VALIDATION AND QUALITY MANAGEMENT OF THE SAN DIEGO I-15 ICM AIMSUN ONLINE REAL-TIME SIMULATION MODEL

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Abstract

The San Diego I-15 ICM U.S. DOT pilot project uses a state-of-the-art Decision Support System to help system operators evaluate and respond to incidents and other events throughout the corridor. Part of this system is a real-time microsimulation model using Aimsun Online. This model uses both analytics and microsimulation to predict traffic conditions at five-minute intervals over the next 60 minutes and evaluate potential response plans. In order to safeguard against forecasting errors and ensure operators' trust, the system needs to be able to track the quality of the predictions and the validity of the model. This paper describes the tolls and thresholds put together to provide this information.

Key Words:
Integrated
Corridor
Management
Decision
Support
Analytical
Prediction
Incident
Simulation
ATMS
ICM

INTRODUCTION

In late 2009 the I-15 corridor in San Diego, CA was selected by the U.S. DOT, as one of two sites to demonstrate their Integrated Corridor Management (ICM) system. The strong consortium of agencies in San Diego was increasing multi-jurisdictional and multi-agency collaboration on corridor management with the San Diego Association of Governments (SANDAG) as the lead agency. Caltrans, the City of San Diego, the City of Escondido, the City of Poway, the Metropolitan Transit System, and the North County Transit District accompanied SANDAG. The San Diego ICM team was responsible for designing, building and implementing the ICM system and was focusing the preliminary demonstration phase on the Interstate 15 corridor, a heavily congested north-south interstate corridor, where the ICM system was scheduled to go live in November 2012. This 21-mile stretch of road from SR 52 in San Diego to SR 78 in Escondido forms the primary artery for the movement of commuters, goods, and services from northern San Diego County to downtown San Diego. It was already a model for the deployment of the latest and evolving technologies for data collection, demand management, and pricing strategies through its I-15 High Occupancy Vehicle (HOV) Express Lanes Project.

Using Measures of Effectiveness (MOEs) such as travel time, delay, reliability and emissions, the San Diego team was evaluating various ICM strategies, including en-route and pre-trip traveller information; Responsive Traffic Light Synchronization; coordinated ramp metering; increased HOV occupancy requirements; and bus priority on arterials.

One of San Diego's core ICM strategies, however, was the configuration and implementation of a Decision Support System (DSS). The DSS is a "smart" traffic management system that gives system managers comprehensive awareness of the current and predicted performance of the entire corridor: building upon the state-of-the-art systems already in use on the I-15 it allows operators to take proactive steps to prevent system breakdown using enhanced controls across multi-jurisdictional devices such as traffic signals, ramp meters, and dynamic message signs.

DECISION SUPPORT SYSTEM (DSS)

The DSS, which allows operates to be proactive rather than reactive to traffic conditions, is comprised of three main components that differ from a typical advanced Traffic Management System (ATMS). Those components are the Business Rules Engine (BRPMS), the Network Predictive Subsystem (NPS) and the Real Time Simulation Subsystem (RTSS). Tying the three components together within the DSS are the data hub, that collects and stores all internal and external data sources in real-time and iNet, developed by Parsons, that provides the Graphical User Interface for graphically representing the system.

Network Prediction Subsystem (NPS)

The NPS is responsible for the details and accurate prediction of the future conditions of the network. It takes an accurate reproduction of the current traffic status by collecting the current status feeds from the data hub as the starting point and uses Aimsun Online analytics and microsimulation to forecast the next 60 minutes of network conditions. This information is produced every 5 minutes and stored within the data hub. Having a continuous 5 minute data flow helps to have a model that is always ready for evaluations, as the predictions are used to dynamically adjusting demands and generate the initial traffic states as a starting point to the next simulation.

Business Rules Engine (BRPMS)

The BRPMS, developed by Parsons, collects the NPS predictions from the data hub and uses them with the user-defined congestion thresholds to identify locations of non-reoccurring congestion by comparing them against historical data. Non-reoccurring congestion may be due to changes in either the demand or changes to the network capacity due to factors such as an incident, weather or construction. Based on the configured system parameters, the BRPMS then selects a number of alternate routes. When selecting the route the system checks for available devices (signals, ramp meters and signs) along the route that can be used as part of a response plan and that the routes have available capacity to handle additional traffic. When the routes and the devices have been selected the BRPMS generates a group of response plans to test the various strategies such as changes to the signal timing, ramp metering rate or posting new messages to the variable message signs. This process can generate anywhere from 1 to 12 response plans. Once the plans are generated they are sent to the RTSS, where Aimsun Online uses microsimulation to evaluate each response plan.

Real-Time Simulation Subsystem (RTSS)

The RTSS is responsible for evaluating and classifying each of the plans proposed by the BRPMS. This evaluation process is variable and can take anywhere from 3 to 10 minutes depending on the time of day, the impact of any events and the number of response plans. Once the evaluations are complete, the results from the simulations are stored on the data hub and the plans are given a score. The score is derived from a direct comparison of the microsimulation results of the response plans contrasted against the "Do Nothing" plan. The "Do Nothing" plan is as it sounds, the evaluation of the system with no changes to any of the device outside of normal operations. The comparison of the "Do Nothing" against each response plan is used to provide a traveler-based, timesaving metric (not a per vehicle metric). Once the best response plan has been selected, the system sends the requests to either the agencies or directly to the device (depending on the configuration) in order to implement the proposed strategy. Once the congestion is no longer present in the NPS predictions, the BRPMS steps out of the response plan stance and returns devices to their normal time of day operational mode. The general architecture of the DSS is shown in figure 1.

