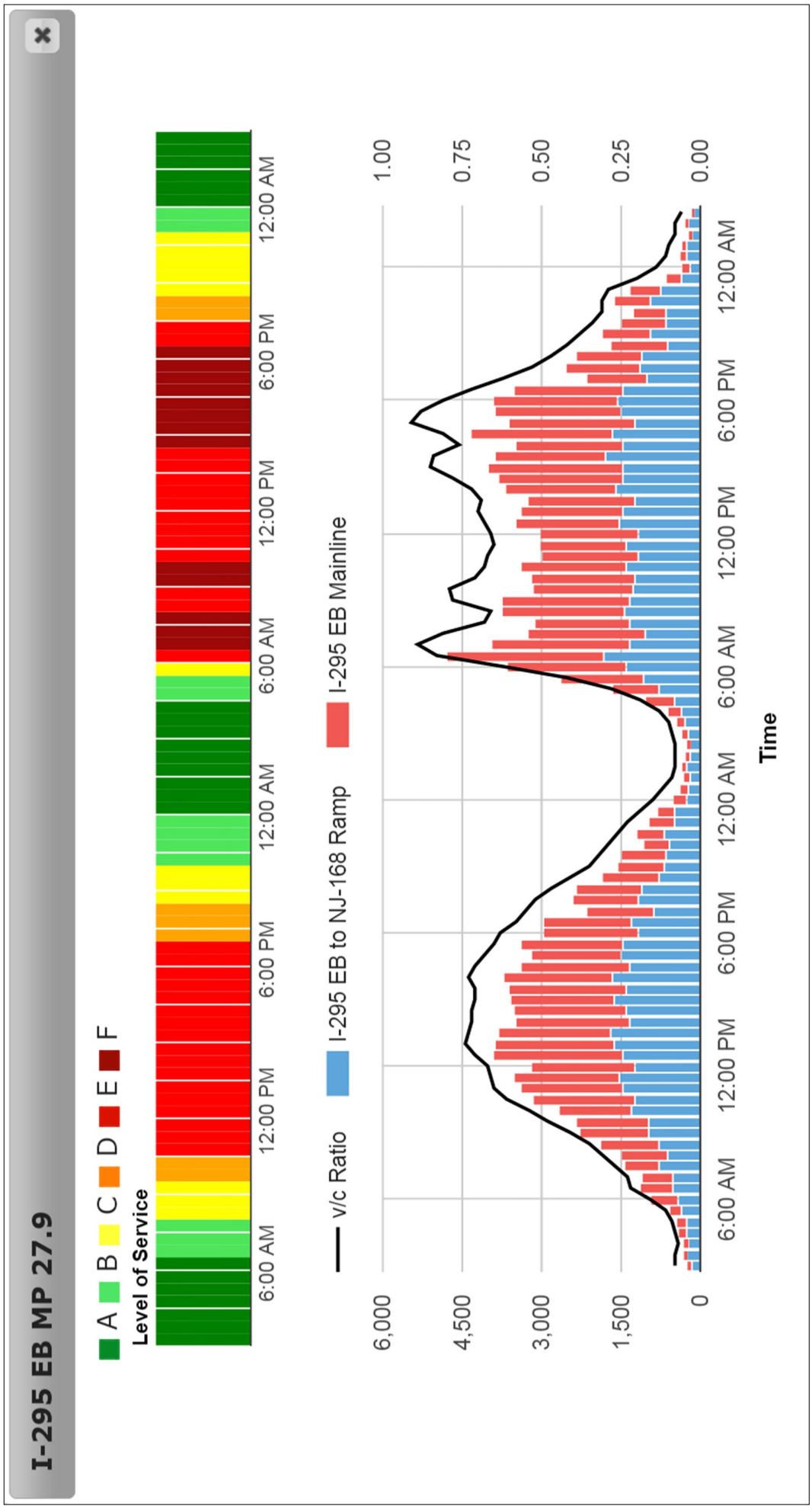
Location-based Performance Measures

The charts pertaining to location-based data collected by RTMS displays for the user once the yellow RTMS data icon on the map is selected. Because of the strategic locations of the RTMSs, two distinctive types of volume (i.e. mainline volume and ramp volume) are available, as shown below. Available data (up to the latest 5 minutes) is listed as follows:

- Mainline Volume
- Ramp Volume
- Volume/capacity ratio
- Level-of-service (LOS).



