DSS and GUI, Decision Support System and Graphical User Interface to Assist in Choosing Appropriate Lane Configurations at Toll Facilities

By

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Abstract

This study shows that tools can be devised to assist engineers and operators make decisions concerning a network of toll roads. A Decision Support System, DSS, was connected to a database containing highway network hourly geometric and traffic information for one typical day. The DSS provided operators with on-line tools that could assist with their hour-to-hour decisions concerning toll plaza lane configurations. This pilot study could be extended and the DSS could be connected to a real time database to assist operators with their day-to-day decisions. Operators could plan for special scheduled events in which traffic volumes are known to surge. Engineers could design lane configurations at toll facilities that could meet traffic requirements. Engineers could also design new interchange locations and predict the effect on toll plazas segments. They could also predict the effect of adding additional lanes to busy highway segments. Highway operators could determine the effects of an incident or other unscheduled lane closing at any particular hour of the day. Furthermore, they could schedule maintenance and lane closers for construction at hours of the day in which bottlenecks are at a minimum.
Introduction

Every driver who has experienced driving through a toll plaza, especially one in a metropolitan area, knows that they often become bottlenecks and cause traffic jams. In fact, there is no standard way for analyzing the effects of toll plazas on the network even though their number is growing rapidly. This makes it difficult for planners to design and operators to intelligently respond to changing traffic conditions at the plaza.

Toll Collection Facilities consist of several lanes. The arriving traffic can be subdivided in certain customer types. Each lane is able to process one or more customer types. The lane configuration of a plaza specifies which types of customers can be processed in each of its lanes. The maximum processing rate for each lane depends on the composition of customer types in each lane. By modeling the queuing at toll collection facilities, the throughput (vehicles per unit time) of the entire plaza may be predicted. Suggestions to reconfigure existing lanes to allow specific customer types or recommendations to open or close lanes with certain allowed customer types at the plaza may increase hourly throughput and improve plaza performance.

The Decision Support System, DSS, created by the UMass Dartmouth Research Team with the financial support from the Center for Advanced Transportation Systems Simulation, CATSS, is an interactive website that allows users to determine maximum hourly throughput of any plaza with a lane configuration of their own design. Hourly throughput has units of vehicles per hour, vph.

Accessible by a login, the DSS provides clients with Toll Network Capacity Calculator, TNCC, and SHAKER, two algorithms that compute No-Queue-Maximum-Throughput, NQMT, a plaza performance measure. NQMT is the maximum number of vehicles that can be processed by a given lane configuration in one hour such that no queues exist in any of its lanes at the end of the hour. In order to compute NQMT, both TNCC and SHAKER must be given the percentage of the hourly approach vehicles that belong to the individual categories of customer types along with their average hourly processing rate. For instance, 40% of the approach vehicles may belong to category X and 60% of the vehicles belong to category Y, where X vehicles are processed at 600 vph and Y vehicles are processed at 1200 vph. The lane configuration of the plaza may look something like X_X_X_XY_XY_Y, which is a six lane plaza, three of which process X vehicles, one of which process Y vehicles and two of which process both X and Y vehicles.

The Geographic User Interface, GUI, of the DSS is a user-friendly interface that allows users to input several alternative lane configurations at the toll facilities on the network of toll roads. The GUI reports back the bottlenecks in a graphical mapping format using ArcGIS / ArcIMS software. The DSS uses TNCC’s logic to formulate the capacity of highway segments on the network that contain toll collection facilities and the DSS uses traditional capacity calculating techniques from HCM 2000 to formulate the capacities of the basic highway segments located between toll facilities.

The DSS has an Oracle Database containing geometric and traffic variables used in the computation of the capacities of 299 highway segments for each hour in a 16 hour peak traffic day. The segments are located on the OOCEA’s network of toll roads in Orange County, Florida. The toll roads are divided into segments according to the HCM 2000 specification for dividing highways into segments. The Database also contains approach traffic volumes for each of 16 hours of a typical day on this same network, November 5, 2002. Programs written in JAVA
compare volumes to capacities to determine bottlenecks, near-bottlenecks and potential bottlenecks for each hour of that day between the hours of 5 a.m. and 9 p.m. Each highway segment is represented as a polygon on an ArcGIS map, whose color property is stored in a FoxPro Database attached to the DSS. Polygons on the map turn red, if the highway segment is a bottleneck, and orange, if it is a near-bottleneck, and yellow, if it is a potential bottleneck. Otherwise all polygons or highway segments appear green in color. Some of the segments are blue, this indicates that the capacity calculation was not performed. These are generally located at one of the two interchanges or at a terminal highway segment.

