UNIVERSAL REAL-TIME HIGHWAY INFORMATION SYSTEM DEVELOPMENT PROGRAM

Final Report on Phase II

Prepared for

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16. Abstract

The final phase of a two phase effort was undertaken to establish data forms and communication protocols to provide the New York State Department of Transportation access to the unique highway data resource, HIVIS developed in the initial phase of the program. Computer processes were established to calculate basic performance metrics. Processes and web applications were developed to automated streams of a variety of forms of highway data into NYSDOT servers. Further processes were developed to rapidly form and post web applications giving clients such as NYSDOT graphical access to traffic metrics displayed in an GIS environment. The capabilities established under the two phases of the program were further leveraged to provide support to FHWA programs on the US/Mexican border.

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ABSTRACT

The final phase of a two phase effort was undertaken to establish data forms and communication protocols to provide the New York State Department of Transportation access to the unique highway data resource, HIVIS developed in the initial phase of the program. Computer processes were established to calculate basic performance metrics. Processes and web applications were developed to automated streams of a variety of forms of highway data into NYSDOT servers. Further processes were developed to rapidly form and post web applications giving clients such as NYSDOT graphical access to traffic metrics displayed in an GIS environment. The capabilities established under the two phases of the program were further leveraged to provide support to FHWA programs on the US/Mexican border.

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SUMMARY

Calmar Telematics has completed a thirty month effort to build a highway information system, known as the Highway Visibility System (HIVIS), based upon the data mining of the millions of messages that are passed between commercial vehicles and their dispatchers each day. The first phase of this project was focused on the establishment of supply chain structures, the statistical and economic realities of this data source and the business model considerations that must be taken into account in constructing a highway information system around passive probe data. The second phase, reported herein, was focused on establishing information exchange protocols to provide New York State Department of Transportation (NYSDOT) and other clients with ready access to this unique data source.

This final report covers the work laid out in the proposal to New York State Energy Research and Development Authority (NYSERDA), NYSDOT and the Federal Highway Administration (FHWA) titled Universal Real-Time Highway Information System Development Program Phase II Section 4.2 Steps A-E. The primary tasks of establishing the basic data exchange protocols, web-based GUI interfaces and data streams have all been accomplished. Further accomplishments of the program were realized by providing FHWA with support in efforts to passively monitor border crossing activity at the Otay Mesa – Tijuana crossing in Southern California.

Overall, while NYSDOT is still considering the uses of commercial vehicle probe data, the program has successfully developed a unique highway data resource and a series of processes and technologies to rapidly deploy data interfaces as clients such as the NYSDOT and the FHWA request them. The overall program and the resulting HIVIS system remains quite revolutionary and it is reasonable to expect that it may be some time before transportation professionals have responded to the availability of this new data resource. This program has established the basic resource, the data forms and delivery methods. As professionals learn to use this resource HIVIS will continue to expand in data detail and delivery capability.

Accomplishments of Phase II Include:

- Fleet data supply increased to a rate in excess of 5M points per month.
- GIS system expanded to include compatibility with national base maps including Navteq.
- HIVIS system increased in computing capacity to handle 5M points per month in New York State.
- Streaming data accounts have been establish to deliver traffic data in the form of XML files.
- A web application structure that allows the rapid generation of a graphical display of data is established.
- Web based interfaces were created to display traffic speed predictions, real-time traffic speeds, and iCone data.

1.0 DISCUSSION

Calmar Telematics undertook a two phase program with the New York State Energy Research and Development Authority (NYSERDA) and the New York State Department of Transportation (NYSDOT) to assess the issues associated with using commercial vehicles as probes to measure the status of traffic on the highways. The resulting Highway Visibility System (HIVIS) is actively producing traffic speed data along the Interstate corridors in New York State, the Northeast and Southern California.

The first phase of this program was focused on the study of the statistics and economics associated with the use of the passive monitoring of commercial vehicle telematics systems as a source of traffic data. This program included an extensive effort to establish the data retrieval mechanism and relationships of a data supply chain. To this end, relationships have been developed between Calmar Telematics, the commercial fleet operators, the New York State Motor Truck Associations, the American Trucking Association as well as other state and national trade associations. The relationships with these 'Pioneer Fleets' have been fostered through continuous communication and feedback providing a basis for the establishment of the economics of accessing data.

The second phase of the program increased the scope of the effort from a regional to a national program incorporating a bigger segment of the industry. The technical aspects of the second phase are focused around the integration of the resulting data stream into a series of interfaces for use by a variety of stakeholders in the process. Tools for accessing the data for standardized analysis and for special research needs have been formalized and data streams established in Phase I have been made available to NYSDOT including the 511 program.

Specifically, Phase II included the construction of a web based user interface which displays the primary Calmar Telematics traffic speed data feed (documented in the Phase I report, The Economics and Statistics of Passive Telematics Monitoring as a Source of Traffic Data, Report 20079110). It was the intent of this program to incorporate additional sources of data from public and private sources. As the program progressed the only secondary source of data that was made available was iCone data from a sister company of Calmar Telematics. This data has been used to develop and test a state-wide and cross border GUI that is capable of including layers from other data sources with a few days of effort. The resulting multi-layer web application is fully ready to incorporate layers from other sources as they become available.

STANDARDIZED METRICS AND DATA FORMS

As a first step in developing data exchange mechanisms it is necessary to understand the nature of the information sought and how it is understood by the analyst. The appropriate delivery method for information forms may vary from summary values, to tables, to field values, or even multi-dimensional vector data. The appropriate mode of delivery for each of these modes is different. Therefore, it is necessary to have some understanding of the information sought in the development of the delivery methods.

Throughout the first six months of this second phase of the program Calmar put a significant effort into soliciting input from NYSDOT on which transportation metrics would be sought from HIVIS. With HIVIS data a very new concept in the transportation community it has proved to be very difficult for engineers to decide what metrics will be of interest in the future. Building on initial input from the NYSDOT, Calmar chose a number of metrics which demonstrated the potential of this data resource and also exercised some of the demands that might be made of a delivery system.

Traffic Forecast

Current traffic conditions on highway network are of high interest to the public. Interestingly the trucking industry has expressed significantly more interest in what traffic is likely to be on a route than what the conditions are currently. In order to serve the trucking contingency and generate useful metrics for NYSDOT, Calmar chose to devise a simple forecasting methodology based on a portion of the multi-year archive of HIVIS data. As a straight forward mode of forecasting traffic conditions Calmar has chosen to craft an algorithm which averages the traffic conditions for the same time of day and day of week for three preceding weeks.

So, for a given time and a given segment of highway the forecast speed is calculated as follows:

- Construct a 30 minute time window ranging from 15 minutes before the given time to 15 minutes after the given time for the given day of the week. In other words the forecast for 12:00PM (noon) on Tuesday would consider data occurring from 11:45AM to 12:15PM on Tuesdays.

- Search the database for data that is geo-located to the same section of highway and occurs in the time window for the preceding three weeks.

- Calculate a straight average of all speeds.

The HIVIS Pro speed maps can be accessed at:

http://www.calmartelematics.com/speedmap.php

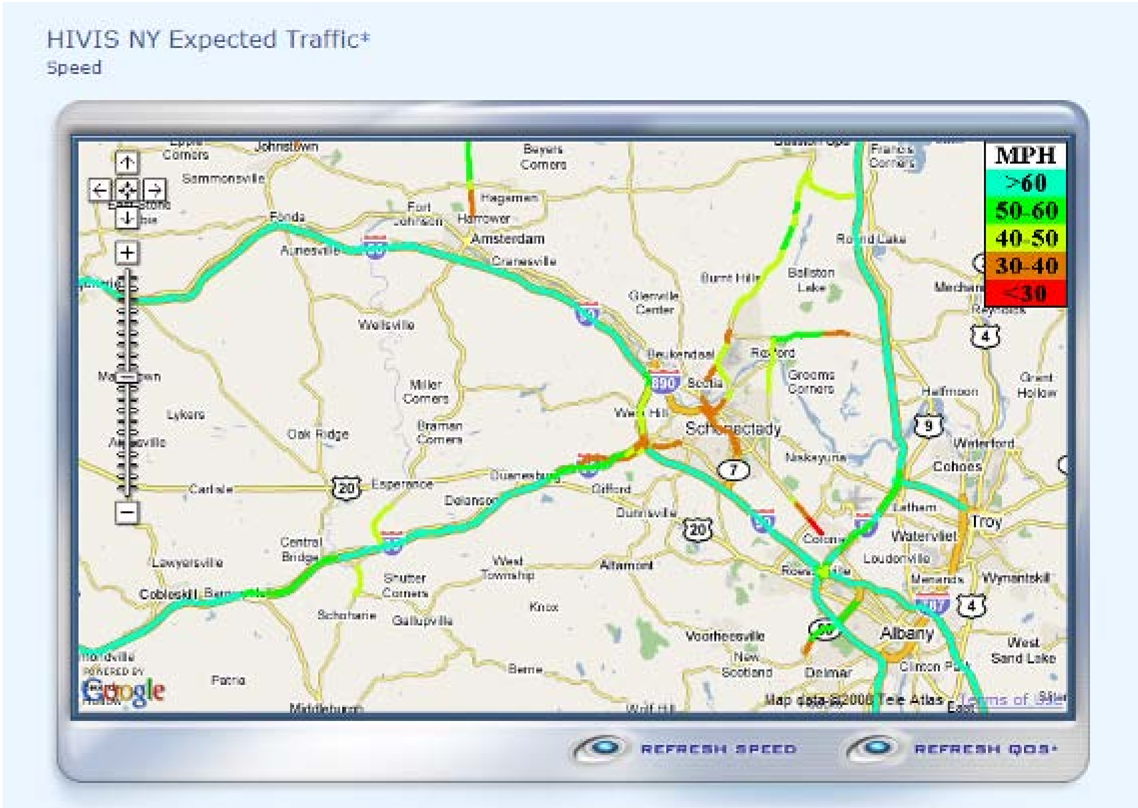

Figure 1. HIVIS Web-application – Expected Traffic

Quality of Service (QOS)

” Quality of Service (QOS) borrows from the American Association of State Highway and Transportation Officials (AASHTO) adopted traffic condition characterized as Level of Service (LOS). LOS is a fully approved means to represent traffic conditions, meeting all engineering standards concerning the driver's expectation of how traffic should be flowing for a given facility type. Lane width, parking activity and similar detailed knowledge is used to arrive at LOS using deterministic methodologies.

Calmar arrived at the HIVIS based Quality of Service (QOS) metric as an adaptation of the Highway Capacity Manual (HCM) level of service (LOS) concept. Within the HCM, LOS is a qualitative measure that is based upon quantitative analysis of traffic volume and geometric particulars of the highway segment being studied. An outgrowth of this quantitative analysis via the HCM approach is the estimated highway segment speed as reported in the basic freeway segment, arterial segments and two way rural highway analytical methods covered within the HCM.

The Calmar QOS method borrows upon these HCM concepts by investigating the speed reported upon the highway type that is being considered. Detailed geometry is generally not available to perform a quantitative HCM analysis. However, the highway type, including the likely presence of traffic signals, are available as useful inputs to arrive at expected traffic speeds within a particular highway segment of a specific highway classification.

The QOS concept follows the logic that, on the whole, the lower the traffic speed is, the poorer the quality of traffic flow. However, this logical construct must be balanced with the type of highway that is being evaluated. For example, speeds of 30 mph on a signalized arterial are quite good. Conversely, the same speed on a freeway is considered to be very poor traffic flow. Calmar's QOS concept addresses this reality, while remaining minimal in data needs required to arrive at such an assessment. The threshold limits for Calmar's QOS metric are defined below, using the New York State's ALIS network as a reference.

The expected QOS for a New York Highway can dynamically viewed as a user option within the HIVIS web-application.

(http://www.calmartelematics.com/speedmap.php).

Figure 2. HIVIS Web-application – Quality of Service

ALIS Classification	General Highway Type	Observed Speed (MPH)	Calmar QOS Assessment	QOS Numeric Value	Webpage Color	Comment
1	**Freeway**	65	Very Good	1	Blue	Grade separated freeways
		60	Good	2	Green	
		50	Fair	3	Yellow	
		45	Marginal	4	Orange	
		>30	Poor	5	Red	
2	**At grade Expressw ay**	60	Very Good	1	Blue	May include rural two way highways
		55	Good	2	Green	
		40	Fair	3	Yellow	
		35	Marginal	4	Orange	
		>30	Poor	5	Red	
3	**Arterial**	35	Very Good	1	Blue	Signalized arterials
		30	Good	2	Green	
		20	Fair	3	Yellow	
		15	Marginal	4	Orange	
		>10	Poor	5	Red	
4	**Local Street**	35	Very Good	1	Blue	Minor collector or lesser classification
		30	Good	2	Green	
		15	Fair	3	Yellow	
		10	Marginal	4	Orange	
		>10	Poor	5	Red	
9	**Special Use Highways**	55	Very Good	1	Blue	Freeway ramps, etc.
		50	Good	2	Green	
		35	Fair	3	Yellow	
		30	Marginal	4	Orange	
		>30	Poor	5	Red	

Table 1. Quality of Service Reference Table

Network Route Probability

One of the rather far reaching possibilities that comes from the very large record of commercial vehicle activities that is now in HIVIS is the ability to actually use the travel patterns to calculate the probability of a vehicle choosing to turn right, left or continue on the same road. Knowledge of these behavior patterns can help inform efforts such as the examination of the future of I-81 in Syracuse. As part of this program Calmar has developed a first look study of routing tendencies on the Interstate highway network around Syracuse.

The HIVIS data enables a unique ability to see details of actual routing which seems to be very new. As such it wasn't exactly clear how to view this data and what the import might be. What has been done as a first pass is to break the Interstate network in to a series of links labeled as shown in the figures below.

The HIVIS database was then queried for trips on any two links in this network between September 2007 and September 2008. Trips were defined as two or more points for the same truck during the 24 hour period after a truck first reports from a link in the network. For each link the trips that contained a data point on that link were aggregated and the downstream points were considered to calculate the percentage of those trips which also had data points appearing on the other links in the network.

So, for all trips that appeared on A-north (I-81N)

- 37% also show up on B-north (I-81N)
  Take I-81 into the city

- 36% also show up on C-north (I-481N)
  Take I-481 around the city

- 31% also show up on D-west (I-690W)
  Head west out of the city

- 20% also show up on H-west (I-90W)
  Head west toward Rochester

- 30% also show up on K-east (I-90E)
  Head east toward Albany

- 14% also show up on N-north (I-81N)
  Continued north toward Watertown and Canada

- 17% also show up on A-south (I-81S)
  Returned back down I-81 during

After having considered the results of this first analysis it is clear that there is much more that could be done to further understand the routing. For instance it is particularly interesting that while there is nearly an even split between trucks heading eastward on I-481 and westward on I-690 most of the eastbound trucks get on the Thruway while more than 1/3 of the trucks heading west don't get on the Thruway.