Location-based Performance Measures Window Overview

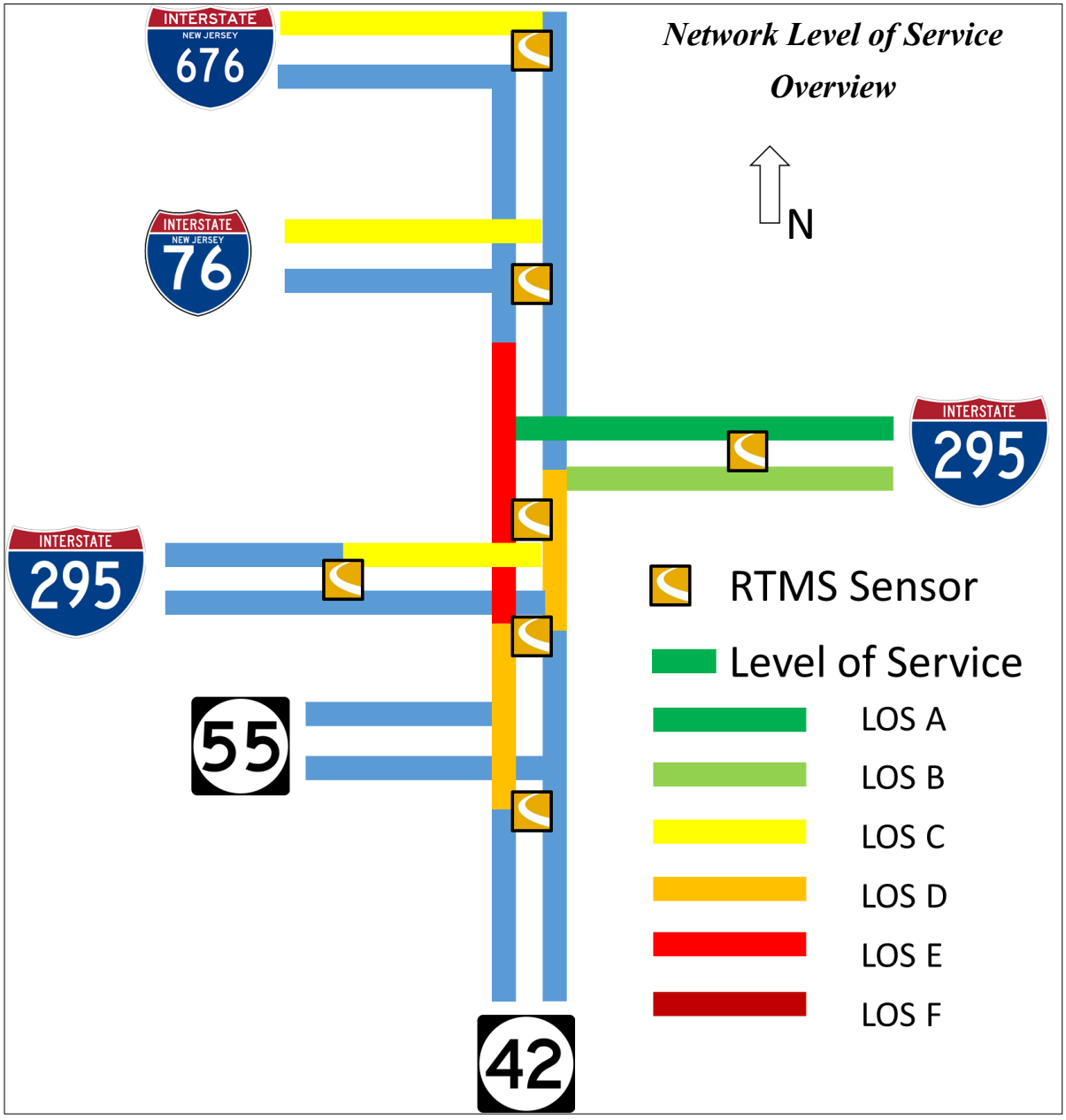


WIMAP Location-based Performance Measure Window

Additional Monitoring Tools

Level of Service Overview

Utilizing the RTMS data collected from the work zone area, WIMAP is able to generate a simplified map as shown below with only the essential roadway geometric information preserved. Users are able to understand the overall