The DSS’s mapping page contains many layers of information of Florida’s highway system via an ArcIMS interface. Zooming-in to Orange County, 16 of the layers provide sixteen maps of the OOCEA’s network of toll roads, each representing one of the sixteen hours of the November 5, 2002, traffic data and highway geometry data. The lane configurations for the 10 plaza (20 unidirectional plaza segments) change from hour to hour, which is also displayed on the maps. JAVA programs access TNCC in order to compute the NQMT or capacity of these 20 plaza segments. If the approach volumes to the plazas are greater than the NQMT values, the plaza segments are considered bottlenecks and their polygons become a red color. The other 279 highway segments that use the algorithms in the HCM 2000 to compute their capacities also become red in color when JAVA programs find the approach traffic volumes greater than their capacities.

DSS users have options to change variables in the Database, reload the hourly maps, and identify new locations of red, orange and yellow polygons, or bottlenecks on any of the 16 maps. DSS users first highlight the portion of the highway on the map, then input changes to the variables and submit and store the changes in a separate user database. Maps are reloaded and may be compared to other maps with different variables. Variables include the approach traffic volume to the segment, the interchange density along the segment’s portion of highway, the percentage of trucks in the traffic stream, the number of lanes in that segment and the ideal free flow speed on that segment. If the segment is a plaza segment, variables include the number of lanes, the types of lanes (or what types of customer categories are serviced in the lanes), ETC usage rates, and other category-percentages, such as the percentage of automatic coin machine, ACM, users. ETC is the Electronic Toll Collection option for users that install a transponder on their vehicle.

**Literature Review**

There are microscopic and macroscopic traffic flow models. Microscopic models simulate the situation by knowing the state (position, velocity, and sometimes additional information) of every vehicle [1][2][3][4][5][6]. In contrast, macroscopic models define variables of state such as average speed, volume, and density that describe the system or parts of the system. Car-following and cellular automata belong more to the microscopic domain whereas queuing theory can be viewed as more macroscopic. Van Dijk suggests hybrid models for most problems in practice [7]. He observes that simulating the toll plaza scenario before constructing the actual site helps better achieve the desired results. They further suggest a combination of queuing and simulation models would be the most powerful strategy while designing a toll plaza. [7] Queuing provides the conceptual way of thinking and insights from which variants could be derived that may be modeled and analyzed by simulation. He shows this approach in the application at the Westerschelde Tunnel Toll Plaza [8]. The hybrid model Toll Network Capacity Calculator
(TNCC) is described in Zarrillo [9][10]. Zarrillo and Pietrzyk deal especially with the electronic
toll collection (ETC) aspect, implementation [11][12], management [13], and practice [14].
Sastry evaluates car-following model corridor traffic simulation model (CORSIM) using Global
Positioning System (GPS) field data [15]. Huang uses a cellular automata approach to model
highway sections with tollbooths [16]. Webster simulates the impact of trucks on highway
freeway sections [17]. Festa compares microscopic and macroscopic models for traffic flow [18].

In Al-Deek [19] the microscopic model DQUEUE, described in [3], is used to study the
impact of introducing Electronic Toll Collection (ETC). Simulation often is too complex, with
high computational cost and too slow in practice. Lin uses the Toll Plaza Simulation (TPS)
model described in [20] to develop a rather simple delay model, which is much simpler and
easier to use [21].

The service time under a non-waiting condition is sometimes intuitively mistaken to be
shorter than it really is. Under light traffic, the toll collectors may actually consume more time
than when pressured with a queue. When toll collectors are under greater pressure from a
growing queue, they tend to process transactions faster. [22] Also, when queues develop,
motorists have time to search for needed change before the transaction. [22]

Certain models pay attention to the geometrical aspects of the toll plaza. Astarita et al. have
developed one such microscopic model, which is able to represent the traffic demand/supply
interaction and the effects on traffic induced by the geometrical and functional characteristics
of the infrastructure. [6] Such models are more useful again when building a toll plaza or to trouble-
shoot the existing bottlenecks when comparing them to any other plaza with the same lane
configuration but is more efficient.

