Traffic Operations Infrastructure Plan (TOIP) Update

Corridor Prioritization and Deployment Density Class Analysis and Recommendations

March 22, 2011

Introduction and Overview

The Wisconsin Department of Transportation (WisDOT) has developed a methodology and associated tool to evaluate operational projects in the same manner as infrastructure projects, and to integrate operations into the planning process. The purpose is to evaluate potential operational improvements for technology applications, improve communications, and Intelligent Transportation Systems (ITS) planning.

For the preparation of the Wisconsin Long-Range Plan, WisDOT segmented the entire state trunk highway system into 37 corridors and published the *Connections 2030[1]*.   The TOIP effort adopted the 2030 Corridor Network as the basis for planning of operational enhancements.

The TOIP includes an operationally-oriented methodology and provides deployment recommendations integrating three areas: Freeway Surveillance and Ramp Control, Travel Warning and Information Systems, and Traffic Signal Systems.

The TOIP is very spatially oriented and relies heavily on figures and maps. This document constitutes a descriptive narrative intended to accompany many graphics provided on the TOIP website (www.topslab.wisc.edu/its/toip), with the intent that the reader is referring to those materials.

Traffic Operations Infrastructure Plan (TOIP) Final Report

TOIP Methodology

Based on the TOIP Final Report[2],one of the principal results is a Deployment Density Class (DDC) recommendation for every considered length of roadway, in the form of baseline, low, medium, or high operational deployment recommendation. The DDC is reached through an analysis of 10 critical inputs (which encompass mobility, safety, environmental conditions, and special events). These criteria are grouped into tiers by level of recommended deployment (baseline, low, medium, and high).

A threshold is established for each criterion as well as for each roadway classification. The roadway classifications considered in the TOIP are: Urban Interstate, Urban Expressway, Urban

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[1] *Connections 2030: Wisconsin's long-range transportation plan*. Available at
http://www.dot.wisconsin.gov/projects/state/connections2030.htm

[2] *WisDOT Traffic Operations Infrastructure Plan.* Wisconsin Department of Transportation and Cambridge Systematics, Inc. May 2008. Available at
http://www.topslab.wisc.edu/its/toip/Final%20Reports/WisDOT__Traffic_Operations_Infrastructure%20Plan.pdf

Other, Rural Interstate, Rural Expressway, and Rural Other. Points are given for each criterion. If criteria fall into the baseline tier, zero points are awarded to the segment. Likewise, low receives one point, medium receives three points, and high receives five points. After all criteria have been assigned a score, the inputs go through a weighting process. The weights were selected by WisDOT stakeholders and they capture the importance of each criteria as a driver for operations technology deployment. After the weighting process takes place, a final value, which is the sum of all the weights for each criteria, results in the DDC of the segment. Table 1 shows the criteria and their weights, Table 2 shows the segment scoring and thresholds for urban interstate while Table 3 shows the overall score of a roadway segment.

Table 1 Criteria and Weights

Criteria	Weight
MOBILITY	**45%**
ADT Base Year	10%
ADT Forecast Year	7%
HC ADT Base Year	4%
Peak-Hour V/C - LOS	12%
Congestion Forecast	12%
SAFETY	**37%**
Crash Rate	15%
Crash Severity	13%
Weather Index	9%
ENVIRONMENTAL CONDITIONS	**18%**
ADT Growth	7%
Event/Traffic Generators	11%

Table 2 Threshold Example for Urban Interstate

		Threshold			
Mobility	ADT Base Year *(ADT/lane)*	>22,500	15,001 - 22,500	7,500 - 15,000	<7,500
	ADT Forecast Year *(ADT/lane)*	>22,500	15,001 - 22,501	7,500 - 15,001	<7,501
	HC ADT Base Year	>11%	9% - 11%	4% - 8%	<4%
	Peak-Hour V/C - LOS	LOS F	LOS E	LOS D	LOS A,B,C
	Congestion Forecast	LOS F	LOS E	LOS D	LOS A,B,C
Safety	Crash Rate *(total crashes per vehicle mile)*	>131K	99K - 131K	65K - 98K	<65K
	Crash Severity *(Fatalities and incapacitating injuries per vehicle mile)*	>474	317 - 474	158 - 316	<158
	Weather Index	>80"	60" - 80"	30" - 59"	<30"
Environ-mental Conditions	ADT Growth	>50%	36% - 50%	20% - 35%	<20%
	Event/Traffic Generators	>10	6-10	1-5	0
	DDC	*High*	*Medium*	*Low*	*Baseline*