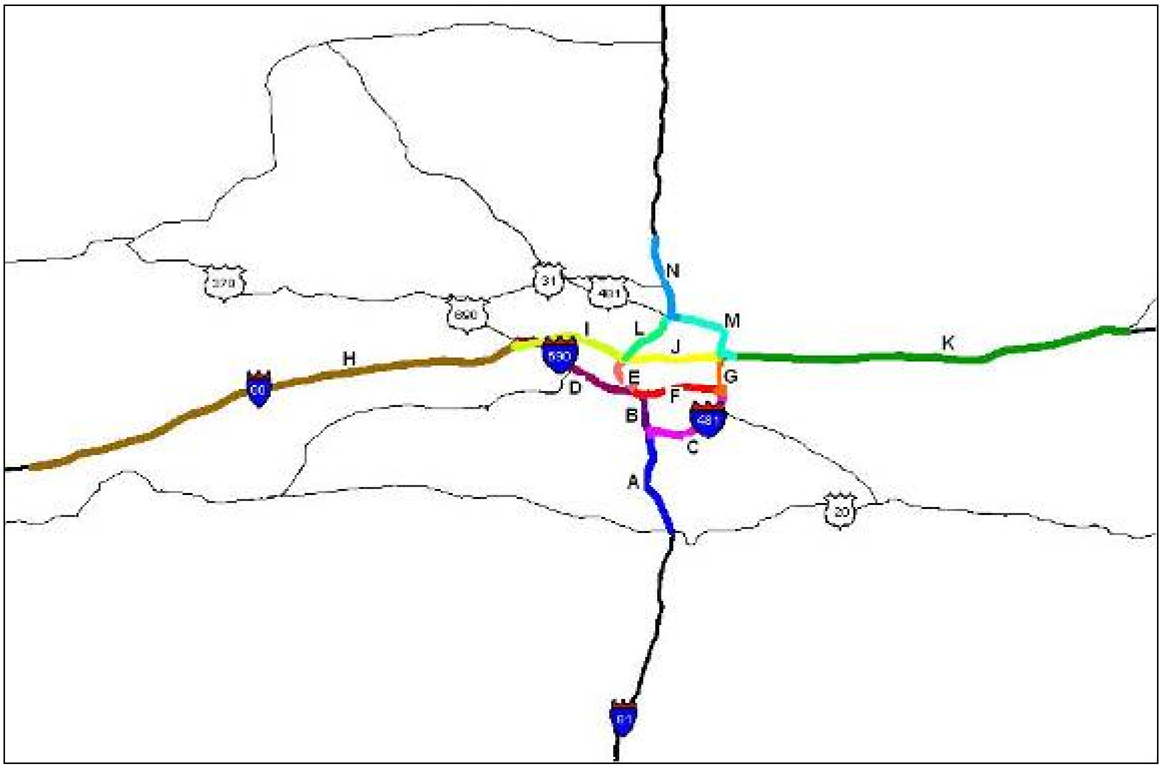

Figure 3. Network Route Probability – Syracuse Network

	A-N	A-S	B-N	B-S	C-N	C-S	D-E	D-W	E-N	E-S	F-E	F-W	G-N	G-S
A-North	100.00%	48.43%	3.27%	9.62%	4.44%	16.79%	4.39%	3.43%	1.55%	2.86%	4.75%	6.33%	7.54%	10.78%
A-South	16.70%	100.00%	7.28%	13.35%	7.65%	19.12%	6.30%	4.79%	3.06%	4.57%	6.13%	7.91%	8.21%	11.40%
B-North	36.99%	26.44%	100.00%	25.42%	14.95%	28.08%	10.33%	8.81%	11.92%	12.75%	10.49%	9.53%	4.15%	3.42%
B-South	17.01%	12.77%	29.68%	100.00%	18.36%	17.96%	15.35%	13.80%	17.57%	19.49%	16.97%	18.08%	7.58%	6.75%
C-North	36.21%	30.25%	8.08%	12.30%	100.00%	27.05%	5.09%	4.53%	3.91%	4.64%	8.23%	8.82%	7.71%	11.32%
C-South	6.24%	4.82%	5.81%	5.36%	11.24%	100.00%	4.92%	4.28%	3.13%	3.29%	10.24%	6.71%	5.43%	10.03%
D-East	20.50%	14.72%	19.53%	15.26%	15.41%	17.82%	100.00%	40.20%	13.32%	14.22%	15.64%	19.00%	12.07%	12.80%
D-West	30.75%	21.66%	27.12%	19.49%	20.19%	23.51%	42.45%	100.00%	14.34%	15.35%	20.40%	27.28%	13.27%	15.73%
E-North	19.51%	20.47%	40.44%	32.59%	28.72%	28.30%	19.84%	18.04%	100.00%	43.00%	21.13%	24.33%	6.38%	7.83%
E-South	16.60%	17.85%	34.08%	28.69%	25.35%	23.78%	19.61%	18.46%	54.98%	100.00%	16.48%	17.43%	8.30%	7.15%
F-East	19.30%	15.65%	22.72%	16.54%	18.85%	23.47%	17.72%	13.91%	10.63%	11.61%	100.00%	32.28%	17.08%	20.43%
F-West	19.25%	15.65%	17.90%	15.25%	34.38%	29.06%	12.96%	11.40%	9.98%	9.68%	35.84%	100.00%	20.70%	29.09%
G-North	33.77%	26.35%	3.87%	5.36%	27.19%	17.96%	7.21%	5.49%	1.74%	3.15%	19.27%	17.78%	100.00%	56.13%
G-South	21.44%	16.71%	3.03%	3.23%	14.30%	10.70%	5.75%	5.23%	1.81%	2.30%	11.05%	12.97%	56.58%	100.00%
H-East	8.53%	5.50%	3.83%	3.68%	4.78%	3.58%	3.82%	4.79%	2.63%	2.72%	3.04%	3.94%	17.65%	13.72%
H-West	19.61%	12.56%	7.38%	6.02%	8.57%	6.22%	10.63%	11.64%	3.54%	3.87%	5.27%	6.41%	22.32%	17.91%
I-East	18.26%	11.00%	7.71%	6.05%	10.63%	7.61%	13.38%	17.33%	4.06%	5.09%	6.82%	8.81%	23.33%	19.30%
I-West	15.66%	9.69%	6.52%	5.20%	8.95%	6.90%	8.37%	9.52%	4.07%	4.22%	5.56%	6.29%	23.54%	18.42%
J-East	12.96%	8.54%	5.13%	4.63%	8.37%	5.96%	7.22%	7.78%	3.58%	3.57%	5.17%	6.47%	23.67%	19.77%
J-West	8.58%	6.90%	2.99%	3.81%	7.19%	5.19%	3.46%	3.08%	2.70%	2.74%	4.16%	4.24%	24.07%	18.97%
K-East	29.97%	22.29%	3.11%	4.24%	20.08%	13.21%	6.75%	6.35%	1.88%	2.52%	12.67%	15.59%	43.90%	39.86%
K-West	12.07%	9.64%	1.29%	1.94%	7.84%	5.28%	3.42%	2.96%	0.86%	1.23%	5.51%	6.34%	25.71%	21.17%
L-North	18.11%	11.29%	13.89%	9.61%	12.35%	9.90%	13.61%	16.27%	16.35%	11.30%	8.02%	11.27%	4.91%	5.98%
L-South	16.34%	10.36%	12.44%	9.54%	12.85%	9.81%	12.85%	15.17%	13.97%	9.99%	8.42%	9.26%	7.35%	6.07%
M-North	24.14%	18.91%	2.66%	3.55%	17.82%	12.63%	6.65%	5.90%	1.72%	2.51%	13.26%	14.92%	61.11%	51.07%
M-South	13.42%	8.59%	2.82%	2.11%	8.07%	6.14%	4.54%	4.95%	2.19%	1.80%	8.10%	10.58%	22.15%	20.65%
N-North	14.15%	7.23%	6.73%	3.58%	7.34%	6.22%	10.76%	13.14%	4.23%	4.17%	5.44%	5.98%	4.34%	3.91%
N-South	12.75%	5.71%	5.60%	2.69%	5.89%	4.84%	9.16%	11.90%	2.67%	2.96%	4.63%	4.89%	3.90%	3.10%