Some of the work done on toll systems includes the effect of toll booths placed in the traffic
stream. For instance, Huang et al [16] simulated a toll plaza where the traffic flow and the phase
transition in the presence of tollbooths was studied. They further conclude that the setup of a
tollbooth influences the traffic flow significantly. As no vehicles are allowed to bypass the
tollbooth, the effect is not short ranged but can extend to the whole lattice. [16] The same roads
can handle increased volumes of traffic if the time that each vehicle stays on the road decreases.
Increasing the speed limits on the roads can do this as well.

The concept of Level of Service (LOS) is very common for all kind of traffic facilities. But
there is still no standard way to define LOS for toll plazas. Woo and Hoel propose the traffic
density as a LOS criteria [22]. Lam [23] models whole networks but needs link capacities as
inputs. Since these links contain toll plazas our study could help to provide those link capacities.
Another interesting question about the blocking probabilities of a general network is
mathematically addressed in the paper of Chouhury [24]

The model developed in SHAKER can handle five traffic categories, electronically paying
cars, $E_p$, and trucks, $E_T$, automatic coin machine users, $A$, manual paying cars, $M$, and trucks, $T$.
TNCC places all electronically paying vehicles in the same $E$ category. The mixed lane problem
was treated earlier in [9]. A cosine function was used to model the throughput of mixed lanes of
the type $AE$ or $ME$ or $MTE$. This cosine function was used in TNCC [25][26][27] and although
the model is quite accurate the cosine function had no fundamental basis. In the SHAKER
model, car-following theory is used to derive a model for mixed lanes. [28][29][30] The cosine
function was replaced by using car-following analysis.
TNCC Tool

TNCC computes the NQMT, maximum hourly throughput in vph such that queues do not exist in any of the plaza’s lanes at the end of the hour using optimization techniques. To begin the iterative computation of NQMT, TNCC dumps a large volume of traffic into the plaza, equivalent to the product of the number of lanes in the plaza and the hourly processing rate for the quickest category of traffic, ETC vehicles. Initially, all T vehicles are placed equally into available MTE and MT lanes. MTE lanes on the Oceansia’s network are mixed lanes providing service to M, T and ETC customers. Other categories are similarly placed into their allowed lanes, with the exception of ETC vehicles, which are primarily placed into the dedicated ETC lane prior to the mixed lanes.

TNCC then computes the allowed time allocated to service all vehicles of one particular category in a lane. In order to do this, for each lane in the plaza, each percentage of the total vehicles placed in that lane that belong to a category must be found. By dividing the percentage of vehicles dumped in a lane that belong to that particular category by its processing rate as listed in Table 1, TNCC computes the portion of an hour allocated to processing vehicles in that category. In a mixed lane, TNCC sums up the times to service all categories in that lane and inverses this sum to determine the processing rates for that mixed lane in units of vph. The sum of the processing rates for all the lanes equates to the plaza’s hourly throughput.

The processing rate for ETC vehicles, used in the computed division for a dedicated ETC lane is taken to be a constant, measured in the field. However, if the lane is mixed, in other words, if ETC vehicles are mixed in with M, A or T vehicles, then the processing rates for the ETC vehicles used in the computation ranges is value from a low value of the processing rate for the slowest traffic category in that lane to the high constant ETC processing rate value measured in the field. In other words, as the portion of all vehicles in a mixed lane approaches 100% ETC vehicles, the value of the mixed lanes’ processing rate for all vehicles approaches the constant ETC-processing-rate measured in the field.

Initially, there are more vehicles than can be processed in the hour, so TNCC either moves them into a lane that has not used up its entire hour or discards the leftover vehicles. It is important to emphasize that vehicles are discarded in a way that maintains the given initial proportion of vehicles approaching the plaza that belong to each of the categories. These overall proportions of approaching vehicles in each of the categories to the plaza do not change, however, the proportions of approaching vehicles in each of the categories to each of the individual lanes does change. In the next iteration of the calculation, all vehicles not discarded are considered the new approach volume to the plaza and the computation begins anew with a new distribution. During each computation, the approach volume is reduced and converges to an accurate plaza hourly maximum throughput such that there are no queues at the end of the hour in any of the plaza’s lanes. The program ends when the discarded number of vehicles reaches a threshold value close to zero.