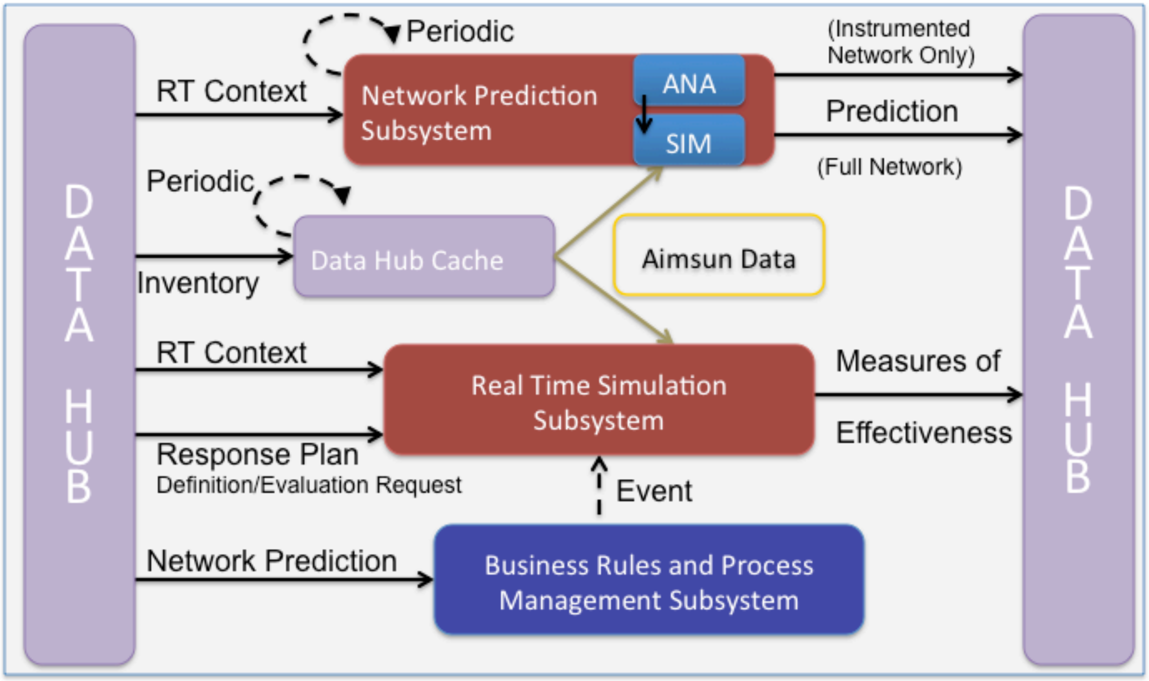

Figure 1. Decision Support Subsystem Design

AIMSUN ONLINE – THE NPS AND RTSS

The core engine of the RTSS and the NPS is Aimsun Online, which uses a microscopic Aimsun model. The base corridor and the corresponding microsimulation network structure are shown in figure 2.

Prior to creating the online model that runs 24 hours a day, 7 days a week, it was critical to have a well calibrated base typical day "offline" model and have a detailed understanding of the variation in traffic patterns through out the week, and during different conditions such as holidays, weekends, and adverse weather conditions. The calibration approach applied to the offline model is based off of the approaches laid out by the Federal Highway Administration (FHWA) within the Traffic Analysis Toolbox Volume IV[1] and Volume III[2]. Figure 3 (based on figure 45 from Volume IV) summarizes within a flow chart the basic iterative structure of the approach. After meeting the validation criteria a detailed visual audit was done with the local agencies before accepting the model for Online usage.

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[1] Peter Holm, Daniel Tomich, Jaimie Sloboden, Cheryl Lowrance, Traffic Analysis Toolbox Volume IV: Guidelines for Applying CORSIM Microsimulation Modeling Software, FHWA-HOP-07-079, Federal Highway Administration, January 2007

[2] Dowling, R., A. Skabardonis, and V. Alexiadis, Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software, FHWA-HRT-04-040, Federal Highway Administration, July 2004

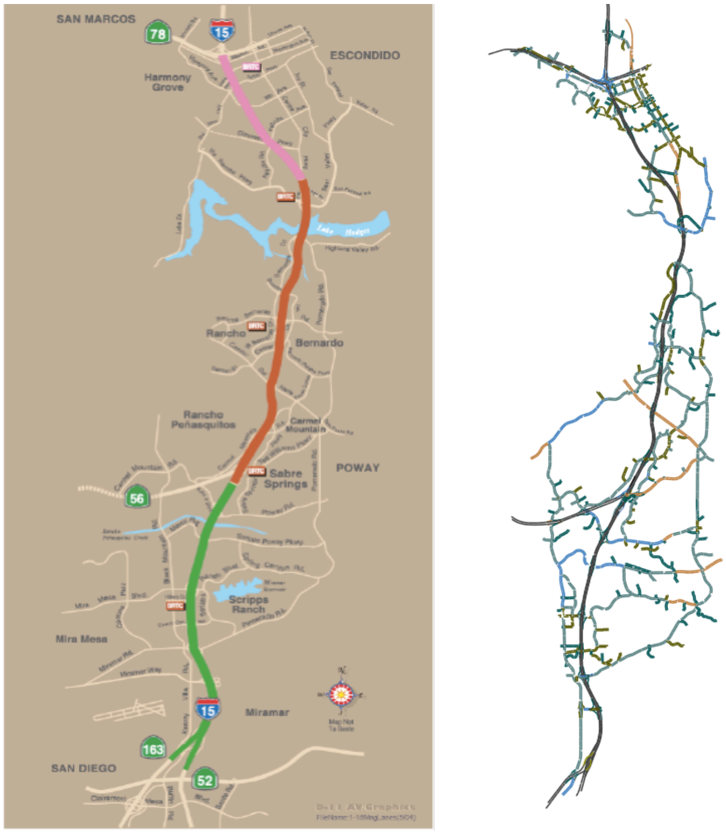


Figure 2. I-15 Corridor and the Aimsun Online Microsimulation Network

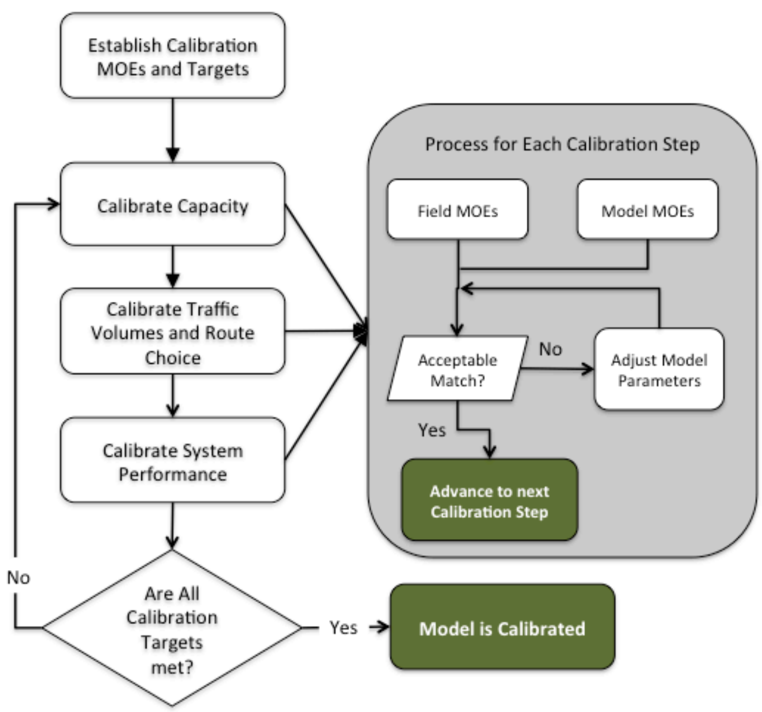


Figure 3. Calibration Approach Flowchart

To prepare the model for online usage an extensive review of the available historical data was performed, and the station detector data was analyzed to generate the initial 15-minute demands and identify the various day types. Figure 4 shows how the data from one Vehicle Detection Station (VDS) was used to help identify the day types.