Table 3 Deployment Density Class Scoring

Tier	Score
Baseline	Below 93
Low	From 93 to 158
Medium	From 158 to 224
High	Greater than 224

TOIP Data Resources

The TOIP methodology was developed based on three datasets to ensure that the methodology can be revisited and updated easily. The primary dataset used was the Meta-Manager. The Meta-Manager was developed by the Division of Transportation Investment Management's Bureau of State Highway Program. It integrates a variety of data of pavement, safety, congestion, and also future projections, and it is updated three times per year. It was used for most of the criteria in the TOIP methodology, except for the Weather Index and the Event Generators.

The weather data used for the methodology were processed by the University of Wisconsin TOPS Laboratory and it was documented in the paper Application of Road Weather Safety Audit to the Wisconsin Highway System[3].

The special events data used was provided by the WisDOT Bureau of Traffic Forecasting which prepared a list of the top 86 special events around the state.

Meta-Manager Rolling-up Methodology

Once the Meta-Manager is obtained, it has to be organized and prepared before the methodology takes place. The rolling-up process was performed in order to aggregate multiple consecutive links with similar characteristics with the purpose of reducing the number of links to analyze in the scoring process. It was necessary to make sure that the data was organized and that the "next" link was on the same route, same direction, and consecutive.

The aggregation process involved several fields: accident rate, severity index, percent of trucks, average annual daily traffic (AADT) (base year and forecast year), LOS (base year and forecast year), length, intersecting street name and other fields. The aggregation was performed based on the following equations:

$$Rate = \frac{(AADT_1)(Length_1)(Rate_1) + (AADT_2)(Length_2)(Rate_2)}{\sum(AADT * Length)}$$

$$Severity\ Index = \frac{(AADT_1)(Length_1)(SI_1) + (AADT_2)(Length_2)(SI_2)}{\sum(AADT * Length)}$$

$$Level\ of\ Service = Average(LOS)$$

$$Length = Average(Length)$$

$$AADT = \frac{(AADT_1)(Length_1) + (AADT_2)(Length_2)}{\sum Length}$$

$$\%\ Truck = \frac{(\%Truck_1)(Length_1)(AADT_1) + (\%Truck_2)(Length_2)(AADT_2)}{\sum(AADT * Length)}$$

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[3] *Application of Road Weather Safety Audit to the Wisconsin Highway System.* Available at
http://www.topslab.wisc.edu/projects/documents/rwsa.pdf

AADT$_{1,2}$ = individual AADT values of each single link

Rate$_{1,2}$ = individual rate values of each single link

Length$_{1,2}$ = individual lengths of each single link

SI$_{1,2}$ = individual severity index of each single link

%Truck$_{1,2}$ = individual percent of truck of each single link

AADT = aggregated AADT of the resulting link

Rate = aggregated rate of the resulting link

Severity Index = aggregated severity index of the resulting link

%Truck = aggregated percent of trucks of the resulting link

Based on the equations the aggregated values of the fields are determined which are applied to each of the corresponding single links. Once the aggregating process is completed the TOIP links are split based on seven criteria.

1. Route and direction; when either route or direction changes, a new link is started

2. Number or lanes; when the number of lanes changes, a new link is started

3. Level or Service; when the LOS letter designation changes, a new link is started

4. Seasonal Factor Group (SFG); this value is relatively constant, however, it is accumulated but ultimately the SFG in that region is correctly captured

5. Functional class; when the functional class of the roadway changes, a new link is started

6. Total length; when the accumulated length reaches beyond 100 miles, a new link is started

7. Contiguity; when the start point of a given link is further away (10 feet) than the end point of the (current) last link in a rolled up link, a new link is started