SHAKER Tool

SHAKER, like TNCC, computes the NQMT, maximum hourly throughput in vph such that queues do not exist in any of the plaza’s lanes at the end of the hour. In addition, SHAKER also computes the hourly maximum throughput in vph even when queues exist at the end of the hour. In that case, the approach hourly volume is a necessary input to the algorithm.
Like TNCC, SHAKER dumps a large volume of traffic using an arbitrary initial distribution of vehicles into each of the plaza’s lanes. The initial distribution and any subsequent distribution of vehicles determine the probability or frequency of occurrence in each of the lanes for the individual categories of traffic. SHAKER then determine the average time it takes to service a vehicle dumped in any of the lanes using the physics motion equations and probability. Unlike TNCC, input to the motion equations includes the properties for the different categories of traffic listed in 1: the drivers’ reaction time, the categories’ stop-to-pay-time, the vehicles’ average length and headways, and the vehicles’ average acceleration and deceleration rates. ETC vehicles are split into two categories: passenger cars using ETC and vehicles other than passenger cars using ETC, such as trucks. The 5 categories of traffic, M, A, T, E_P and E_T, are described in Table 1.

In the case of a mixed lane, providing service to more than one category, servicing times for each of the categories are weighed by their probability or frequency of occurrence in that lane. SHAKER determines the remaining-queue-numbers, RQN, or the number of vehicles remaining after one hour of time is used up to process these vehicles. Because the arbitrary initial distribution of vehicles into the lanes most likely will not result in an optimal hourly throughput, “shaking” is initiated with the intention of equalizing the RQNs in all the lanes. This also determines the “correct” distribution of vehicles into their lanes. The “shaking” process moves vehicles from one lane into another lane. If SHAKER finds that the RQN for the two lanes changes very little in value, by less than 1.00 vph, then the program is nearer to finding the “correct” distribution. Once the “shaking” process correctly distributes the arriving traffic into the plaza’s lanes an accurate value for the average vehicle service time for all lanes can be established, thus leading to a “correct” value for the throughput. The “shaking” process also ensures that all lanes will be utilized as much as possible during the hour by moving vehicles from queued lanes into the lesser-queued lanes.

SHAKER inverses the value of the average servicing time for the vehicles in a lane in order to determine the processing rates in units of vehicles per hour, vph, for each of the lanes. The sum of the processing rates for all the lanes equates to the plaza’s hourly throughput for that initial arbitrary distribution.

SHAKER’s calibration is accomplished by adjusting the vehicle-properties for all five categories so that the model’s output for the hourly throughput for a lane servicing only one category of traffic matches those measured in the field, listed in Table 1.

DSS Development and Testing

It was decided early on in the project that if the ArcGIS map of Florida could be acquired, it would be an excellent backdrop for the DSS’s GUI. Additional map layers with additional information could then be constructed of the OOCEA toll roads and the Florida Turnpike plazas and overlaid on top. ArcIMS software allows viewers to turn off or on the various layers. By connecting a database of information to the GUI maps, DSS users could view bottleneck locations as well as highway segment information on the toll network in a familiar mapping format. Maps provide detailed segmenting of the highway in Orange County and additional plaza lane configuration patterns on the OOCEA’s network. Ten unidirectional plazas located on the Florida Turnpike are also included on the 7 to 8 a.m. map.
The ArcGIS software ArcTools was used to convert the 16 AutoCAD Map-files into ArcMaps that could be viewed using ArcIMS on the DSS. Five types of files are created for each map in this conversion process, two of which are most important, the *.shp files (shapes and polygons on the maps) and *.dbf files (the attribute table for the polygons). ArcIMS stores the attributes in a FoxPro database. One of these attributes is the color of the polygons. For all 16 maps, this color is green whenever traffic volumes do not exceed capacity values. JAVA software was written to compare the hourly capacity of the highway segment to the hourly volume of traffic approaching the segment. Approaching traffic volumes were collected and provided by Post, Buckley, Schuh and Jernigan, Inc., PBS&J. If the approach volume exceeds the capacity for a particular segment for a particular hour of the day, the highway segment’s polygon color attribute is converted from green to red, indicating a bottleneck’s location on the DSS map. The color is converted to orange if the bottleneck is a near-bottleneck, or the approach volume is 90% of the segment capacity. The color is converted to yellow if the bottleneck is a potential bottleneck or the capacity of the previous (upstream) segment is larger than a segment’s capacity. In other words, if the capacity of a segment is less than 99.9% of the previous segment’s capacity, then it becomes a yellow potential-bottleneck. Bottlenecks can be viewed, identified and located on the system for each of the 16 hours. To help summarize the networks bottlenecks, the DSS maps homepage allows users to view in Table format the number of red, orange, yellow and green polygons for each of the hours of the busiest 16-hour day. Out of the 299 highway segments studied in this research project, Table 2 displays the number of bottlenecks located on the OOCEA’s network of toll roads for the data in the default Oracle Database for the busiest 16 hours of the day November 5, 2002. This summary table and the maps assist operators to access the performance of the network as a whole.