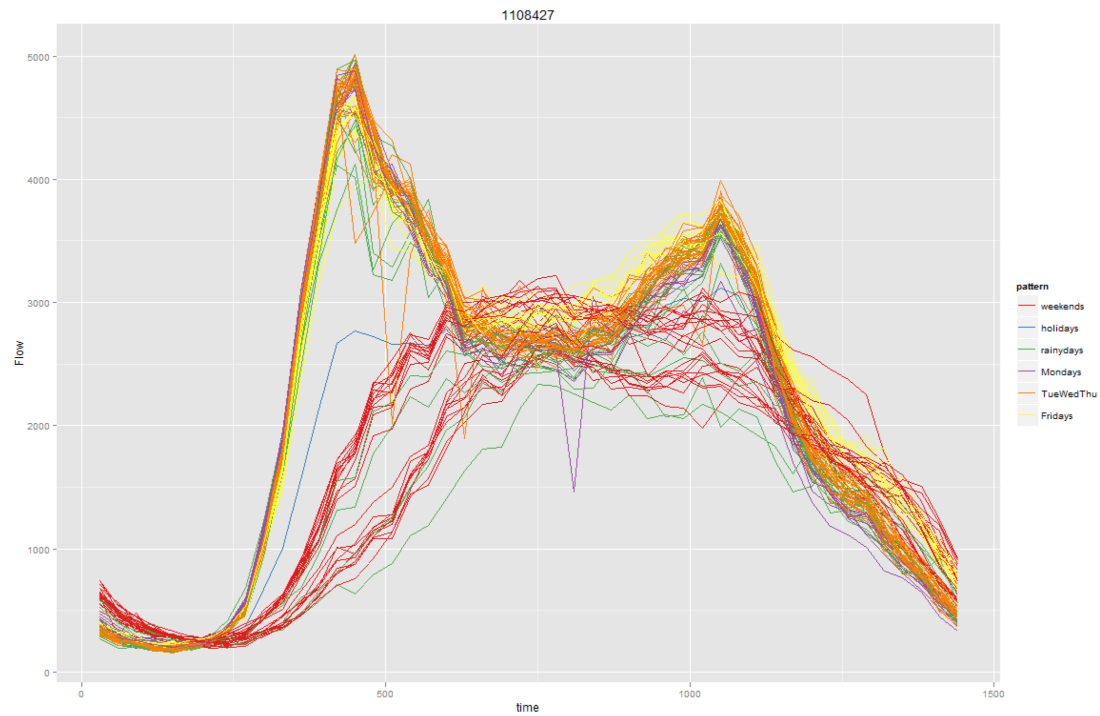


Figure 4. Patterns example for VDS ID-1108427

At the end of the analysis 11 different day patterns were identified, those patterns are the follows:

- Monday
- Tuesday and Thursday
- Wednesday
- Friday
- Saturday
- Sunday
- Soft Holidays (like Columbus day)
- Hard Holidays (like July 4^{th})
- Rainy Weekday
- Rainy Weekend
- Thanksgiving and Christmas

As the project evolves and goes through maintenance cycles these patterns will be updated and it is expected that with more data and more data points the number of patterns would increased to include conditions such as the Wednesday before Thanksgiving.

MONITORING THE SYSTEM AND RESULTS

In running a model in an online 24/7 environment it was critical to develop a solid monitoring process to allow users to track the operations of the RTSS and NPS. To meet this need the Aimsun Online system includes a web interface that displays the current status of the system and the latest quality of the predictions. Figure 5 shows a screen shot of the control panel components. The control Panel allows operators to track the status of each component of the system. From all tabs on the control panel the user actions, server statistics (including current usage graph) and the link to the RTSS executors (servers that are being used to run the evaluation simulation associated with the RTSS).

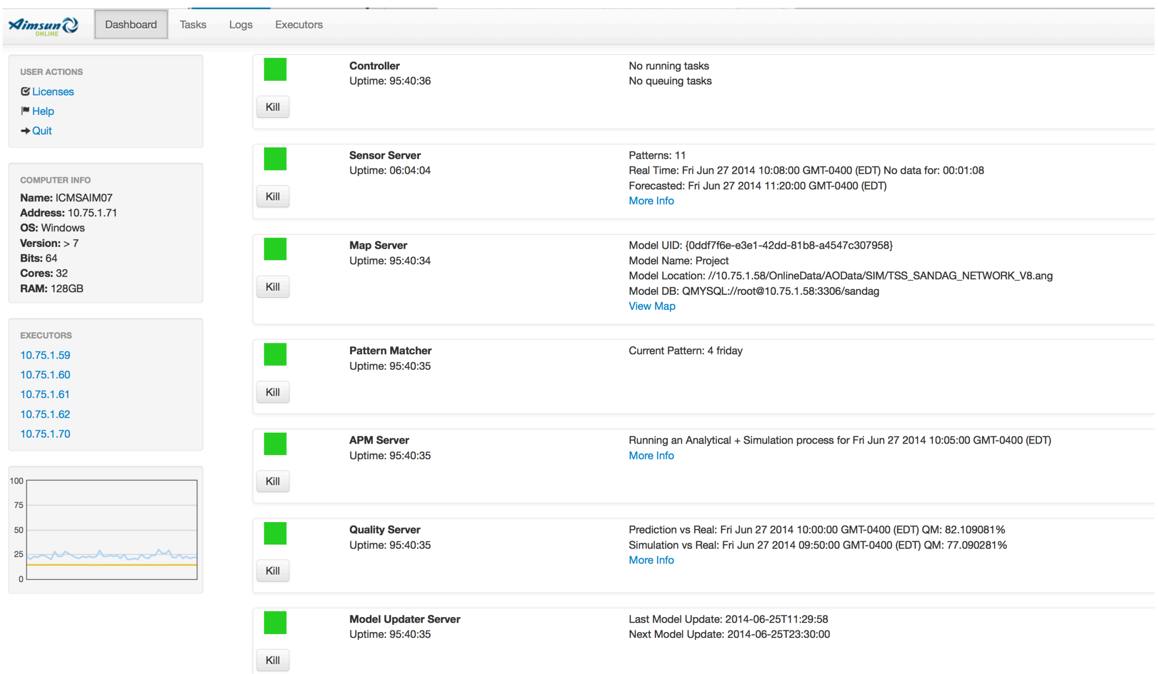


Figure 5 Aimsun Online Control Panel Screenshot

<u>Control Panel - Dashboard</u>

The Dashboard tab allows the operator to monitor the status of each of the main components of the Online System. The contents of the control panel via the web service contain the following information and links:

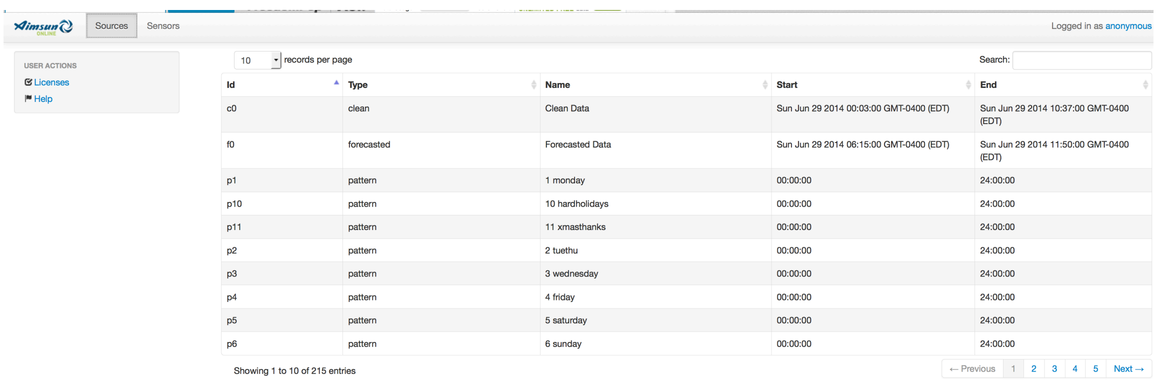
- Controller;
- Sensor Server;
- Map Server;
- Pattern Matcher;
- APM Server
- Quality Server
- Map Update Server;

Controller

The controller service provides a summary of the current number of response plan evaluation requests from the BRPMS, and the number that are either in the queue or being simulated by one of the executors. The details of the current simulations are provided within the "Tasks" Tab of the web service.