network traffic status in a straightforward visualization mode.



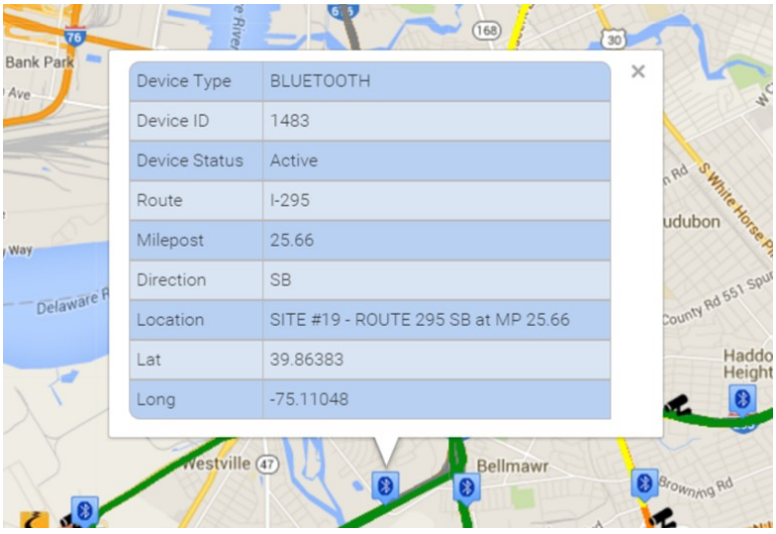
Real-time CCTV Camera Feed

In addition to the network level of service overview, WIMAP also provides real-time CCTV camera feed by streaming live CCTV footage from the NJ 511 website, enabling the operators to conveniently obtain visual confirmation of any traffic incident which may cause congestions or delays.