In order to facilitate decisions concerning the lane configuration design during particular hours of the day or decisions concerning the design of the highway geometry, DSS users are allowed to change the associated characteristics. Maps can be reloaded and the new bottleneck locations can be viewed. In addition, the DSS allows input of the future traffic volumes on the various highway segments. Again, maps can be reloaded and the new bottlenecks and their locations can be predicted.

Finally, scenarios have been created in which TNCC’s DSS is employed for disruption management. Scenarios include fictitious lane closings, incidents or maintenance checks. Other scenarios demonstrate its ability to predict the impact of surging traffic volumes during special events and to predict the influence of forecasted growth in traffic volumes on the performance of the toll network of highways.

**Fictitious Lane Closing:**

Figure 1 displays the input form of the DSS with modifications of the number of lanes on portions of the OOCEA’s westbound Route 408 at the peak morning rush hour from 7 to 8 a.m. Five of its highway segments have a lane reduction: WB 29, 30, 31, 32 and 33. Note that the capacity has been reduced from 9123 vph to 6798 vph for segment 29. Similarly, segments 30, 31, 32 and 33 lost over 2000 vph in their capacity values.

Figure 1 also displays the resulting DSS maps before and after the lane has been closed. Note that the bottlenecks have changed. Segment 29 and 30 became bottlenecks; they went from a green to a red color. Segment 31 was a potential bottleneck and has also become a bottleneck;
it went from a yellow to a red color. Segments 32 and 33 have become near-bottlenecks; they went from a green color to an orange color.

Lane closings can be caused by incidents or can be scheduled maintenance. The DSS indicates that the same lane closings at a different hour of the day, 9 a.m., have no negative impact. At this later time, all segments remain unchanged: segments 29, 30, 32 and 33 remain green and segment 31 remains yellow. If the lane closers were due to scheduled maintenance or construction, then 9 a.m. would be a better time.

**Surging Traffic Volumes:**

Figure 2 displays the input forms of the DSS with modifications in the traffic volumes due to drivers entering Route 408 westbound between 9 and 10 a.m. A special event is scheduled for 10 a.m. in downtown Orlando, and 210 drivers are entering the highway each at segment 25, 26 and 29. ETC rates are lower; 15% of the approach is passenger cars with ETC rather than 58.53%. Figure 2 also displays the resulting DSS maps before and after the surging traffic volumes. A red bottleneck has been created at the Holland East Main Plaza. After lane reconfiguration, this bottleneck becomes an orange near-bottleneck rather than a red bottleneck. The specific reconfiguration of the lanes, two of the dedicated ETC lanes becoming mixed MTE lanes and the one ME lane becoming an AE lane on the DSS form, increases the plaza’s capacity from 3090 to 3821 vph.

**Comparison of NQMT outputs from TNCC and SHAKER**

The percent difference in the NQMT values were computed by TNCC and SHAKER for all twenty unidirectional plazas on the OOCEA’s network of toll roads for the morning peak hour of the day, from 7 to 8 a.m. Most percent differences lie below 5%, however, one of them is a high 9%. In addition, the percent difference in the NQMT values were computed by TNCC and SHAKER for the ten unidirectional plazas on the Florida Turnpike. These were all less than 1%.