Sensor Server

The sensor server provides the status of the data subscription service and displays the time laps since the last set of live data was received, allowing the operator to check if any anomalies within the system. When further analysis is required the dashboard also provides a link to the Sensor Server web page. This page provides both the sources of the sensor data as shown in figure 6. Furthermore operators can check the data sources for individual sensors. Shown in figure 7 is the comparison of the historical pattern data, the real current data and the current forecast data. This comparison shows that current traffic is much lower than the pattern data for this location but through the adjustment process using the analytical predictions the forecast data is a good match to the real data as apposed to the pattern data.



Aimsun ONLINE Sources Sensors Logged in as anonymous

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Id	Type	Name	Start	End
c0	clean	Clean Data	Sun Jun 29 2014 00:03:00 GMT-0400 (EDT)	Sun Jun 29 2014 10:37:00 GMT-0400 (EDT)
f0	forecasted	Forecasted Data	Sun Jun 29 2014 06:15:00 GMT-0400 (EDT)	Sun Jun 29 2014 11:50:00 GMT-0400 (EDT)
p1	pattern	1 monday	00:00:00	24:00:00
p10	pattern	10 hardholidays	00:00:00	24:00:00
p11	pattern	11 xmasthanks	00:00:00	24:00:00
p2	pattern	2 tuethu	00:00:00	24:00:00
p3	pattern	3 wednesday	00:00:00	24:00:00
p4	pattern	4 friday	00:00:00	24:00:00
p5	pattern	5 saturday	00:00:00	24:00:00
p6	pattern	6 sunday	00:00:00	24:00:00

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Figure 6. Sensor Server data sources.

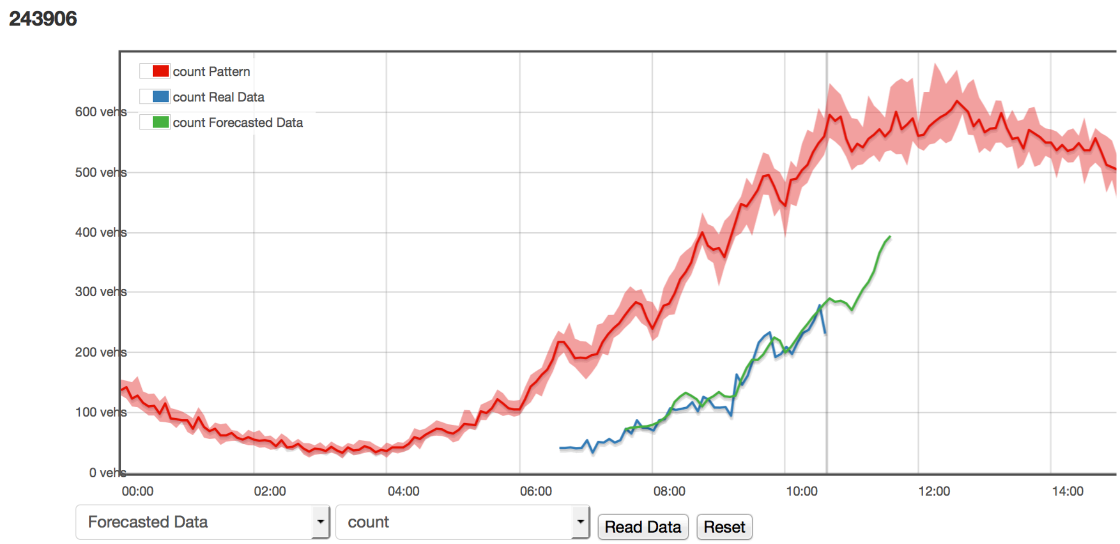

Figure 7. Sensor 243906 Pattern Data versus Real Data versus Forecast Data.

Map Server

The map server allows the operator to monitor the latest model and database locations and names. It is important to be able to track the model id and location when reviewing data provided through the data archiver and also when dealing with system issues. With each update to the model or system the network needs to be mapped to the system. If the model is not mapped to the correct location the system is unable to load the model and run either forecast simulations or evaluation simulations.

Pattern Server

The pattern server allows the operator to validate that the system is using the correct pattern as a starting point to the network demand.

APM Server

The APM server represents the Aimsun Prediction Model (APM) server and provides the status of the current NPS processes that are running within the system. If any issues appear within the GUI of the system the operator can then use the link from the dashboard to get more details on the predictions. Figure 8 shows information provided by the APM web service, from this information the operator can check what the latest processes were and how long each process took to run, knowing that the simulations should take between 120 and 300 seconds, a problem can be found when simulations fall outside of that range. (Processes that include adjustments can take up to 420 seconds).

Started	Type	Duration
Sun Jun 29 2014 10:55:00 GMT-0400 (EDT)	Analytical + Simulation	Running
Sun Jun 29 2014 10:50:00 GMT-0400 (EDT)	Analytical + Simulation	173
Sun Jun 29 2014 10:45:00 GMT-0400 (EDT)	Analytical + Simulation + Adjustment	296
Sun Jun 29 2014 10:40:00 GMT-0400 (EDT)	Analytical + Simulation	155
Sun Jun 29 2014 10:35:00 GMT-0400 (EDT)	Analytical + Simulation	155
Sun Jun 29 2014 10:30:00 GMT-0400 (EDT)	Analytical + Simulation + Adjustment	260
Sun Jun 29 2014 10:25:00 GMT-0400 (EDT)	Analytical + Simulation	150
Sun Jun 29 2014 10:20:00 GMT-0400 (EDT)	Analytical + Simulation	151
Sun Jun 29 2014 10:15:00 GMT-0400 (EDT)	Analytical + Simulation + Adjustment	261
Sun Jun 29 2014 10:10:00 GMT-0400 (EDT)	Analytical + Simulation	149

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Figure 8. APM web service details.

Quality Server

The Quality server provides the latest summary of the quality from both the analytical predictions and the simulated predictions. This information gives a quick view of the quality of the model runs and if the system is forecasting an accurate representation of the real world data. From the extended link the quality server web service provides more detailed information about the model accuracy including, Analytical Quality, Simulation Quality, RTSS simulation quality, and speed contour tables. The quality manager and the quality targets will be discussed further in the section – "Quality Manager".