Table 2. Network Route Probability – Link Table

	H-E	H-W	I-E	I-W	J-E	J-W	K-E	K-W	L-N	L-S	M-N	M-S	N-N	N-S
A-North	4.66%	3.59%	5.15%	3.79%	4.69%	3.64%	6.37%	10.82%	5.22%	7.44%	7.44%	8.86%	6.17%	7.09%
A-South	5.88%	4.86%	6.72%	5.27%	5.42%	4.30%	6.27%	11.03%	7.27%	9.79%	7.76%	10.22%	9.02%	10.22%
B-North	5.74%	4.67%	6.28%	5.63%	5.16%	4.42%	1.55%	2.36%	12.59%	12.40%	1.93%	3.92%	9.36%	9.54%
B-South	9.81%	8.31%	9.80%	9.57%	9.59%	8.62%	3.71%	6.25%	17.20%	19.81%	4.64%	6.60%	12.08%	12.88%
C-North	2.67%	2.80%	3.83%	3.58%	4.51%	3.55%	6.04%	10.45%	5.20%	7.28%	7.30%	9.81%	5.69%	6.10%
C-South	2.11%	2.38%	3.39%	3.01%	3.58%	2.95%	3.84%	6.81%	5.09%	5.08%	4.78%	8.35%	5.47%	6.24%
D-East	16.93%	16.95%	21.54%	24.17%	14.54%	14.06%	7.53%	12.81%	26.73%	29.23%	9.58%	12.04%	31.10%	33.87%
D-West	16.18%	18.09%	26.58%	24.74%	16.38%	15.49%	8.60%	14.06%	31.37%	34.07%	10.59%	13.49%	38.44%	42.25%
E-North	10.68%	10.23%	12.08%	13.26%	13.45%	13.97%	3.71%	6.14%	29.34%	27.39%	4.34%	5.56%	16.58%	13.22%
E-South	11.19%	12.23%	17.50%	15.36%	15.63%	13.55%	4.81%	8.19%	49.21%	57.31%	6.41%	8.23%	29.77%	26.20%
F-East	5.43%	7.33%	9.71%	10.24%	9.07%	8.03%	11.59%	21.27%	14.37%	19.50%	15.26%	15.72%	14.27%	15.26%
F-West	5.36%	7.16%	9.59%	9.55%	9.90%	8.62%	13.49%	24.10%	13.46%	15.64%	17.34%	18.69%	12.75%	14.00%
G-North	16.70%	16.46%	16.50%	18.29%	24.98%	26.56%	21.99%	32.18%	4.35%	8.60%	34.44%	28.62%	4.94%	5.49%
G-South	19.27%	19.82%	19.50%	21.75%	29.62%	31.48%	25.17%	37.76%	6.25%	6.78%	41.73%	43.89%	8.48%	10.36%
H-East	100.00%	38.77%	16.05%	30.16%	20.45%	36.08%	6.25%	9.89%	4.64%	5.38%	8.75%	6.45%	6.61%	7.94%
H-West	51.90%	100.00%	35.95%	53.30%	41.80%	57.80%	16.20%	17.49%	12.42%	14.34%	12.32%	11.00%	17.65%	21.98%
I-East	51.85%	43.53%	100.00%	52.10%	28.63%	46.79%	9.28%	14.19%	19.75%	22.98%	13.02%	12.96%	28.95%	35.50%
I-West	38.08%	24.54%	43.75%	100.00%	44.93%	64.16%	16.86%	18.30%	17.76%	20.47%	12.86%	12.33%	25.78%	31.52%
J-East	43.56%	34.62%	45.67%	37.89%	100.00%	49.63%	9.64%	15.27%	6.92%	8.98%	13.80%	11.53%	9.21%	11.69%
J-West	31.36%	18.22%	26.92%	20.63%	43.22%	100.00%	17.76%	20.40%	2.80%	3.08%	13.19%	11.03%	2.88%	3.07%
K-East	22.41%	15.61%	21.43%	17.03%	35.06%	24.62%	100.00%	48.40%	5.84%	7.97%	31.40%	49.42%	11.20%	16.73%
K-West	16.53%	10.25%	14.64%	10.83%	23.27%	15.19%	40.77%	100.00%	2.44%	3.68%	15.37%	20.65%	4.11%	4.94%
L-North	8.22%	13.34%	26.62%	16.80%	11.84%	5.55%	3.65%	5.85%	100.00%	32.53%	4.14%	7.28%	35.81%	39.63%
L-South	7.99%	11.73%	23.42%	14.18%	10.62%	4.39%	4.97%	7.92%	58.07%	100.00%	6.71%	10.37%	56.34%	61.60%
M-North	19.32%	20.60%	20.56%	22.59%	32.39%	32.32%	27.93%	47.18%	5.94%	7.63%	100.00%	47.82%	7.69%	9.81%
M-South	5.64%	6.76%	8.86%	7.80%	10.55%	9.13%	14.85%	28.79%	10.33%	6.17%	28.11%	100.00%	16.51%	22.42%
N-North	8.03%	12.42%	24.83%	15.57%	9.87%	3.82%	2.93%	7.23%	41.43%	24.09%	5.62%	7.73%	100.00%	42.35%
N-South	7.33%	10.77%	22.18%	12.69%	8.34%	2.54%	2.66%	5.62%	33.06%	19.85%	4.61%	6.60%	61.69%	100.00%

Table 3. Network Route Probability – Link Table (2)

<u>Border Crossing Analysis – Peace Bridge</u>

As an extension of the effort to explore the uses of the HIVIS data Calmar performed a short study of the international border crossings in New York. The HIVIS system has a large amount of data in the very busy Buffalo/Niagara region and many thousand crossings of the Peace Bridge every year.

This border crossing is very busy and generates a lot of data but it is also very geographically compact which makes it difficult for a single vehicle to generate two reports in the region of interest.

In order to analyze the crossing times two geo-fences were drawn, one on either side of the Canadian customs facility. For each HIVIS telemetry point on the US side, the travel distance to a fixed point before the customs gate was found. Similarly, the travel distance for each telemetry point on the Canadian side of customs was found from a fixed point after customs. Using the known distance between the two fixed points, accurate travel times and distances for trips that crossed both points were found. Figure 8 shows the geo-fences used, with the starting geo-fence in green and the ending geo-fence in red.

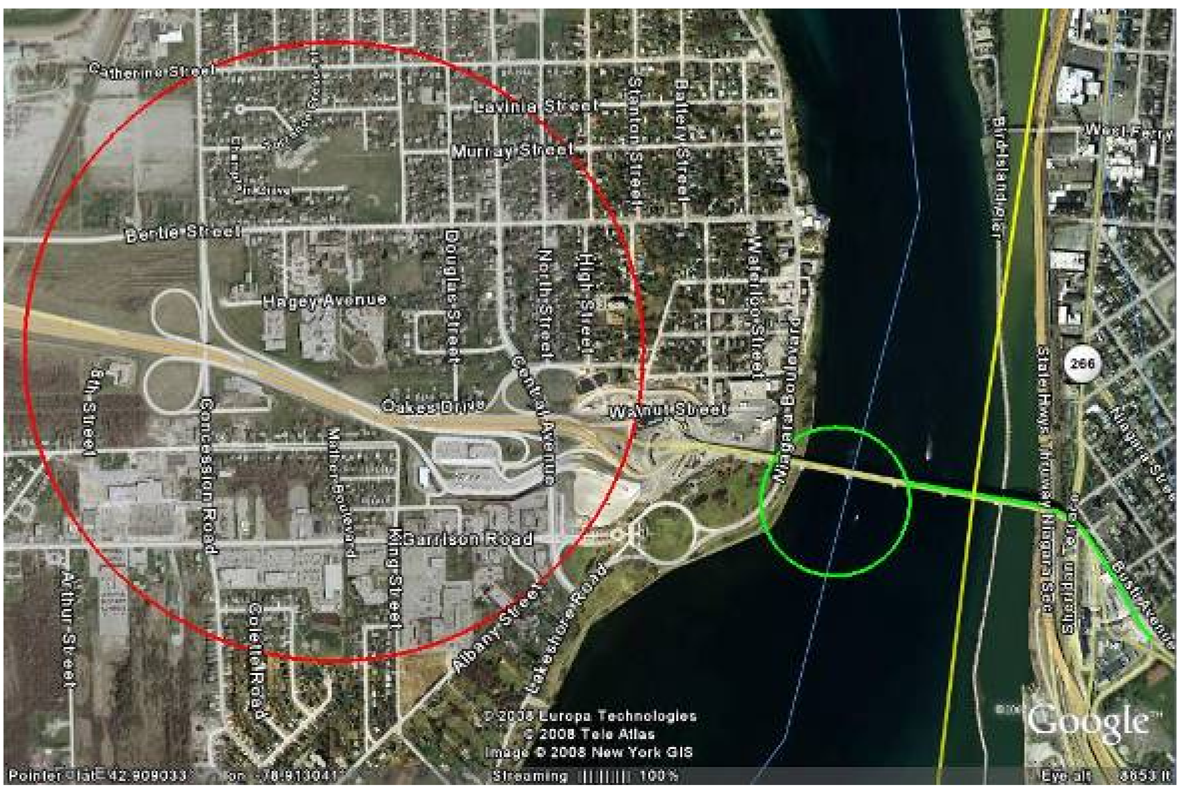

Figure 4. Border Crossing Analysis – Peace Bridge Image

The HIVIS data that fell into the general area was processed to remove known errors such as duplicate points or points that lie outside the bounds of the highway system. The telemetry point distribution can be seen in Figure 5, with the red dots represent all points in the area, the cyan squares represent the valid geo-fenced points, the blue circles represent the points in the starting geo-fence that were used, and the magenta circles represent the points used in the ending geo-fence.