Original TOIP Results

A Visual Basic Graphic User Interface (GUI) was developed on a spreadsheet that allows the execution of the methodology. This tool provides the Deployment Density Class (DDC) assignment for each roadway segment. Each of the 37 Connections 2030 corridors were evaluated in order to identify the operational technology deployments that best serve the mobility and connectivity of the state. Based on the DDC results, the corridors were prioritized in order to identify corridors with the greatest needs for traffic operations investment. A weighting process was performed; each center line mile of high DDC adds a score of three, medium adds two, and low adds one. The top corridors were defined as Priority Corridors and the second tier of corridors as Emerging Priority Corridors for a total of 14 corridors as described below:

Priority Corridors

1. Badger State (Eau Claire to Madison)
2. Capitol (Madison to Milwaukee)
3. Chippewa Valley (Minnesota to Eau Claire)
4. Fox Valley (Milwaukee to Green Bay)
5. Hiawatha (Milwaukee to Illinois)
6. South Central Connection (Madison to Illinois)

Emerging Priority Corridors

1. Cornish Heritage (Dubuque to Madison)
2. Coulee Country (La Crosse to Tomah)

   > *Note: This corridor was added to the list based on WisDOT recommendations, instead of the priority score*

3. Glacial Plains (Beloit to Milwaukee)
4. Peace Memorial (Eau Claire to Duluth-Superior)
5. Southern Tier (Janesville and Beloit to Kenosha and Racine)
6. Titletown (Milwaukee to Green Bay)
7. Wild Goose (Madison to Fond du Lac)
8. Wisconsin River (Madison to Ironwood, MI)

Once the corridors are ranked they were reviewed in GIS, setting up the corridors to see both east/west and north/south at the same time. This process was necessary to assign the same DDC on bi-directional segments which for some reason have different DDCs on each direction. A professional review called "smoothing" was performed which reviews the major corridors, removed any illogical little blips and made the same DDC for both directions, typically applying the higher class.

The DDC methodology was intended to foster consistency across Wisconsin corridors. After this process was completed, the signposts were assigned based on professional engineering judgment applying local knowledge and analysis, such as the technologies that would work on any given roadway. All the recommendations were kept within a logical parameter, so roads in different locations but with same operational characteristics would have similar recommendations.

A Statewide Priority Corridors map[4] showing the statewide Priority and Emerging Priority corridors was developed. Also, traffic operations maps illustrating the technology deployment recommendations for each corridors were prepared as part of the TOIP Final Report and included

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[4] *Statewide Priority Corridors Map*. Available at
http://www.topslab.wisc.edu/its/toip/TOIP%20Update/2010_Statewide_Priority_Corridors_Map.pdf

as an appendix[5]. The operational needs are most significant in high-traffic areas of Milwaukee, Madison, the Fox Valley and the Chippewa Valley, plus the roadway connections between them and external activity center such as Minneapolis and Chicago.

Traffic Operations Infrastructure Plan (TOIP) Update

The TOIP Final Report was completed in May 2008 followed by the implementation plan[6] which refines the location to install ITS technologies. The TOIP Communication System Layer (CSL) was recently completed identifying statewide communications infrastructure needs and developing detailed deployment plans considering connections to related devices and facilities.

The TOIP was intended to be re-visited, re-evaluated and eventually updated as part of ongoing planning activities. As mentioned, the TOIP was performed based on different data principally from the Meta-Manager. The Meta-Manager used for the final report was from 2007. The weather data as well as the special events data were part of separate documentations.

As part of the TOIP update, the intent is to apply newer data reflecting current patterns on the roads that might be different to the original report and could potentially change the DDC recommendation. The update is also intended to include additional ITS technologies not considered in the original report. The Meta-Manager used on the update is from August 2010. Since the weather information used on the TOIP was basically the amount of snow registered and the special events information was based on 86 events statewide, these information were not considered to vary from the original report, and were included, as it is, in the update.

TOIP Update Priority Score

The data was organized and analyzed applying the rolling-up methodology, aggregation and split criteria. Once the completed methodology was applied to obtain the DDC for each segment of roadway, the weighting process was performed to obtain the priority score. This process consisted in assigning a score of 3 for each centerline of high DDC, a score of 2 for medium, and low receives a score of 1. The scores were added for each corridor and the results are shown in a table[7] and chart[8] which compares the 2008 and 2010 scores.