Model Updater Server

The model updater server tracks when the model was last updated and when the next scheduled update will take place. Currently the model is automatically updated twice a day to import any changes to the signal control plans.

Tasks

The Tasks tab from the control panel tracks all of the RTSS tasks that have been run within the system since the last restart of the system. From the tasks tab the following data can be tracked or retrieved:

- Model Errors – Any crash of a simulation is recorded here and the error number provided;
- RTSS Simulation run times & status – When tracking an evaluation the progress of a simulation can be seen as well as the event id and response plan id.
- RTSS simulation logs – If an evaluation fails to score the logs can be review to see if there were any issues within the simulation, helping an operator to track any potential issues within the system.

- Executor id – For each evaluation simulation the server that ran the simulation is provided.

Figure 9 provides an example of the tasks tab with simulations both completed and in the progress of simulation. The status bar provides an estimate of the progress of the current simulation.

Logs

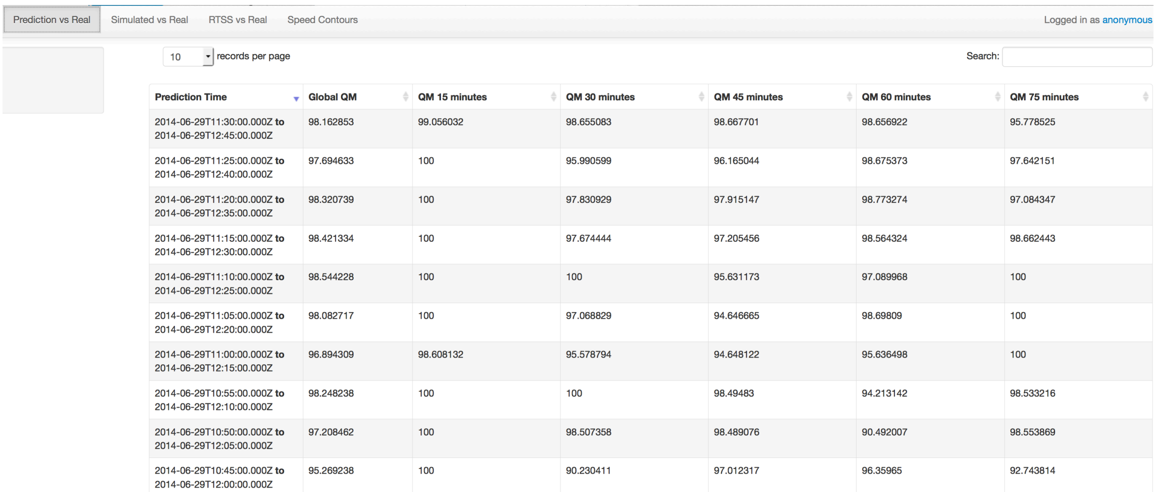
The log tab provides a unified location where all of the recent logs (except for RTSS simulation logs) can be accessed. These represent all of the logs associated with the main service of Aimsun Online System that controls the operations of all the parts of the NPS and the RTSS, including the sensor logs, the data service logs, the analytical prediction logs, the adjustment logs and the prediction simulation logs.

QUALITY ASSESSMENT

Unlike a typical planning or analysis model where the quality of the system is based on a static set of data, the online systems is continually simulating and collecting real data. With the mind set a balance is needed between the quality that can be achieved and the quality that is needed to insure an accurate prediction. As the data provided by the predictions (in particular, speeds; queues; and volume/capacity) are used by the BRPMS system to evaluate congestion and ultimately base the decision to implement recommended actions to the field devices on, it is critical that the predictions provide a sufficient level of accuracy. With the typical day model, the quality is based on a validation of counts and travel times that are known and on a network that has known system changes throughout the model period. With the online system the quality of each simulation is based on the results of the next 60 minutes data and assumes that any changes from the typical time of day operations are present at the start of the simulation as changes that happen during the simulation (such as incidents or device failures) will not be captured till the simulation following the change. Because of this specific difference the quality of each simulation is tracked and analyzed every 15 minutes against the counts, and a higher importance is associated with the 15-minute and 30-minute periods as opposed to the 45-minute and 60-minute periods. Quality results are available as the data becomes available and is usually posted 60 minutes after the simulation is completed. As well as the quality of the simulations, the quality of the analytical predictions is also tracked for each 15-minute period.

Analytical Predictions

The analytical predictions, which currently provide the speed, and volume predictions to be used with the demand adjustment process, are tracked from 0 to 75 minutes out and the quality is based on the percentage of stations where the difference of the count versus the predicted volume is within 15%. As the analytical process is less sensitive to capacity and incidents within the system and is based on historical data and analytics it is expected that it can produce a higher accuracy rate with the target being greater than 88% for the 15-minute and 30-minute periods. Figure 10 shows an example of the summary quality data for the Analytical Predictions.


Prediction vs Real | Simulated vs Real | RTSS vs Real | Speed Contours | Logged in as anonymous

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Prediction Time	Global QM	QM 15 minutes	QM 30 minutes	QM 45 minutes	QM 60 minutes	QM 75 minutes
2014-06-29T11:30:00.000Z to 2014-06-29T12:45:00.000Z	98.162853	99.056032	98.655083	98.667701	98.656922	95.778525
2014-06-29T11:25:00.000Z to 2014-06-29T12:40:00.000Z	97.694633	100	95.990599	96.165044	98.675373	97.642151
2014-06-29T11:20:00.000Z to 2014-06-29T12:35:00.000Z	98.320739	100	97.830929	97.915147	98.773274	97.084347
2014-06-29T11:15:00.000Z to 2014-06-29T12:30:00.000Z	98.421334	100	97.674444	97.205456	98.564324	98.662443
2014-06-29T11:10:00.000Z to 2014-06-29T12:25:00.000Z	98.544228	100	100	95.631173	97.089968	100
2014-06-29T11:05:00.000Z to 2014-06-29T12:20:00.000Z	98.082717	100	97.068829	94.646665	98.69809	100
2014-06-29T11:00:00.000Z to 2014-06-29T12:15:00.000Z	96.894309	98.608132	95.578794	94.648122	95.636498	100
2014-06-29T10:55:00.000Z to 2014-06-29T12:10:00.000Z	98.248238	100	100	98.49483	94.213142	98.533216
2014-06-29T10:50:00.000Z to 2014-06-29T12:05:00.000Z	97.208462	100	98.507358	98.489076	90.492007	98.553869
2014-06-29T10:45:00.000Z to 2014-06-29T12:00:00.000Z	95.269238	100	90.230411	97.012317	96.35965	92.743814