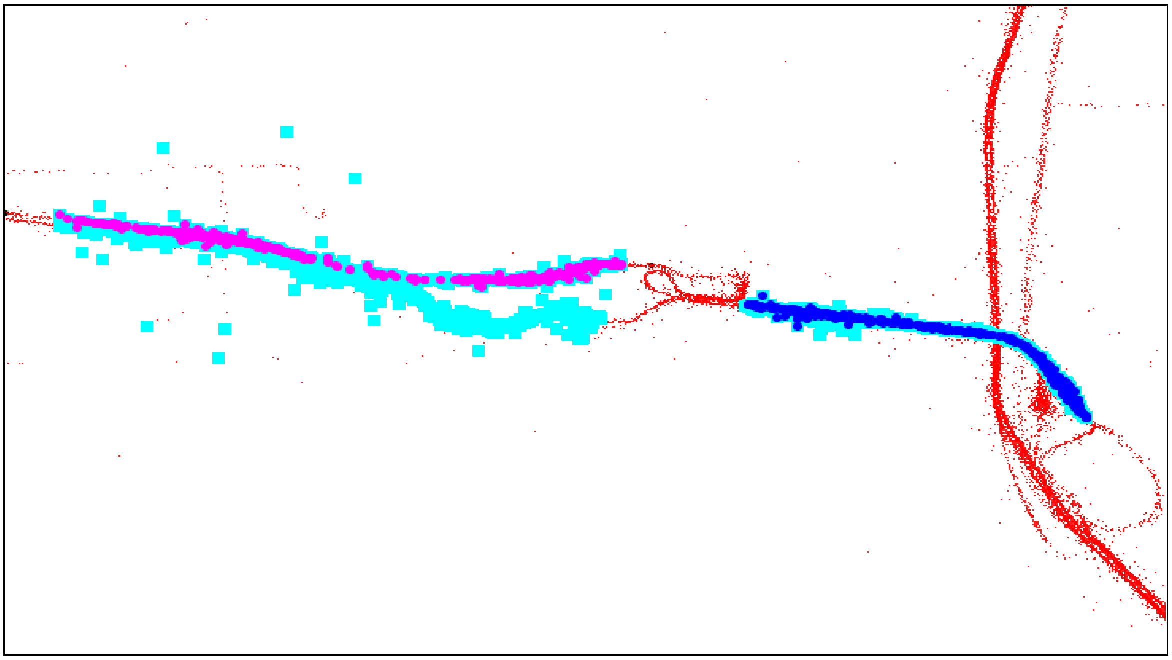

Figure 5. Border Crossing Analysis – HIVIS Data

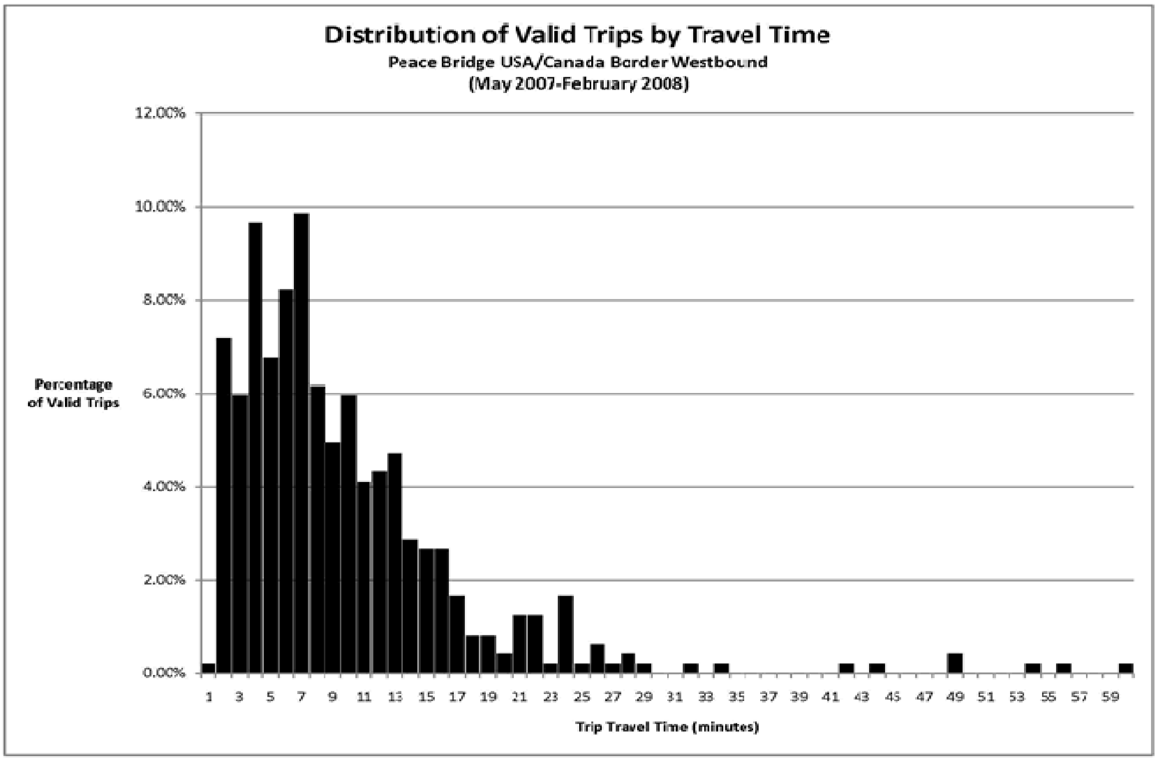

Figure 6. Border Crossing Analysis – Trip Time Distribution

The analysis results in distribution of crossing times as shown in Figure 6. The average travel speed of the 487 trips that went through customs was approximately 13mph. There are clearly some outliers caused by a couple of factors: trips range from .5 to 2.5 miles and from 1 minute to 3 hours, also the individual trip average speeds go from less than 1 mph to around 50 mph.

While there may be questions regarding the accuracy of the results of this effort, the overall achievement of establishing the level of service at the border with less than a man-month of effort is a significant achievement. Since February 2008, when this task was completed the data available at this crossing has more than doubled. An extensive study of the performance of this or other New York border crossings is now feasible in a matter of one or two man-weeks.

SCOPE OF DATA RESOURCE

The first phase of the program was focused on establishing the basic structures that are necessary to securely receive data from the commercial fleets. While the first six months of this effort was slow to show returns the first phase ended with HIVIS was receiving approximately three million points per month with almost all data generated in the Northeast.

With the business and security structures in place, the second phase of the program has seen continued growth in the participation from the fleets and seen the geographic range expand across the entire country. The data rate has now increased to exceed six million points per month. Figure 7 demonstrates the data density in the HIVIS system at the end of Phase II.