Most of the corridors had an increase in the priority score, most notable in the Priority Corridors. Very few decreased, however, and for most of them it is not a considerable drop and they did not fall from either the Priority Corridors or the Emerging Priority Corridors. A notable exception is Peace Memorial Corridor (Emerging Priority Corridor), which had a significant drop.

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[5] *Appendix A - Traffic Management and Surveillance Operations Infrastructure Plan and Cost Estimates*. Available at http://www.topslab.wisc.edu/its/toip/Final%20Reports/WisDOT_TOIP_AppendixA_Traffic Management&Surveillance.pdf

[6] *TOIP Implementation Documentation.* Available at http://www.topslab.wisc.edu/its/toip/implementation.html

[7] *Corridor Priority Score*. Available at http://www.topslab.wisc.edu/its/toip/TOIP%20Update/Corridor_Priority_Score.pdf

[8] *Corridor Priority Score Chart*. Available at http://www.topslab.wisc.edu/its/toip/TOIP%20Update/Corridor_Priority_Score_Chart.pdf

As noted in the table and chart, most of the corridors experienced an increase in priority score, and some others a decreased, most notably the Peace Memorial Corridor. Also, there are corridors in the Emerging Priority list that obtained higher values than some on the Priority list, likewise some corridors that fall neither in the Priority nor the Emerging Priority list obtained higher values than some in the Emerging Priority list. The reasons for these changes vary, but the principal reasons are the AADT, LOS, crash rate, and the percent of trucks. Some other reasons would be construction projects affecting traffic as well as previous infrastructure improvements that lowered the volume and the incidence of crashes.

Peace Memorial Corridor Comparison

This corridor (Eau Claire-Superior) obtained a decreased of 51 from 2008 to 2010. The main reason for this drop is a decrease in AADT for most of the segments but especially the US 53. This segment of US 53 had an AADT reduction of up to 43% while the growth was up to 27% less than 2008. The crash rate was also reduced significantly at about 34%, and the percent of trucks remained fairly constant. Another segment that experienced significant reduction in AADT was WIS 124 in Eau Claire. This particular road had a reduction of up to 72% in AADT, however, the crash rate increased by 33%, severity index doubled and the percent of truck increased at 4% (previously the percent of truck was 0% for this segment). Nonetheless, the segment remained at a baseline DDC since the AADT reduction was considerable.

The US 53 segment in Eau Claire was recently built into a freeway, bypassing most of the city, and thus alleviating congestion on the original route. This new alignment was not considered in the 2008 Final Report, and the original US 53 route was not included in the updated 2010 Meta-Manager meaning that this new alignment of US 53 will actually have different patterns. However, one would assume that the difference in AADT between the two alignments would not be significantly high. A reason could be that people heading north into Chippewa Falls or up to Superior are actually bypassing the city using this new freeway, while workers and people related to residences and businesses in the city are still commuting on the original alignment and consequently the AADT are split into the two alignments. A map[9] was developed showing the two different alignments of US 53 in Eau Claire.

Fox Valley Corridor Comparison

This corridor (Milwaukee-Green Bay) had an increase of 76 resulting in the highest increase of any corridor. In contrast to Peace Memorial Corridor, the reasons would be an increase on one or several criteria. This corridor covers segments of US 45, US 41, US 10, WIS 23, and WIS 441.

The US 45 route had a constant AADT and a growth throughout, however, some segments had a slight increase in crash rate as well as the severity index. The percent of trucks is the only criteria that increased significantly in some segments. US 41 had an increase in AADT in most of the segments, however, the growth remained fairly constant. Also, the crash rates and severities

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[9] *US 53 Original and New Alignment*. Available at
http://www.topslab.wisc.edu/its/toip/TOIP%20Update/US_53_Original_and_New_Alignment.pdf

increased in most of the segments with some exceptions. US 10 also experienced increases in AADT and percent of trucks, however, it decreased on crash rate and severity index. WIS 23 was the only road that experienced a decrease in most of its criteria, and therefore, in the DDC. WIS 441 had a significant increased in AADT for the entire segment and the percent of trucks remained constant, however, crash rates and severity indexes were reduced.