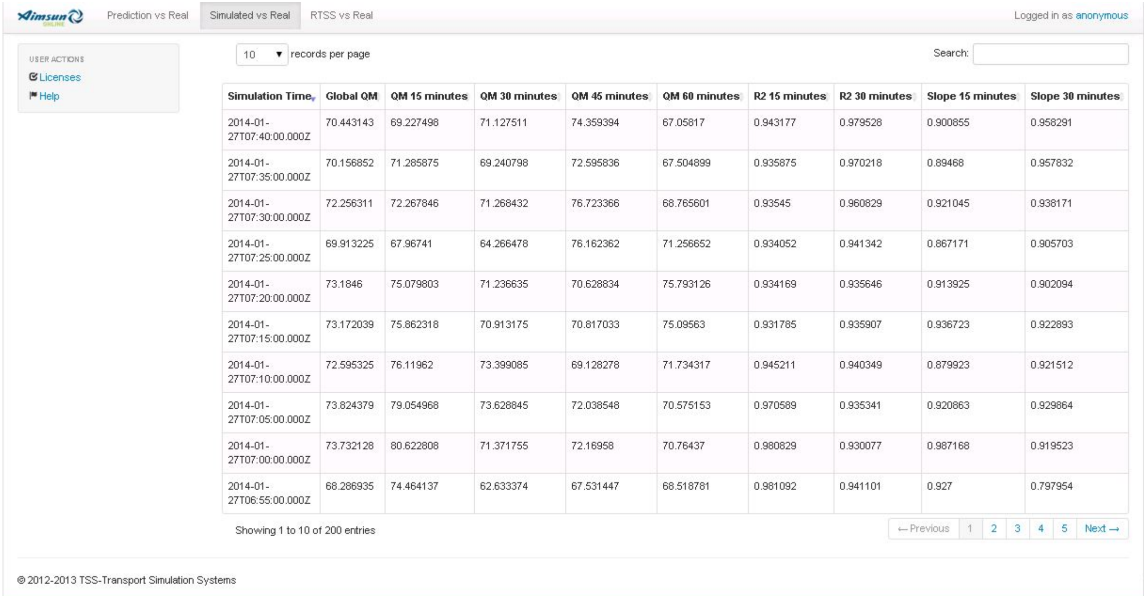
Figure 10. Analytical Prediction vs Real Quality.

Microsimulation Predictions

As the microsimulation predictions simulate every trip and vehicle during the hour over all the links within the network it is more complex and more sensitive to the changes within the Intelligent Transportation System related devices and any changes to the network capacity as could take happen during an incident. With this complexity in mind the goal for the simulation quality is to reach a match of 70% or more of the counts within 15% and to always have an R-squared and slope between 0.92 and 1.08. Figure 11 shows an example from of the quality from the simulated forecasts. These results are tracked by the quality manager and also stored on the archiver drive for 90 days, and these values can be reviewed to see if the system is preforming as expected and if maintenance may be required to bring the quality back to the expected ranges.

It is expected that as the time from the last maintenance cycles grows the quality may drop and indicate the need for a model update. These changes could be due to a number of factors; some of the known potential changes are as follows:

- Capacity Improvements – Changes to the infrastructure can change levels of congestion, roadway capacities, travel patterns and even demands;
- Land Use Changes – the construction of new developments whether residential or commercial can greatly change the network demands and require a change to the initial pattern data to insure that these changes are captured with the aid of changes found within the San Diego regional model;
- Background Travel Pattern changes – With time the travel along a corridor may change, things like new transit services, economical changes or changes in the price of gas can determine how trips are made and at what time of day they are made.



Prediction vs Real | Simulated vs Real | RTSS vs Real — Logged in as anonymous

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Simulation Time	Global QM	QM 15 minutes	QM 30 minutes	QM 45 minutes	QM 60 minutes	R2 15 minutes	R2 30 minutes	Slope 15 minutes	Slope 30 minutes
2014-01-27T07:40:00.000Z	70.443143	69.227498	71.127511	74.359394	67.05817	0.943177	0.979528	0.900855	0.958291
2014-01-27T07:35:00.000Z	70.156852	71.285875	69.240798	72.595836	67.504899	0.935875	0.970218	0.89468	0.957832
2014-01-27T07:30:00.000Z	72.256311	72.267846	71.268432	76.723366	68.765601	0.93545	0.960829	0.921045	0.938171
2014-01-27T07:25:00.000Z	69.913225	67.96741	64.266478	76.162362	71.256652	0.934052	0.941342	0.867171	0.905703
2014-01-27T07:20:00.000Z	73.1846	75.079803	71.236635	70.628834	75.793126	0.934169	0.935646	0.913925	0.902094
2014-01-27T07:15:00.000Z	73.172039	75.862318	70.913175	70.817033	75.09563	0.931785	0.935907	0.936723	0.922893
2014-01-27T07:10:00.000Z	72.595325	76.11962	73.399085	69.128278	71.734317	0.945211	0.940349	0.879923	0.921512
2014-01-27T07:05:00.000Z	73.824379	79.054968	73.628845	72.038548	70.575153	0.970589	0.935341	0.920863	0.929864
2014-01-27T07:00:00.000Z	73.732128	80.622808	71.371755	72.16958	70.76437	0.980829	0.930077	0.987168	0.919523
2014-01-27T06:55:00.000Z	68.286935	74.464137	62.633374	67.531447	68.518781	0.981092	0.941101	0.927	0.797954

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Figure 11. NPS Simulated Counts versus Real Counts Quality.

Speed Contours

With such a dynamic system it is important that counts and traffic flows are not the only point of quality. For this reason, speed was added as a to the quality manager, with the ability to view the speed contours for the real, analytical and simulated predictions. These contours can be used to visually confirm that the predicted speeds and queues are providing a fair representation of the real world congestion, showing the magnitude of predicted speed drops, the extent of the queue and the duration of the queuing. Figure 12 shows an example of the predicted speeds in a speed contour from the quality manager.