The NQMT values calculated by TNCC and SHAKER for all 16 hours for the WB Holland East Main Plaza located on the 408 on the OOCEA’s network is provided in Figure 3, as well as those calculated for the EB Dean Main Plaza located on the 528 and the SB University Main Plaza located on the 417. Again, most percent differences lie below 5%, however, some of them are high.

In order to explain some of the large percent differences in SHAKER’s and TNCC’s computation of NQMT, the differences in the categories has to be examined. SHAKER splits up the approaching ETC traffic volumes into two categories, one for passenger cars approaching the plaza and one for vehicles other than passenger cars approaching the plaza. TNCC places both categories into one. Under most circumstances, this does not seem to play a large role in the computation of the NQMT. Percent differences between the TNCC and the SHAKER computations are lower than 4% in 313 of the 320 cases evaluated on the OOCEA’s network of toll roads. However, whenever there is a substantially large ETC usage rate and the plaza does not dedicate at least one lane to ETC users, TNCC overestimates the NQMT. Percents are also largely different if there is no available ACM lane in the configuration whenever there are large ETC usage rates. This can be explained by the model’s differences in there treatment of ETC users in the ACM lanes.

TNCC’s methodology dumps ETC vehicles into the AE lanes whenever there are no dedicated ETC lanes at the plaza. This includes both passenger cars using ETC and vehicles
other than passenger cars using ETC such as trucks. However, trucks are not allowed to use the
faster AE lanes on the OOCEA’s toll network and should be dumped into the slower MTE lanes.
TNCC thus computes an inaccurately high processing rate for the ETC trucks.

SHAKER, on the other hand, splits up the ETC category into two; thus the model can more
accurately reflect the policy that trucks are prohibited from using the AE lanes. SHAKER
restricts all trucks to the slower MTE lanes, both ETC trucks and non-ETC trucks. The Dean
Main Plaza illustrated this point. From the hours of 10 a.m. to 2 p.m., the lane configuration
eliminated dedicated ETC lanes. NQMT values were overestimated by TNCC and were 14% to
16% higher than they should have been. SHAKER is thus the more accurate model of the two
models for computing the maximum number of vehicles possibly processed in one hour at a toll
collection facility such that no queues exists at the end of the hour.

Finally, it was found that there are three significant factors that impact the maximum
number of vehicles possibly processed at the plaza during an hour. These include the addition or
subtraction of a lane at the plaza, the changing of the plazas lane-configurations and/or the
significant change in the percentages of arriving vehicles belonging to the different categories of
traffic.

Summary and Conclusions

Programs were written based on the HCM 2000 and incorporated into a Decision Support
System to compute the capacity for each of 299 highway segments for every hour in a typical 16-
hour day on a network of toll highways in Orange County Florida. Comparing these capacities to
real hourly traffic approach volumes resulted in the identification of bottleneck locations on this
network for each hour of the 16 hours. Highway geometric characteristics as well as typical
traffic characteristics for a typical 16-hour day served as input to these programs. For twenty of
these segments, it was difficult to compute the capacity because they contained a toll facility in
which the lane configurations varied from hour to hour on the given day. However, TNCC and
SHAKER were developed to compute the MOE, NQMT in units of vph. These NQMT values
served as the capacity of these 20 highway segments. TNCC used a methodology based on
optimization, where as SHAKER utilized the physics motion equations and probability. Both
models compute the NQMT values of the 20 highway segments for the 16-hour day within a
small error; most are below a 5% difference. SHAKER is the more accurate model of the two
because it splits up the ETC traffic category into two separate categories leading to a more
accurate simulation.

In the development of the DSS, it was found that ArcGIS software and maps provided the
necessary backdrop for the GUI. Programs connected the GUI with the Oracle Database and
provided a “Form” interface in which users input changes to traffic and geometric data variables
as well as changes in plaza lane configurations. Recalculated capacities are then compared to the
newly inputted traffic volumes to identify and place on the maps the new bottlenecks and their
locations. This assists operators in their hour-to-hour decisions concerning the lane
configurations at the plazas.

Finally, two scenarios were discussed, a fictitious lane closing and surging traffic volumes,
that illustrate how the DSS can be used by operators of toll collection facilities to improve
throughput and mobility on the network of highways. It was shown how operators can create
other scenarios in which bottleneck locations can be viewed to shift, increase in number or disappear, as the case may be.