As mentioned, the entire Fox Valley Corridor experienced increases in AADT, some increases in crash rate, severity index, and percent of trucks. Although there was an increase in AADT, the projected growth for the entire corridor remained similar as the growth reported in the 2008 Final Report.

There are some construction projects that were executed and are still underway in this corridor. In the city of West Bend, there was some minor construction projects in local roads around US 45 and affected the traffic patterns. This could have resulted in volume variability as well as crashes. The most significant construction project in this corridor is the US 41 Project in Brown and Winnebago Counties. This project covers 17 miles in Winnebago County and 14 miles in Brown County which includes lane expansion, improvement of interchanges, roundabouts and the installation of traffic cameras. This project could have contributed to the trucks increased as well as the crashes in the area.

Priority and Emerging Priority Corridors

Originally, the 2008 TOIP Final Report included 13 corridors which were classified as Priority and Emerging Priority based on the priority score. Together, they encompass the vast majority of freeways and interstate highways. In the case of Coulee Country Corridor, it covers a section of I-90 from La Crosse to Tomah and it did not receive a high priority score. Since this corridor has a portion of interstate highway, WisDOT chose to include it into the Emerging Priority list. Also, the Chippewa Valley Corridor (Eau Claire-Twin Cities) was moved from the Emerging Priority to the Priority Corridors list.

The 2010 TOIP update being performed includes the priority score as described. There were mixed results; some corridors increased, some others decreased while others remained slightly equal. The reasons for either increase or decrease were described above for the Peace Memorial and Fox Valley Corridors, both resulting in the highest decrease and highest increase, respectively. The patterns for increase and decrease are basically the same for the rest of the corridors, but in a lesser effect.

The Priority Corridors list remained the same, since all the corridors experienced an increase in the priority score. Furthermore, the order of priority remain unchanged having Badger State Corridor as the highest priority corridor. Changes are most notable in the Emerging Priority list. The Wisconsin River Corridor (Madison-Ironwood, MI) remained at the top of this list, but due to significant increases and decreases in some corridors the order of this list has changed. The same situation is seen with the "Remaining Corridors" list.

There are two particularly interesting results from the priority score. As mentioned, Peace Memorial had the highest decrease in score from 86 to 35. This new score of 35 has resulted in a value too low to be considered in either the Priority and Emerging Priority list. On the other hand, the Wisconsin Heartland Corridor had an increase from 51 to 78 resulting in a score higher than some corridors listed in the Emerging Priority list. The reasons for the big drop in score for

Peace Memorial Corridor have been explained; mainly the US 53 by-pass in the City of Eau Claire and a drop in AADT along the corridor. The Wisconsin Heartland Corridor, which is basically WIS 29, runs east-west from Green Bay to Eau Claire passing through Wausau making it an important corridor connecting major cities. This entire corridor experienced an increase in AADT and percent of trucks, however, it is most notably around the Wausau area. This corridor experienced up to a 3.5% increase in AADT and up to a 40% increase in trucks, mostly in Wausau and a portion near Eau Claire. While the segment between Wausau and Abbotsford had an increase of up to 25% in trucks. Crashes and severity had a slight increased throughout the corridor, again must notably in the major cities.

Recommendations

The purpose of the 2010 TOIP update is to provide guidance on prioritization and ITS deployment recommendations reflecting updated Meta-Manager data. The 10 criteria were implemented obtaining the DDC for each segment and finally a priority score for each of the 37 corridors. The priority scores have changed for all the corridors, some of them increased while others decreased. Of the 10 criteria assessed for the TOIP, the most notable increases in priority score were due to increases in AADT, crashes and percent of trucks. While some decreases in priority score were due to decreases in criteria, some decreases are attributed to infrastructure improvement, such as by-pass, interchange improvement, and lane expansion.

The Priority and Emerging Priority Corridors remain basically unchanged, with two exceptions: Peace Memorial Corridor and Wisconsin Heartland Corridor. The Peace Memorial Corridor had a significant decrease on its score with a value less than corridors on the "Remaining Corridors" list. On the other hand, Wisconsin Heartland had an increase on priority score with a value higher than some corridors in the Emerging Priority list.