Real-time CCTV Camera Feed

Real-time Device Inventory

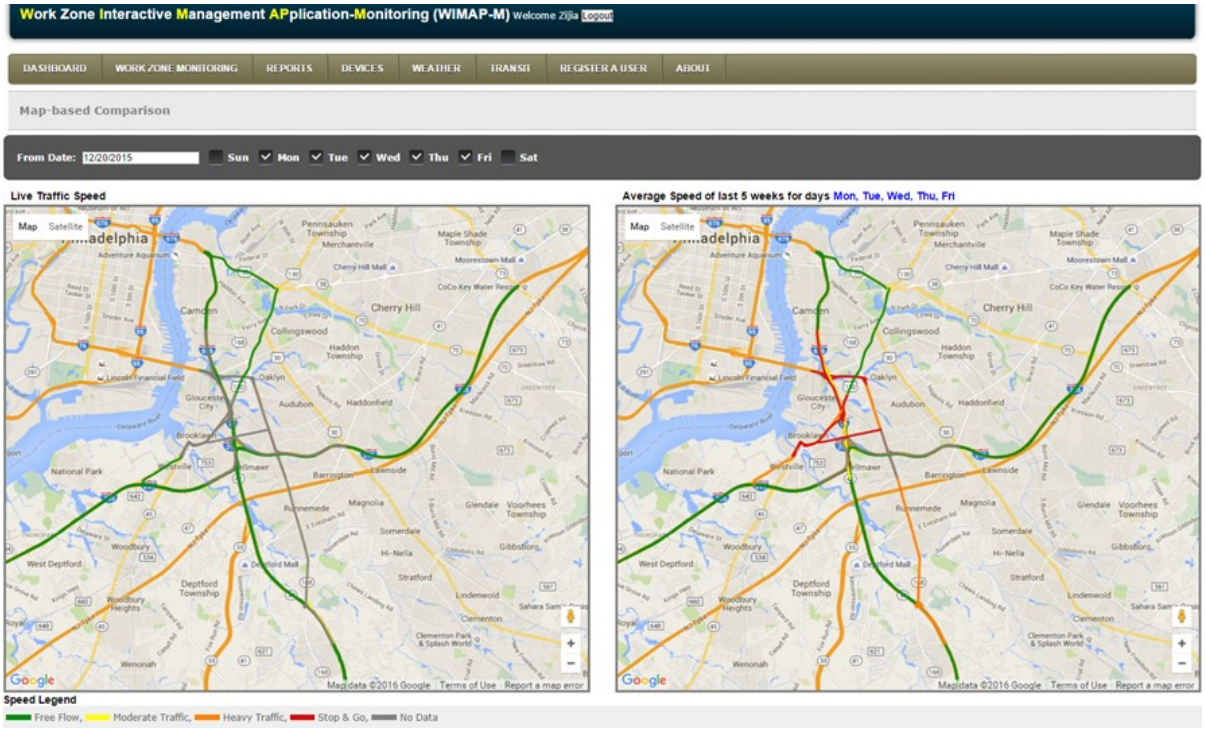
The device inventory module provides users with information regarding the status of all ITS devices deployed in the proximity of the work zone, including device location and operational status, in a user-friendly map-based interface. It provides valuable real-time information regarding the devices, for a more efficient maintenance ability.



Real-time Device Inventory

Archived Data Mapping

WIMAP is able to retrieve the historical data stored on its database server and conduct geospatial plotting for visual analytics. By default, WIMAP is able to retrieve traffic data for the previous 3 months and then map the data side-by-side with the real-time traffic status maps. Moreover, WIMAP also allows the user to select the range of the historical data on demand and then produces the comparison in side-by-side traffic status maps.