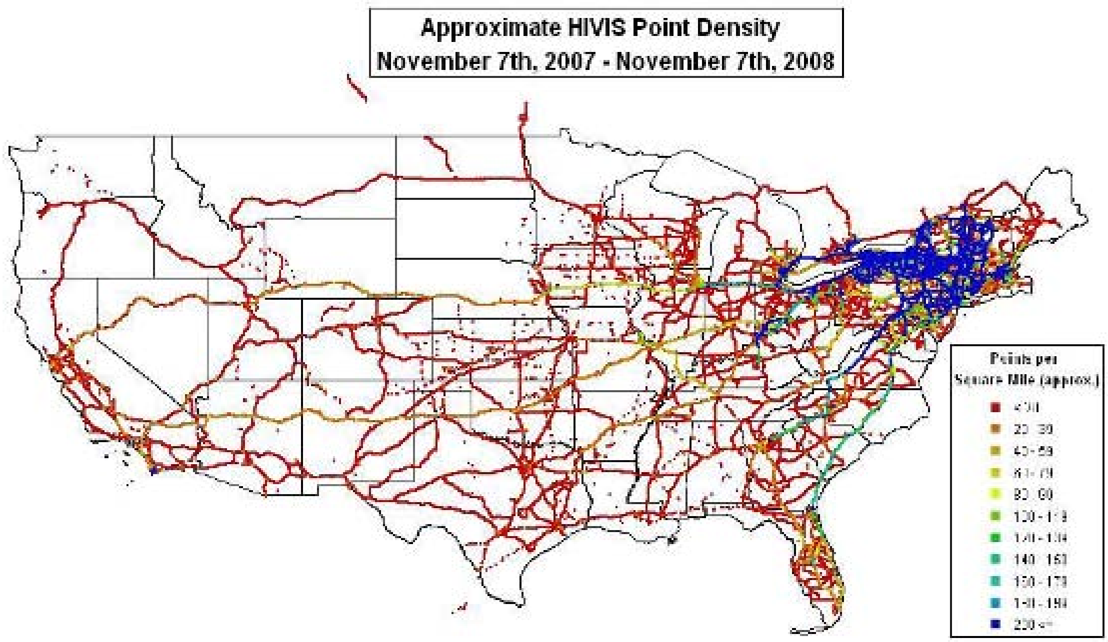

Figure 7. Nationwide Data Density

The single most significant data-acquisition result achieved during the second phase of the program was the demonstrated ability to take the model that had been established in the Northeast and successfully implement it in the Southwest to bring fleet data in to support a FHWA border crossing analysis project. Consistent with that experienced in Phase I, it required about six months to obtain usable telemetry density in the Southwest. Calmar suspects that this ramp up time will be the standard for gaining acceptance from the fleets within a particular geographic region.

Now that this program has concluded, the HIVIS database will continue to grow supporting transportation research within New York State, the Northeast and across the country. Upcoming efforts include expanding the data supply for Florida and the Midwest.

DATA EXCHANGE PROTOCOLS

The Intelligent Transportation Systems (ITS) industry has diligently worked to establish data exchange protocols to facilitate the transfer of traffic information between agencies and suppliers. Unfortunately, the establishment and adoption of standards while set, are not universally, nor uniformly, applied. Experience indicates that the types of data available, the forms that the data naturally take, and the business models of the providers are generally changing more rapidly than the standards.

The majority of the Traffic Management Centers (TMC) around New York State are built as systems that receive data from fixed, infrastructure based, sensors and generate speed, volume and trip time conclusions from the know interrelationship of these sources. The Traffic Management Data Dictionary (TMDD) data protocols call for a message that includes a sensor identification number (sensor #31) and a speed (54 mph) and possible a volume (27 vehicles). Each sensor reports to the central servers and the system is preprogrammed for the sensor locations and their positions relative to each other. The TMC algorithms are designed to take this structured data, indicate one of several pre-determined traffic conditions, and then represented by a pre-programmed display at the TMC, on the 511 system, or on a web-site.

Data that is generated by unconstrained probe-based sources such as the truck telemetry data in HIVIS has the characteristic of being independent of any particular geographic location in the highway network. Unconstrained probe-based data is representative of the direction toward which vehicle infrastructure integration (VII) is taking the traffic community. As such, the particular location associated with any given set of probe data is not known ahead of time and therefore it is not possible to simply query a fixed sensor to obtain a highway speed and know exactly how it relates to other speed measurements within the network.

In the absence of a TMDD standard for unconstrained probe data (e.g. mobile data reported wherever the vehicle chooses to report it), Calmar has devised a stream format that includes the geographic identifiers latitude/longitude and associated highway link as well as time-stamp, the traffic speed and the standard deviation of the traffic speed. These basic variables allow the traffic centers to choose from two standards to geographically place the data in their system and adequate speed statistics to weigh the value of the data against other data sources

Data Streaming

Calmar has established the computing infrastructure that is necessary to support data functions at the rate of 1000 points per minute (PPM) with streams to at least twenty clients. Accounts for streaming data from HIVIS have been set up and tested.

http://myhivis.com/feeds/viewers/NYSFeed.aspx.
The page auto updates every five minutes.

The login info is:
Unm: nysdot
Pwd: hivisData

A sample of the format of the data feed follows:

logged in as [*nysdot*]
Logout

Download Time: 2008-10-29 21:29:03

Longitude	Latitude	StName	PeriodEnd	avgSpeed	sdSpeed
-79.670270	42.294870	I 90	2008-10-29 21:30:00	72	0.000
-79.583920	42.338610	I 90	2008-10-29 21:30:00	72	-1.000
-79.436610	42.410740	I 90	2008-10-29 21:30:00	72	0.500
-79.303180	42.462740	I 90	2008-10-29 21:30:00	72	-1.000
-79.199040	42.511865	I 90	2008-10-29 21:30:00	69	3.373
-79.107880	42.551230	I 90	2008-10-29 21:30:00	68	4.243
-79.031125	42.602310	I 90	2008-10-29 21:30:00	70	3.116
-79.005090	43.120350	I 190	2008-10-29 21:30:00	53	-1.000
-79.004960	43.120550	I 190	2008-10-29 21:30:00	56	-1.000
-78.992610	43.108150	I 190	2008-10-29 21:30:00	52	-1.000
-78.992015	43.108135	I 190	2008-10-29 21:30:00	54	-1.000
-78.990930	43.075935	I 190	2008-10-29 21:30:00	54	-1.000
-78.990850	43.061470	I 190	2008-10-29 21:30:00	47	4.278
-78.990660	43.085480	I 190	2008-10-29 21:30:00	57	1.414
-78.990595	43.089535	I 190	2008-10-29 21:30:00	47	7.778
-78.990540	43.062370	I 190	2008-10-29 21:30:00	63	8.884
-78.990300	43.045870	I 190	2008-10-29 21:30:00	59	-1.000
-78.985180	43.037840	I 190	2008-10-29 21:30:00	69	4.041

Figure 8. HIVIS Sample Data Stream

While the formats of these data streams may not be completely compatible with NYSDOT systems they have been chosen to exercise the process until NYSDOT can more completely specify a format. The key development in the establishment of this stream is the building of a technical process for robustly generating this or any similar format. As a result, new formats that may be desired by NYSDOT can be completed in a matter of a few days.

With the primary HIVIS feed process established Calmar, and sister company, iCone Products was able to efficiently establish the automated feed for iCone data. This stream has been established and is available for downloading at the site below. Calmar and iCone Products is in the process of creating a customization of this feed for the Oregon and California 511 systems and is prepared to support the NYSDOT 511 system when requested.

> http://iconetraffic.com/test/viewers/itsviewer.aspx.
> The page shows data from the last 15 minutes and auto updates every five minutes.
>
> The login info is:
> Unm: icone
> Pwd: icone

An example of the feed follows:

Interval Start Time: 2008-09-14 01:05:00(0)
Interval Stop Time: 2008-09-14 01:20:00(0)

iConeID	Longitude	Latitude	PeriodEnd	avgSpeed
31	-73.827830	42.661590	2008-09-14 01:05:00	67.00
14	-77.732387	42.839895	2008-09-14 01:06:00	70.00
30	-73.816528	42.651485	2008-09-14 01:06:00	69.00
14	-77.732387	42.839895	2008-09-14 01:08:00	64.00
41	-76.190441	43.092660	2008-09-14 01:08:00	0.00
30	-73.816528	42.651485	2008-09-14 01:08:00	66.00
14	-77.732387	42.839895	2008-09-14 01:10:00	66.00
31	-73.827830	42.661590	2008-09-14 01:10:00	66.00
30	-73.816528	42.651485	2008-09-14 01:10:00	64.00
14	-77.732387	42.839895	2008-09-14 01:12:00	61.00
30	-73.816528	42.651485	2008-09-14 01:12:00	66.00
14	-77.732387	42.839895	2008-09-14 01:14:00	60.00
30	-73.816528	42.651485	2008-09-14 01:14:00	64.00
31	-73.827830	42.661590	2008-09-14 01:15:00	64.00
14	-77.732387	42.839895	2008-09-14 01:16:00	68.00
30	-73.816528	42.651485	2008-09-14 01:16:00	62.00

Figure 9. iCone™ Sample Data Stream

Web-based GIS Interface

A basic requirement of the second phase of the project was the establishment of tools for NYSDOT engineers to interface with the HIVIS system. While few specific data requests have been made, the Calmar team has developed processes through which it is possible to create web-based graphical user interfaces (GUI's).