2014-06-25T18:30:00	72.7	73.2	73.4	63.8	68.9	71.0	73.7	54.1	61.3	65.6	45.6	46.6	67.8	62.6	71.5	61.8	70.7	67.6	47.5	68.0	59.7	69.4	71.0	72.0	66.1	70.3	71.5	63.9	71.2	70.3	59.3	73.4	74.6	74.2
2014-06-25T18:25:00	74.0	74.1	74.0	71.1	47.3	32.1	21.0	43.8	57.0	65.0	29.8	40.3	67.8	62.1	72.3	52.4	71.7	27.8	26.2	62.2	56.7	68.9	69.0	66.6	63.0	69.2	70.0	65.6	70.8	68.2	58.6	72.9	74.0	74.0
2014-06-25T18:20:00	73.8	74.2	73.9	70.0	49.8	33.6	21.3	40.5	57.0	63.0	31.9	36.8	68.2	60.7	72.2	52.1	71.4	28.3	23.6	64.4	58.4	69.2	69.1	65.5	63.0	68.6	70.4	64.6	71.5	67.6	57.8	73.6	74.2	73.8
2014-06-25T18:15:00	73.9	74.5	74.3	70.1	51.4	35.2	22.9	41.7	56.8	62.8	29.9	37.7	66.6	58.9	72.0	48.9	71.6	30.0	25.5	65.5	57.1	69.0	68.0	65.7	63.3	69.3	70.2	66.3	70.5	67.9	61.6	73.4	74.2	74.1
2014-06-25T18:10:00	74.1	71.6	43.2	20.9	20.0	14.4	15.0	39.3	58.1	63.8	30.3	36.5	68.0	49.6	72.2	34.2	70.3	23.1	25.5	64.4	56.8	68.5	66.2	69.9	62.3	66.4	70.4	62.6	70.9	68.1	60.5	72.3	73.3	73.4
2014-06-25T18:05:00	74.2	71.4	40.1	23.3	19.0	14.8	15.7	38.0	55.9	63.7	31.2	34.2	68.4	51.1	72.3	36.4	71.4	20.6	27.1	63.1	58.8	67.9	65.5	69.8	62.3	67.6	70.8	63.2	69.8	68.1	58.3	72.7	73.4	73.2
2014-06-25T18:00:00	73.6	71.6	42.9	22.7	19.6	13.8	14.3	38.1	55.0	63.7	30.5	35.9	68.6	51.7	72.5	32.9	70.8	19.6	26.4	63.5	52.4	68.2	64.7	70.3	61.8	65.9	70.2	64.9	70.6	67.4	61.6	72.5	73.8	73.4
2014-06-25T17:55:00	74.0	40.4	15.7	17.4	16.8	12.0	13.5	38.6	55.4	63.0	30.2	38.1	65.6	46.0	71.7	31.2	71.2	16.7	25.0	68.4	56.5	68.7	63.7	67.4	59.9	60.5	52.0	64.1	68.3	64.1	48.0	71.7	72.7	73.3
2014-06-25T17:50:00	74.1	40.2	15.4	17.6	16.9	11.9	13.0	36.1	55.6	62.6	31.6	35.5	65.3	45.8	72.0	39.0	71.3	16.7	25.1	68.3	58.1	69.1	63.7	67.1	60.6	60.5	54.1	62.9	67.9	63.2	45.4	71.3	72.4	72.8
2014-06-25T17:45:00	74.0	38.3	15.5	18.7	17.4	12.3	13.9	37.8	55.5	61.7	29.1	38.1	65.5	44.0	71.8	35.5	70.7	17.6	24.6	68.0	56.1	68.3	63.5	67.7	61.5	62.8	51.0	62.9	68.9	65.1	48.9	72.0	72.9	73.1
2014-06-25T17:40:00	73.1	31.0	15.7	19.2	17.9	13.0	13.5	35.4	55.9	62.6	28.7	37.6	67.5	52.0	72.3	29.4	70.8	22.9	27.3	63.8	51.7	67.0	55.7	66.2	59.7	58.5	55.9	61.7	67.9	66.0	48.9	71.4	72.1	72.4
2014-06-25T17:35:00	72.9	41.5	16.1	19.2	17.5	12.3	13.5	37.3	57.1	63.7	30.4	37.4	67.3	50.7	71.8	27.3	70.6	19.9	25.9	61.5	54.8	67.3	58.6	67.6	60.2	59.9	52.4	64.3	68.0	64.1	44.9	71.6	73.1	72.9
2014-06-25T17:30:00	72.2	30.9	16.2	18.8	18.1	13.0	13.4	33.9	56.1	58.3	28.3	38.8	68.3	53.1	72.1	30.3	70.9	22.4	26.2	62.9	51.5	67.2	58.3	68.4	58.0	59.0	50.1	61.2	68.1	63.6	45.5	72.3	73.3	72.7
2014-06-25T17:25:00	72.1	27.5	16.9	20.5	19.2	13.5	14.2	36.0	55.9	63.5	28.7	43.3	67.4	54.2	72.2	30.9	70.4	22.8	25.1	62.4	50.8	67.3	62.7	69.2	56.5	59.0	46.7	64.5	68.9	64.4	45.6	71.5	72.9	72.6
2014-06-25T17:20:00	72.1	27.1	17.1	20.8	19.7	14.3	14.9	36.2	56.6	60.5	28.7	39.2	66.8	50.5	71.8	29.0	70.5	22.7	25.9	63.9	56.5	67.2	55.6	69.7	58.3	60.1	50.0	63.5	68.9	65.4	45.2	71.9	73.1	72.7
2014-06-25T17:15:00	71.5	28.7	16.8	20.1	19.0	13.8	14.5	36.8	56.7	62.0	29.1	41.2	67.2	51.7	72.0	30.1	70.4	21.6	23.4	65.4	57.6	67.2	62.0	69.2	58.6	60.1	54.7	64.2	68.1	63.1	48.0	71.9	72.8	72.7
2014-06-25T17:10:00	70.1	40.5	17.3	20.5	21.1	13.7	14.3	37.6	57.7	58.3	28.9	39.8	67.6	51.6	71.9	24.7	70.3	35.4	26.4	63.9	47.0	66.6	54.4	62.4	45.8	56.6	66.9	64.1	69.5	65.0	47.6	70.5	72.7	72.7
2014-06-25T17:05:00	70.3	39.5	17.0	20.7	20.5	14.0	14.6	36.6	57.5	58.5	29.6	37.5	65.8	50.8	71.8	27.7	70.2	35.2	30.6	63.8	44.3	66.0	59.5	59.8	43.9	54.5	64.3	63.4	68.6	64.5	48.7	70.5	72.1	72.1
2014-06-25T17:00:00	70.0	40.1	17.1	20.2	21.2	14.2	14.8	35.2	56.7	56.7	28.8	40.5	67.6	48.7	71.7	26.0	70.5	35.5	26.9	64.9	45.9	66.9	62.8	63.9	46.4	59.1	61.7	63.2	69.6	64.5	47.7	71.1	72.7	73.0
2014-06-25T16:55:00	69.0	52.5	25.5	21.3	20.3	14.3	15.1	37.5	55.6	59.3	28.8	40.6	66.4	49.3	71.5	24.6	70.4	33.7	29.1	61.9	41.7	67.0	49.2	59.0	45.2	58.3	65.4	59.3	67.7	64.1	39.5	71.5	72.6	73.0
2014-06-25T16:50:00	69.4	57.0	25.5	20.9	20.1	14.4	15.2	38.3	55.9	56.5	28.4	39.9	66.6	51.7	71.7	30.6	70.2	35.7	31.9	60.5	36.9	65.6	49.8	64.1	48.7	58.0	64.2	63.3	68.7	63.3	38.5	71.4	72.7	73.1
2014-06-25T16:45:00	69.9	61.6	25.2	21.0	19.7	14.5	15.2	38.2	56.0	57.9	29.1	39.8	66.1	51.2	71.1	30.8	70.9	41.7	32.2	56.7	36.7	66.3	55.0	61.8	48.8	57.3	64.4	60.5	68.2	63.3	36.5	70.9	72.4	72.9
2014-06-25T16:40:00	54.4	65.1	50.2	48.5	43.8	20.0	14.4	37.9	55.1	55.8	29.3	40.5	67.7	54.2	71.5	21.9	70.1	49.4	37.8	58.8	41.8	66.6	53.7	67.3	51.8	55.5	64.9	63.1	67.4	63.1	39.1	71.5	73.1	72.9
2014-06-25T16:35:00	62.8	67.0	58.6	51.3	43.2	21.4	14.3	37.3	56.5	58.0	28.2	45.3	66.2	53.9	71.8	24.7	69.5	39.8	32.7	66.4	47.8	67.1	55.1	68.2	52.4	55.8	65.9	62.7	67.9	61.7	38.1	71.7	73.2	72.5
2014-06-25T16:30:00	48.5	66.1	58.2	52.1	41.7	20.4	14.3	37.9	56.0	51.7	28.3	41.6	68.5	55.4	71.5	28.2	70.3	46.1	31.7	62.8	38.7	66.7	52.5	68.4	52.8	57.9	65.7	60.8	67.2	61.7	36.9	71.5	73.1	72.8
2014-06-25T16:25:00	62.3	61.9	43.0	43.3	36.8	38.5	17.9	31.8	47.2	53.4	33.6	51.0	63.7	55.4	71.9	37.6	70.8	44.9	38.1	69.0	54.4	67.8	51.8	68.7	52.9	58.8	69.1	60.0	66.9	62.2	35.8	62.1	71.8	72.7
2014-06-25T16:20:00	62.2	63.9	48.3	46.3	35.9	39.2	17.4	31.9	46.6	52.5	33.8	49.1	66.2	52.6	71.9	39.1	70.7	38.6	40.9	68.7	58.8	68.2	56.7	69.2	54.5	57.8	66.0	63.3	66.7	63.0	36.1	55.4	72.2	72.2
2014-06-25T16:15:00	69.7	64.9	50.3	47.9	59.5	57.4	35.9	39.3	56.5	58.2	29.1	50.0	66.3	52.2	71.9	34.3	71.1	44.9	31.0	65.8	55.6	67.6	64.1	63.5	49.3	57.5	60.1	63.8	68.1	64.2	46.5	71.9	72.8	72.8
2014-06-25T16:10:00	42.6	65.1	57.6	49.5	61.3	61.6	67.0	41.6	38.8	21.0	64.3	65.4	68.6	52.1	73.0	56.3	71.2	60.8	40.3	67.8	63.6	69.4	65.4	60.9	45.6	55.0	68.9	63.2	70.5	66.6	53.9	72.2	73.6	73.5
2014-06-25T16:05:00	62.3	65.1	51.0	48.5	58.8	63.3	64.5	42.3	38.8	22.2	63.4	63.2	69.3	51.8	73.3	59.1	72.0	63.2	44.7	69.4	59.7	68.1	64.7	59.4	45.0	54.4	68.8	62.4	70.7	66.8	56.5	72.0	73.2	73.3
2014-06-25T16:00:00	36.3	65.0	57.3	51.3	60.8	58.3	63.2	43.8	38.5	22.0	62.3	64.9	69.0	54.3	73.1	55.3	71.8	62.7	44.6	69.5	59.3	69.3	67.1	61.4	43.6	53.0	67.2	62.5	70.1	67.0	53.7	72.5	73.5	73.4