**Recommendations for Further Work: Real-Time-Intelligent DSS**

An extension of this pilot study project would be to implement the DSS using *real-time* traffic volume data, traffic characteristic data and highway geometric data. Real Time Intelligent - Decision Support System, RTI-DSS, would identify bottlenecks on the network, by using the logic of TNCC and SHAKER to formulate the capacity of highway segments containing toll collection facilities and it would use traditional capacity calculating techniques from the HCM to formulate the capacities of the basic highway segments located between toll facilities. The GUI would then report bottlenecks in a graphical ArcGIS mapping format. Apart from being real-time, another novel feature of RTI-DSS, is that it would be intelligent, in the sense that it learns from its interactions with the user and it uses this intelligence to help the user find a desired plaza lane configuration. Real time traffic volume information as well as the network static information could feed into the “intelligence” resulting in optimal toll lane configurations.

Bottlenecks, both their number and severity influence the performance and/or level of service, LOS, of a network of toll roads. RTI-DSS would quantify the performance of a toll network by quantifying both the number and type (severity) of bottlenecks on the toll network real-time given a database with current geometric and traffic characteristics of the network.
Bibliography


List of Tables

TABLE 1  Hourly processing-rates for lanes providing service to a single category of traffic, X, measured in the field at the OOCEA’s plazas [10] and SHAKER’s Calibrated Vehicle-Properties for the 5 traffic categories at the toll facilities [28]

TABLE 2  Number of bottlenecks for the busiest 16 hours of the day November 5, 2002.

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FIGURE 1 DSS modification form with a reduction in lanes on 5 highway 408 WB segments for the 7 a.m. hour. Lane closings increase bottlenecks.

FIGURE 2 Traffic volumes have increased and ETC rates are reduced on the DSS input form resulting in a bottleneck created at the Holland East Main Plaza due to a special event.

FIGURE 3 NQMT values for the WB Holland East Main Plaza located on the 408, EB Dean Main Plaza on the 528, and SB University Main Plaza located on the 417.
The table represents the hourly processing-rates for lanes providing service to a single category of traffic, X, measured in the field at the OOCEA’s plazas [10] and SHAKER’s Calibrated Vehicle-Properties for the 5 traffic categories at the toll facilities [28].

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<thead>
<tr>
<th>Vehicle-Property Description</th>
<th>Category X</th>
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<tr>
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<tr>
<td>( l_X ) = Average vehicle Length (meters)</td>
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<tr>
<td>( b_X ) = Distance between queued vehicles (meters)</td>
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</tr>
<tr>
<td>( a_X ) = Vehicles’ Acceleration (meters/second^2)</td>
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</tr>
<tr>
<td>( d_X ) = Vehicles’ Deceleration (meters/second^2)</td>
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</tr>
<tr>
<td>( t_{stop} X ) = Stop-Time during payment (seconds)</td>
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<tr>
<td>( t_R ) = Drivers’ perception-reaction Time (seconds)</td>
<td>1.8</td>
</tr>
<tr>
<td>( S_X ) (vph) = Processing Rates</td>
<td>498 ± 48</td>
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</table>
TABLE 2 Number of bottlenecks for the busiest 16 hours of the day November 5, 2002.

<table>
<thead>
<tr>
<th>Hour of the Day on November 5, 2002</th>
<th>Number of Red Bottlenecks</th>
<th>Number of Orange Near-Bottlenecks</th>
<th>Number of Yellow Potential-Bottlenecks</th>
<th>Number of Green Polygons, No Bottlenecks</th>
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<td>69</td>
<td>174</td>
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<td>1</td>
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<td>178</td>
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FIGURE 1 DSS modification form with a reduction in lanes on 5 highway 408 WB segments for the 7 a.m. hour. Lane closings increase bottlenecks.
FIGURE 2 Traffic volumes have increased and ETC rates are reduced on the DSS input form resulting in a bottleneck created at the Holland East Main Plaza due to a special event.
FIGURE 3 NQMT values for the WB Holland East Main Plaza located on the 408, EB Dean Main Plaza on the 528, and SB University Main Plaza located on the 417.