With web-based maps, there are three primary concerns: Initial download speed, update speed when the view is changed (i.e. pan or zoom), and universality of the application. The method that Calmar chose was to utilize a tile concept with the Google Maps Application Programming Interface (API). In this method, for a given zoom level, geo-coded square images (tiles) are overlaid onto a map. For any given view, more tiles than are immediately visible are pre-downloaded, allowing for a more seamless panning ability. Each time the zoom is changed a new set of tiles does need to be downloaded, but the area they cover is smaller, so less underlying data is required. So, using tiles allows for both a fast initial download and quick, incremental downloads when moving around the map. The Google Maps API is also completely AJAX based, allowing any Java enabled internet browser to work, and no unique or proprietary software to download.

In order for Calmar to add a tile layer to a map, with or without a current layer, only a minimum of steps are now required. First the desired metric to view is computed, and geo-referenced to a standard shape (point, polyline, or polygon). This data is then associated with a tile creator, which dynamically builds images for a display as they are needed. Finally, the desired map is given a pointer to the tile creator and displays the tiles which the user is viewing.

The establishment of this basic tiling process and utilizing the Google API now allows Calmar to build web applications for viewing GIS based traffic information in a matter of days after a database has been established for the metric(s) in question.

State-wide Merged Traffic Data Interface

The basic processes established to generate web-based GUI access for traffic metrics was applied to generate a multi-layer view of traffic data sources throughout New York State. The layering approach allows several independent streams to be displayed on the same application at the same time. The application can be accessed at:

http://myhivis.com/multilayer/combomap.html

The data layers that are currently displayed on the multi-layer application include the HIVIS traffic conditions and the iCone traffic monitoring. Figure 7 is a screen capture of the multi-layer application on the 10^{th} of November.

This application is showing two separate layers of traffic information. It is worth noting that the iCone on the New York State Thruway in Albany, represented by the 'circle *i*' icon, is demonstrating agreement with the HIVIS data for the same stretch of highway.

This application does not make any attempt at merging the data forms into a single data form, a process commonly known as 'data fusion'. The theory and practice of data fusion is a subject beyond the scope of this effort. However, the results of a data fusion exercise or any other algorithm to generate metrics can be rapidly structured to be accessed through the data interfaces created through this program.

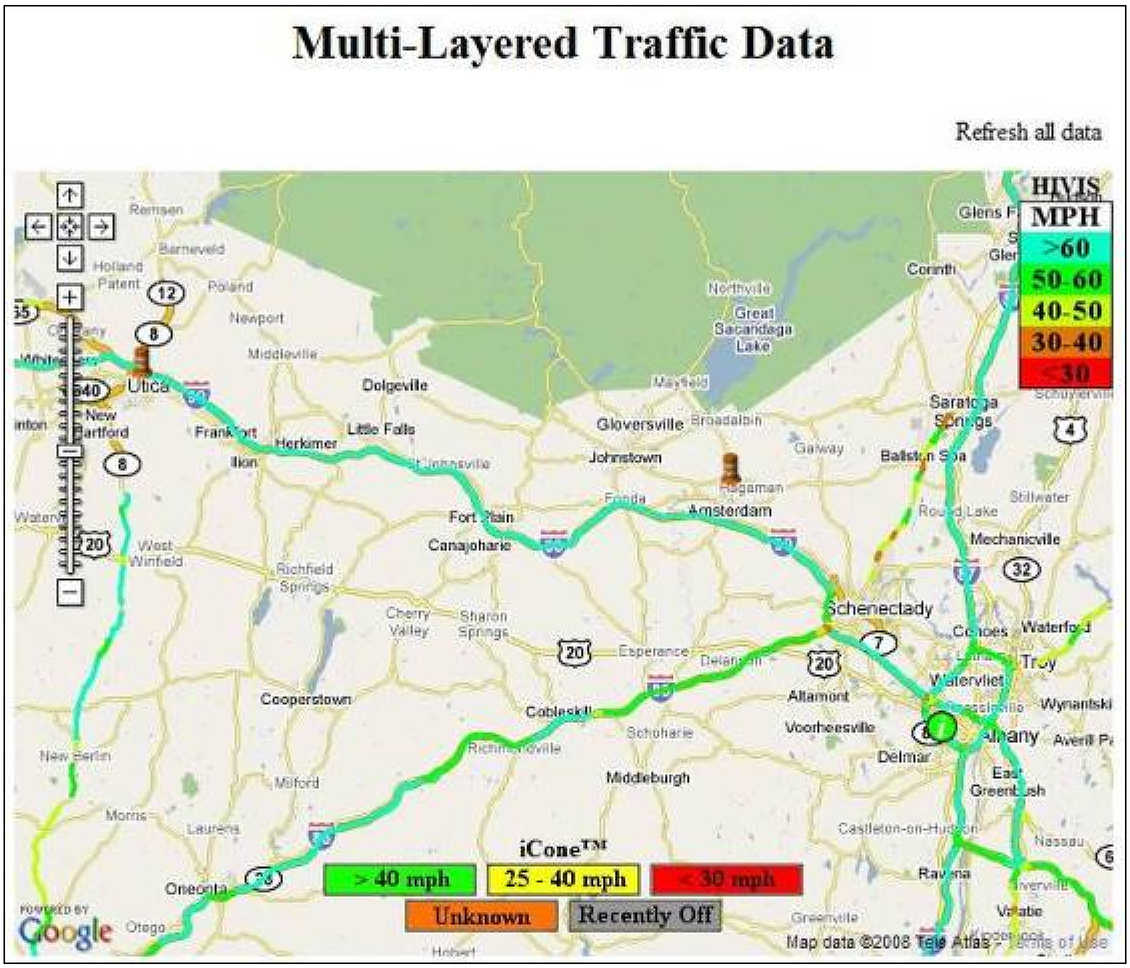

Figure 10. Web Application for Multi-Layered Data

2.0 FUTURE AND EXPANDING EFFORTS

The two phased program that has been executed to create the HIVIS data resource has from the outset been targeted at developing a nationwide market for real world commercial vehicle traffic information. Understanding that a key to any NYSERDA development contract is the successful commercialization of the product, Calmar has been actively marketing HIVIS as a data resource for the last twelve months.

Early efforts to market HIVIS as a real-time traffic information resource have been met with limited results. While organizations such as Delcan, INRIX, and Navteq have approached Calmar for real-time HIVIS data, the price points offered have demonstrated that the commercial value of real-time traffic data is overstated and pales in comparison to the value of commercial vehicle activity trends as demonstrated by contract pricing.

By actively reaching out to the highway modeling and design community through conferences and the presentation of several technical papers Calmar and HIVIS have gathered a bit of following in the transportation community. As a result several agencies are now approaching Calmar to explore how this novel information resource and the close working relationship with the trucking community might revolutionize their business processes.

Some example applications underway are identified below. These examples reflect the continued marketing of Calmar concerning the HIVIS program and HIVIS becoming noticed in the nationwide transportation community.

BORDER CROSSING MONITORING

The border modeling investigation performed under this contract has been leveraged by the FHWA to support a more sophisticated border study at the Otay Mesa – Tijuana border crossing in Southern California.

In 2008 the FHWA awarded a series of contracts to evaluate technologies which can passively monitor the crossing times at the highly congested southern border. A number of technologies are being applied in this effort including license plate readers and telematics monitoring. Science Applications International Corporation (SAIC) and Delcan have teamed on the telematics monitoring project. After unsuccessfully attempting to secure data Delcan asked Calmar to join the team.

While this effort is primarily a technical undertaking, it also has proven to be a test of whether the practices established to gain the partnership of the freight industry in the Northeast was sufficiently general to be transplanted in another region. The stated data threshold for this project was 200 crossing recorded each day. This is an area with very specialized carriers operating in a tight community that have been slow to adopt modern tracking technologies. Just the same, Calmar was brought under sub-contract in April of 2008 and had access to 100 crossings a day by the end of May. Further growth in the data supply required Calmar to encourage the fleets to upgrade their tracking equipment. By early November, the HIVIS system is collecting well over 200 crossings each day.