Figure 12. Predicted Speed Contours for the NB PM peak period.

MAINTENANCE OF THE SYSTEM

The first phase of this project was to get a quality real time model in place and running. With that task achieved it is important to keep the model and system up to date. Hence, the system must be regularly maintained and updated to insure that any real world changes to the network, systems, demands and patterns are captured within the online system. In maintaining the model a number of tasks are already known with the San Diego I-15 corridor network.

Additional Detection

With time as each agency upgrades their street network new data will become available to the system. This data will come mainly in the form of speeds and counts from signalized intersection detectors. Knowing the importance of understanding the traffic conditions on the arterials this additional data will greatly enhance the accuracy of the predictions and ability of predictions to be used to avoid sending additional traffic to arterials that are already near capacity.

With the addition of new detection locations, the information about travel patterns and congestion associated with those locations needs to be added to the demand and pattern files, requiring a re-calibration of the offline network. In order to help facilitate this task a detector manager is being developed that will optimize the systems ability to track detector quality, the characteristics of the various detectors systems and ease the modifications of the offline models, ideally reducing with time the effort required to update the detector sets. A secondary advantage of the detector manager will be an alerting system that will send out alerts when source detector data shows since of problems within the data feed.

Transit Network Updates

Transit networks are continually changing to meet the needs of the users and hence it is not uncommon to find that a transit route has been changed, rescheduled, removed or added. For this reason a public transit tool is being developed to handle the updates to the model that deal with changes to the transit system. This will provided an automated process and remove the need for a transit maintenance task.

Another improvement coming to the I-15 corridor is the addition of a state of the art park’n’ride facility to provide parking along the corridor with access to new Bus Rapid Transit routes. This facility and potential others will be added to the system and the ability for trips to be re-routed to the park’n’ride lot and switch to transit based on the amount of available spots will be calibrated into the model.

Infrastructure Changes

As with any transportation network, agencies are always investing in the infrastructure to improve the capacity of the system and remove any current shortcomings. This may include the construction of new intersections, interchanges or additional lanes. Although the I-15 mainline has gone through a large number of enhancements to the infrastructure with the addition of the managed lanes, completed in January 2012, there are still some improvements under construction, including the construction of the last direct access ramp that provides direct access from the arterials to the managed express lanes. With each maintenance cycle all infrastructure improvements will be added and the model re-calibrated to include new patterns that represent the potential new route choices.

Demand and Pattern Changes

On top of changes to the infrastructure it is possible that land use or economic changes could change the demands and patterns of the system. A potential task as part of the maintenance process will be to update the historical data sets and analysis if any significant changes to the flows and speeds that indicate a change in the demand or patterns. Should a change be found a review of the latest regional model would be done to understand the magnitude and distribution of the change, and day type demand matrices and pattern files would be updated using the The San Diego I-15 ICM U.S. DOT pilot project uses a state-of-the-art Decision Support System to help system operators evaluate and respond to incidents and other events throughout the corridor. Part of this system is a real-time microsimulation model using Aimsun Online. This model uses both analytics and microsimulation to predict traffic conditions at five-minute intervals over the next 60 minutes and evaluate potential response plans. In order to safeguard against forecasting errors and ensure operators' trust, the system needs to be able to track the quality of the predictions and the validity of the model. This paper describes the tolls and thresholds put together to provide this informationupdates. A model check to insure that with the changes the model still meets the quality requirements would be performed.

Offline Modeling Tool

As with a planning model, a secondary benefit of this system is that all data, both input and the generated from each simulation, is archived for 90 days. This allows operators and planners to go back and check the results using an offline tool that loads any stored simulation from either the NPS or the RTSS systems. By running an offline model a visual check can be done to insure all elements were correctly loaded and simulated. This provides not only an online realtime analysis tool but also a very useful statistical and planning tool.

CONCLUSIONS

The San Diego I-15 ICM U uses a state-of-the-art Decision Support System to help system operators evaluate and respond to incidents and other events throughout the corridor. As part of DSS the Aimsun Online system has provided a first of it's kind prediction and evaluation engine that continues to develop and improve. The strong monitoring system provided with Aimsun Online has allowed for a straight forward process for overseeing the model processes and insure the ongoing quality of the prediction and eveluations of the model. As the project has moved into operations the monitoring system and a solid the maintenance and support proceedure insure that the system will continue to succeed.

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