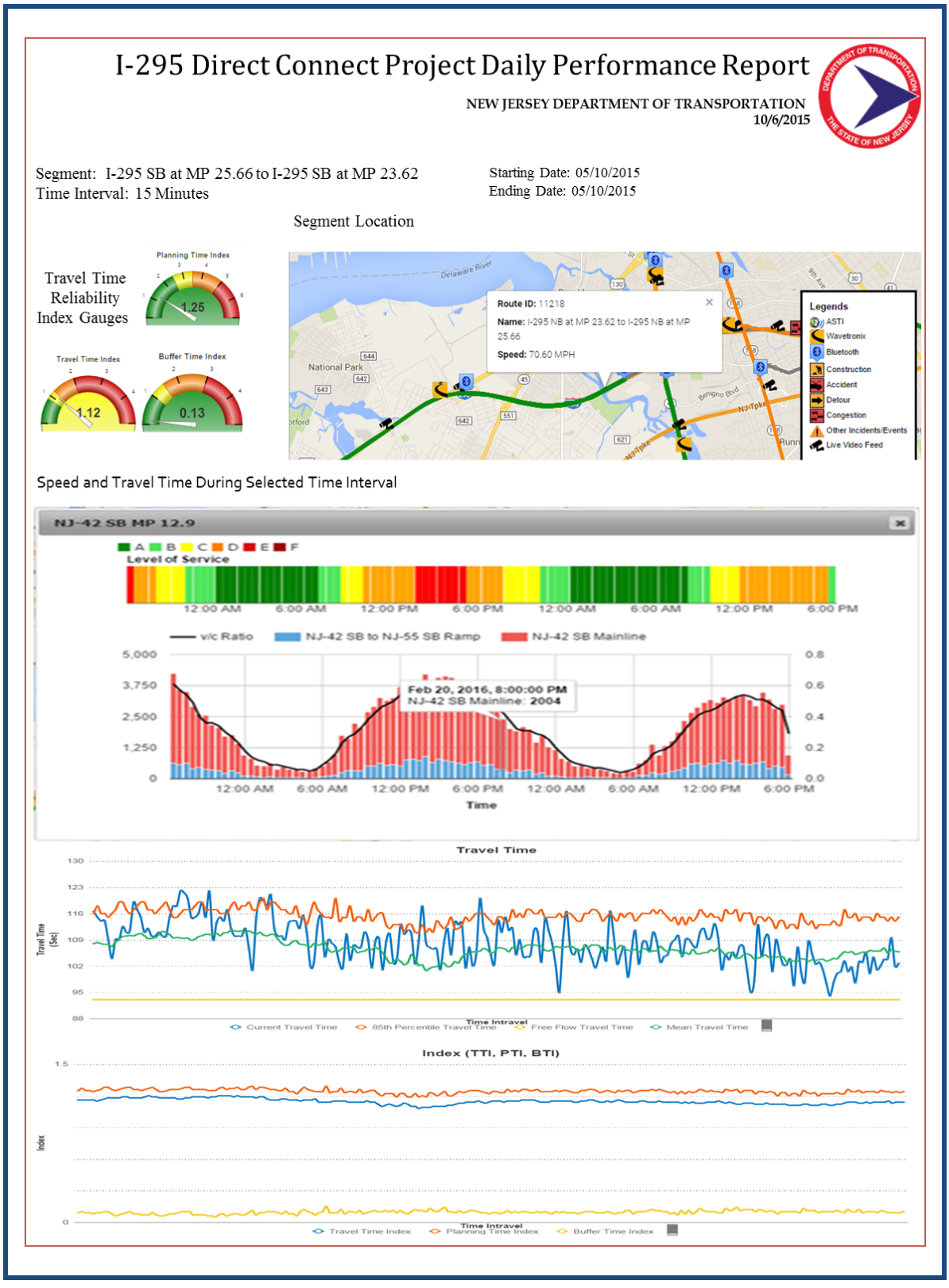
Archived Data Geospatial Mapping

Report Generator

WIMAP can generate reports like the sample shown below by gathering all the available information in the data archived in a specific time period for authorized users. It also offers the flexibility to generate custom reports for users by specifying selected requirements.

WIMAP

ADDITIONAL TOOLS



I-295 Direct Connect Project Daily Performance Report

NEW JERSEY DEPARTMENT OF TRANSPORTATION
10/6/2015

Segment: I-295 SB at MP 25.66 to I-295 SB at MP 23.62
Time Interval: 15 Minutes

Starting Date: 05/10/2015
Ending Date: 05/10/2015

Segment Location

Travel Time Reliability Index Gauges

Planning Time Index 1.25

Travel Time Index 1.12

Buffer Time Index 0.13

Route ID: 11218
Name: I-295 NB at MP 23.62 to I-295 NB at MP 25.66
Speed: 70.60 MPH

Legends
ASTI
Wavetronix
Bluetooth
Construction
Accident
Detour
Congestion
Other Incidents/Events
Live Video Feed

Speed and Travel Time During Selected Time Interval

NJ-42 SB MP 12.9

Level of Service

v/c Ratio | NJ-42 SB to NJ-55 SB Ramp | NJ-42 SB Mainline

Feb 20, 2016, 8:00:00 PM
NJ-42 SB Mainline: 2004

Time

Travel Time

Current Travel Time | 85th Percentile Travel Time | Free Flow Travel Time | Mean Travel Time

Index (TTI, PTI, BTI)

Travel Time Index | Planning Time Index | Buffer Time Index

WIMAP Summary Report (cover page)

Morning Peak Performance Summary for I-295 SB at MP 25.66 to I-295 SB at MP 23.62