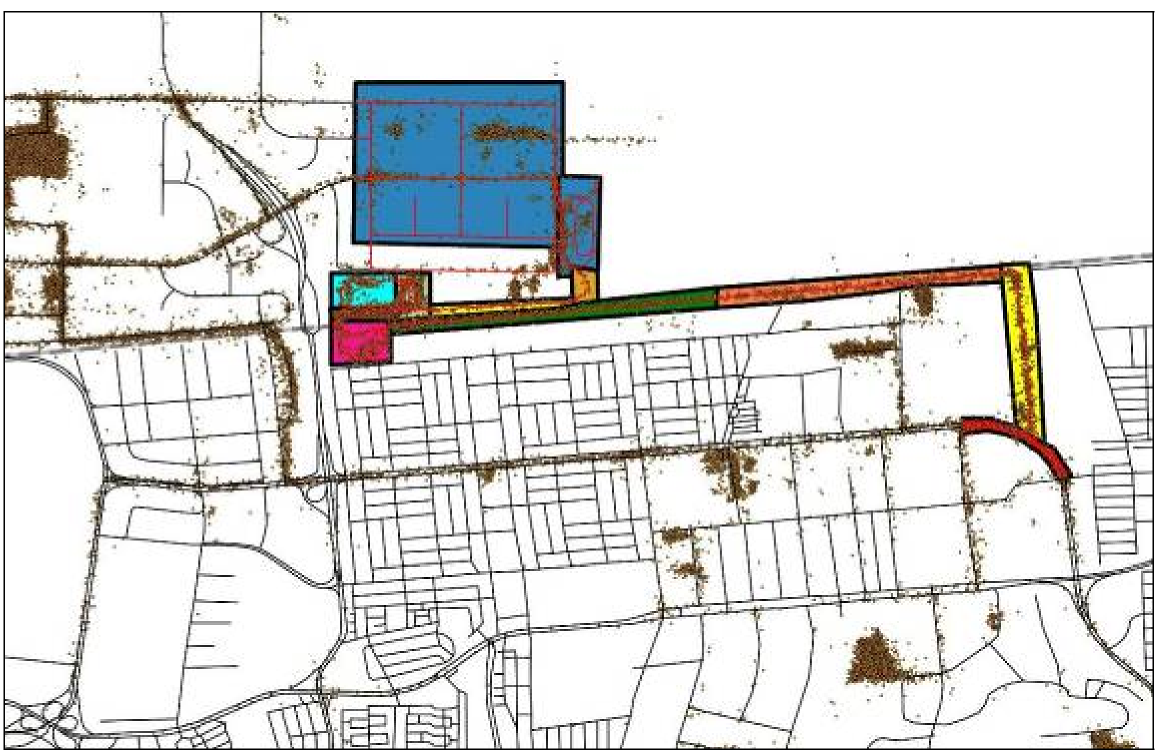

Figure 11. Otay-Mesa/Tijuana Border HIVIS Data

FLORIDA DEPARTMENT OF TRANSPORTATION

During September of 2008 Florida International University (FIU) and the Florida Department of Transportation (FDOT) approached Calmar with a request to expand the HIVIS system to include greater coverage in the Southeast. Florida is seeing a growth in commercial traffic that outpaces much of the rest of the country and FDOT is expecting the pace to continue to increase as shippers move to adopt ports on the eastern seaboard. FDOT and FIU intend to use HIVIS data to build more accurate commercial traffic models in order to improve their ability to forecast the demands of a growing freight industry.

Discussions on the scope of the project are being finalized with the goal of expanding the use of HIVIS to the Southeast by the second quarter of 2009.

MODELING

One of the most compelling uses of the data with HIVIS is the ability to use actual vehicle route structures to provide input and validation data for traffic models. With this understanding and with the support of NYSDOT and NYSERDA, Calmar is undertaking a number of exploratory projects where HIVIS data will inform modeling practices. Foremost among these is the Highway Carbon Footprinting program awarded to Calmar by NYSERDA. The program is well described in the following excerpt from the original proposal:

Approach to the Highway Carbon Footprinting Program

It is proposed to deploy two transportation modeling technologies to create a new capability to analyze highway system design with a degree of accuracy that can identify the specific carbon footprint of a one mile highway segment.

Calmar Telematics has developed a growing commercial vehicle activity database which contains details of fuel consumed on every mile of New York's highways. This database, when combined with the USDOT's Transims modeling capability has the potential to bring the direct cost of fuel consumption, and carbon generation, into the highway design (or re-design) process.

It is proposed to deploy a state-of-the-art transportation modeling system in New York to identify transportation system deficiencies that are not being identified with models being used in the state. The model, Transportation Analysis Simulation System (TRANSIMS), has the resolution capability to identify hidden congestion areas and evaluate transportation policies, such as those being proposed to consider Smart Growth and related issues. Developed and being placed into production under USDOT and EPA sponsorship, this modeling structure retires the 1960's derived models that are being used throughout the state.

These current models do not have good resolution capability to evaluate the effects of the proposed transportation changes in short corridors segments. This inability has resulted in frustration by engineers who attempt to use this tool for corridor studies and specific highway projects. These models do not well represent the effects of highway congestion and will readily estimate traffic volumes traveling through highway sections at levels that are well beyond the roadway's carrying capacity.

Deployed in other areas within the nation, TRANSIMS successfully reflect actual transportation conditions and how highway improvements will affect these conditions. It microsimulates individual vehicle flows and will not permit unrealistic volume levels to traverse a highway segment. Instead, it will queue vehicles and more accurate compute vehicle delays, fuel usage and emissions.

To date, TRANSIMS has been successfully deployed in urban areas, such as Portland Oregon and Alexandria Virginia. It is currently being set up in a number of other urban areas. A challenge that lay before it is the requirement of greater network definition and travel pattern definition. Network definition merely lay with going out and collecting the required data. Greater trip table definition is readily addressed by the State's investment in HIVIS technology. These combined elements remove any practical constraints to the ready deployment of TRANSIMS and its ability to defensibly project a highway section's carbon footprint.

3.0 SUMMARY AND CONCLUSIONS

Calmar Telematics has successfully built and operated a state-wide traffic data system based upon the passive and anonymous monitoring of commercial vehicle telematics systems. The system known as HIVIS is currently converting more than four million reports a month into traffic speed data on the Class 1-3 roads in New York. Accurate reporting of highway speeds has been verified. This data is actively being displayed on a number of web sites and is available as data streams to NYSDOT at their request.

This first phase of Calmar's program was intended to study the economics and statistics of using the passive monitoring of telematics systems for the specific purpose of generating highway congestion and vehicle count data.

This study has made the use of commercial vehicle probes for traffic speed data on major roads a reality in New York State. Furthermore, this study has established, that provided that a proper relationship with the trucking industry is maintained, the process can be a very affordable alternative to fixed sensors.

The operation of a data system such as HIVIS to provide a complete real-time traffic information system for the State of New York will require approximately 10,000 vehicles at a cost of $1M - $1.3M. However, a much smaller fleet of 1,000 to 2,000 vehicles is more than sufficient to generate a transportation data resource that is not matched by any current system.

The staff at NYSDOT and other transportation agencies including CalTrans and Florida DOT are still considering how a data set such as HIVIS is to be worked into their processes including model development and route studies. NYSDOT 511 will not be ready for new sources of traffic information several more months. While this research will continue for some time the basic delivery mechanisms have been completed including advanced processes to rapidly create data streams and user interfaces.

The thirty month duration of this project has proven to be both difficult and rewarding. Some of the achievements of the program were expected, others emerged over time. Certainly the value of the program has been realized, though the center of those values appears to lie in the highway research and modeling disciplines rather than in ITS. But, it is important to realize the strides that have been made.

- Structures and relationships are in place to gather data from the trucking industry.
- Business and security relationships have been successfully demonstrated to be portable to other regions of the nation and continent.
- Over six million data records are collected each month from several thousand vehicles.

- State of the art data access tools have been developed and the methods necessary to rapidly develop additional tools have been established.

- Real-time streams of traffic data are operating and await connection by NYSDOT personnel.

- Several state and federal agencies have recognized the value of the HIVIS data and are entering into business relationships to gain access to this information resource.