Based on the corridor analysis and the priority score obtained, it is recommended that Wisconsin Heartland Corridor be included in the Emerging Priority list, while retaining Peace Memorial Corridor in this list. A map[10] showing the recommended statewide priority corridors was developed and a new Priority and Emerging Priority Corridors list[11] is recommended.

The Statewide Deployment Density Class Recommendations[12] were developed showing the baseline, low, medium, and high segments for all the 37 corridors. As mentioned, most corridors changed their priority score, which was a result of a change in the DDC obtained. If compared with the Statewide Deployment Density Class obtained in 2008, the most notable changes seen are the Peace Memorial Corridor and the Wisconsin Heartland Corridor. US 53 in Eau Claire decreased from mainly medium to baseline. This same road also changed from low to baseline north of the intersection with US 8 up to Superior. One the Wisconsin Heartland Corridor, WIS

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[10] *Recommended Statewide Priority Corridors Map*. Available at http://www.topslab.wisc.edu/its/toip/TOIP%20Update/Recommended_Statewide_Priority_Corridors_20110225.pdf

[11] *Recommended Corridors Priority*. Available at http://www.topslab.wisc.edu/its/toip/TOIP%20Update/Recommended_Corridor_Priority.pdf

[12] *Statewide Deployment Density Class Recommendations*. Available at http://www.topslab.wisc.edu/its/toip/TOIP%20Update/2010_Statewide_Deployment_Density_Class_Recommendations.pdf

29 changed from mainly baseline to low between Abbotsford to Wausau, and a small segment near Eau Claire. However, it changed from low to baseline between Shawano and Wittenberg. The Wisconsin River Corridor also had changes for most of the segments on US 51 north of Wausau from baseline to low. The rest of the corridors have changes throughout. The Deployment Density Class Recommendation for each of the Priority[13] and Emerging Priority[14] Corridors was developed.

The differences between the 2008 and 2010 Priority and Emerging Priority Corridors were identified through a comparison of the number of corridor miles that fall into each recommendation (baseline, low, medium, and high)[15]. In 2008, the total corridor miles for the 13 corridors was 2,320 miles, about 50% falling as baseline. The remaining 50% were split as 29% low, 13% medium, and 8% high. Coulee Country Corridor was not included in this analysis since this corridor was added during the 2009 TOIP Implementation Plan. In the 2010 TOIP update, Coulee Country added about 90 miles for a total of 2,410 miles. Although this corridor added more miles, the miles falling as baseline also increased because this corridor is mostly baseline. Also, Peace Memorial added baseline miles because of its reduction in US 53. The miles falling as low were reduced as well as the miles falling as high, while the medium increased. Although there were changes on each of the different classes, the percentages remained fairly equal between 2008 and 2010. Wisconsin Heartland Corridor was not included in this analysis since it is not an Emerging Priority Corridor yet, it is only been recommended to be included.

The corridor prioritization and DDC recommendations presented in this document reflects the results of the TOIP methodology prepared in 2008, but updated with newer data from 2010. The Statewide Priority Corridors remained unchanged with the addition of Wisconsin Heartland Corridor as a recommended Emerging Priority Corridor. The DDC varies across most of the corridors and have changed from the original report. The DDC changes reflect traffic and safety pattern changes as well as construction projects and new infrastructure improvements.

Since DDC have changed, the technology deployment recommendations and locations will vary from the TOIP Implementation Plan. These changes involve a great deal of manual engineering judgment and will be addressed in subsequent phases of the TOIP update.

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[13] *Recommended Priority Corridors*. Available at
http://www.topslab.wisc.edu/its/toip/update.html
[14] *Recommended Emerging Priority Corridors*. Available at
http://www.topslab.wisc.edu/its/toip/update.html
[15] *Priority and Emerging Priority Corridor Statistics*. Available at
http://www.topslab.wisc.edu/its/toip/TOIP%20Update/Priority_and_Emerging_Priority_Corridor_Statistics.pdf