Date	Time	Speed (mph)	Travel Time (min)	95th Percentile Travel Time (min)	Mean Travel Time (min)	TTI	PTI	BTI
10/5/2015	6:00:00 AM	71	1.75	1.87	1.81	1.130	1.209	0.079
10/5/2015	6:15:00 AM	71	1.75	1.87	1.79	1.131	1.210	0.079
10/5/2015	6:30:00 AM	72	1.74	1.86	1.87	1.122	1.201	0.079
10/5/2015	6:45:00 AM	74	1.68	1.80	1.84	1.087	1.163	0.076
10/5/2015	7:00:00 AM	73	1.71	1.83	1.81	1.104	1.182	0.077
10/5/2015	7:15:00 AM	71	1.75	1.88	1.82	1.132	1.211	0.079
10/5/2015	7:30:00 AM	70	1.78	1.91	1.81	1.150	1.230	0.080
10/5/2015	7:45:00 AM	72	1.73	1.85	1.80	1.116	1.194	0.078
10/5/2015	8:00:00 AM	71	1.75	1.87	1.82	1.126	1.205	0.079
10/5/2015	8:15:00 AM	71	1.75	1.88	1.83	1.132	1.211	0.079
10/5/2015	8:30:00 AM	71	1.76	1.89	1.84	1.137	1.216	0.080
10/5/2015	8:45:00 AM	70	1.79	1.92	1.83	1.157	1.238	0.081

Off-Peak Performance Summary for I-295 SB at MP 25.66 to I-295 SB at MP 23.62

Date	Time	Speed (mph)	Travel Time (min)	95th Percentile Travel Time (min)	Mean Travel Time (min)	TTI	PTI	BTI
10/5/2015	12:00:00 PM	71	1.75	1.87	1.83	1.130	1.209	0.079
10/5/2015	12:15:00 PM	69	1.81	1.93	1.85	1.165	1.247	0.082
10/5/2015	12:30:00 PM	72	1.74	1.86	1.85	1.121	1.199	0.078
10/5/2015	12:45:00 PM	69	1.81	1.94	1.86	1.170	1.252	0.082
10/5/2015	1:00:00 PM	69	1.81	1.94	1.82	1.168	1.250	0.082
10/5/2015	1:15:00 PM	71	1.75	1.88	1.82	1.132	1.211	0.079
10/5/2015	1:30:00 PM	73	1.70	1.82	1.82	1.096	1.173	0.077
10/5/2015	1:45:00 PM	68	1.83	1.96	1.83	1.179	1.262	0.083
10/5/2015	2:00:00 PM	71	1.75	1.88	1.83	1.131	1.210	0.079

Evening Peak Performance Summary for I-295 SB at MP 25.66 to I-295 SB at MP 23.62

Date	Time	Speed (mph)	Travel Time (min)	95th Percentile Travel Time (min)	Mean Travel Time (min)	TTI	PTI	BTI
10/5/2015	4:30:00 PM	74	1.70	1.82	1.81	1.095	1.172	0.077
10/5/2015	4:45:00 PM	71	1.75	1.87	1.83	1.130	1.210	0.079
10/5/2015	5:00:00 PM	69	1.80	1.93	1.84	1.162	1.243	0.081
10/5/2015	5:15:00 PM	71	1.75	1.87	1.82	1.127	1.206	0.079
10/5/2015	5:30:00 PM	70	1.78	1.90	1.81	1.148	1.229	0.080
10/5/2015	5:45:00 PM	72	1.74	1.87	1.78	1.125	1.204	0.079
10/5/2015	6:00:00 PM	73	1.72	1.84	1.76	1.108	1.185	0.078
10/5/2015	6:15:00 PM	73	1.71	1.83	1.72	1.101	1.178	0.077
10/5/2015	6:30:00 PM	74	1.68	1.79	1.73	1.081	1.157	0.076
10/5/2015	6:45:00 PM	78	1.60	1.71	1.79	1.034	1.106	0.072
10/5/2015	7:00:00 PM	72	1.74	1.86	1.86	1.122	1.201	0.079

Table of Events

Date	From	To	Duration	Route ID	Starting Mile Post	Ending Mile Post	Event
10/5/2015	4:30:00 PM	5:30:00 PM	1:00:00	1.70	1.82	1.81	74

WIMAP Summary Report (table summary)