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Task #1 - Second Interim Report: Simulation Modeling of Toll Plaza Traffic at Midpoint, Cape Coral, and Sanibel Bridges

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Simulation Modeling of Toll Plaza Traffic at Midpoint, Cape Coral, and Sanibel Bridges

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CUTR

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for the
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Introduction

The Lee County DOT is planning to open the Midpoint bridge in October 1997, and it is to be equipped with Electronic Toll Collection (ETC) facilities. Because of the additional traffic volumes to be served by the Midpoint bridge, traffic congestion on the Cape Coral bridge may be significantly reduced. It is due to the anticipation that 37% of the traffic handled by the Cape Coral bridge will shift to the Midpoint bridge along with a large shift (63%) from other non-tolled bridges. Lee County DOT also believes that these bridges will experience increased ETC participation, by as much as 50%, once the ETC systems comes in to effect.

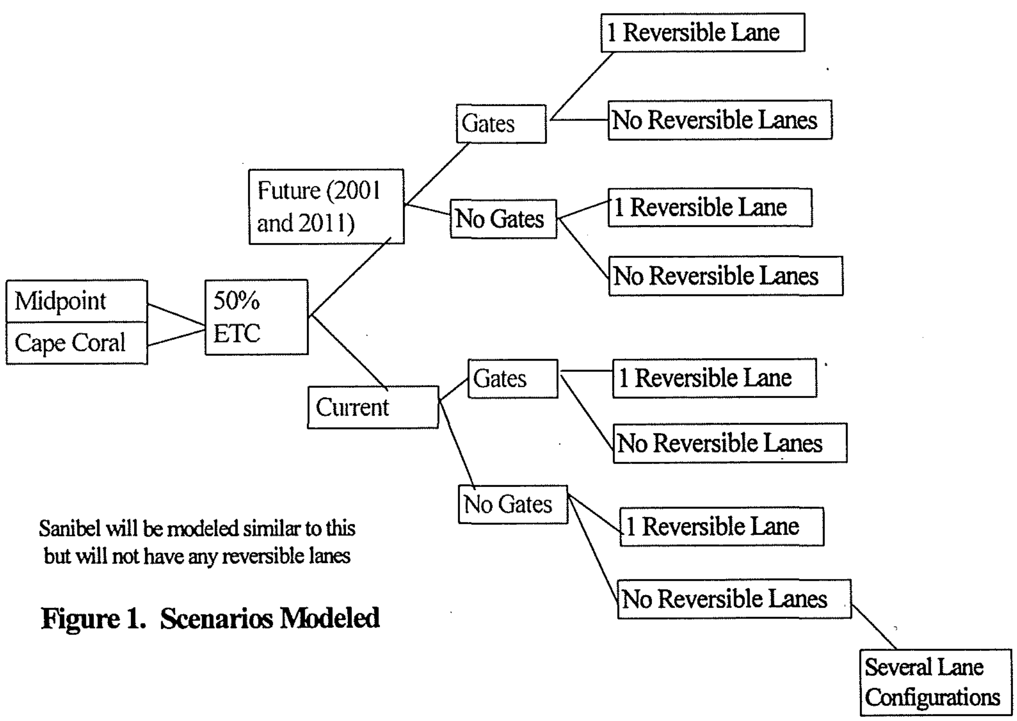
This report examines the potential impact of several factors on the traffic of three toll bridges in Lee County (Sanibel, Midpoint, and Cape Coral bridges). To accomplish this, computer-based microsimulation models developed previously for each of the toll plazas and their approaches have been modified by accommodating new lane configurations, traffic volumes, and toll payment options. The main factors examined in this task include:

- reversible lanes
- gates in the toll lanes
- future traffic conditions
- dedicated ETC lanes

Presently, during peak hours, the Cape Coral bridge operates with six lanes in each direction and out of these, three lanes are for ACM and ETC vehicles, one is a reversible lane meant for ACM and ETC vehicles, and two other lanes are for ACM and Manned vehicles. However, it is believed that the introduction of ETC systems will greatly reduce service times and average vehicle delays of the vehicles in the queue, the throughput of the toll lanes will increase significantly, and the need for reversible lanes will be reduced, or eliminated. This report looks at the impact of reversible lanes on the traffic by considering two scenarios: the implications without any reversible lanes; and the effect of one reversible lane.

Lee County DOT has decided to leave the existing gates at the Midpoint, Cape Coral, and Sanibel bridges due to the absence of any automated violation enforcement systems during the initial implementation period. However, the presence of gates in the toll lane results in increased service times, and may lead to queuing. This study also examines the impact of gates by using two sub models: one with gates and another without gates. These sub models have also been examined with alternative reversible lane configurations.

This report also explores the impact of different lane configurations on the traffic. This has been accomplished by considering two scenarios; one with all mixed-use lanes; and another with one dedicated ETC lane in each direction and the other lanes as mixed-use lanes. As well as modeling current traffic conditions, this study also explored the impact of future traffic conditions in order to determine if any reversible lanes would be necessary in the future. This is accomplished by simulating the predicted traffic conditions now and in the years 2001 and 2011.[1] These future years have been chosen to correspond to the years used in previous modeling efforts. Various scenarios modeled in this study have been presented in **Figure 1.**



Sanibel will be modeled similar to this but will not have any reversible lanes

Figure 1. Scenarios Modeled

1 Bridge traffic estimated by NationsBanc Capital Markets, Inc.

Methodology

Traffic Data Used

By using the methodology adopted in our previous work (Task #1 - First Interim Report - Simulation Modeling of Toll Plaza Traffic at Midpoint and Cape Coral Bridges for November 1997, August 7, 1997), predicted traffic volumes in the peak direction during the peak hour have been calculated. They are shown in **Table 1**.

Table 1: Traffic Volumes Modeled

Facility	Hourly traffic in the peak direction during peak hour (vph)		
	1997	2001	2011
Cape Coral	2,366	2,424	2,616
Midpoint	1,676	2,000	3,078
Sanibel	1,000	1,100	1,300

Toll Payment Options

In order to easily differentiate among the various scenarios being studied, only one level of ETC participation rate has been modeled. This rate is equal to the current sticker rate of 50%. To study the impact of gates, it is assumed that 40% of the users will have traditional ETC tags and will only have to stop for the gate to be raised, while 10% of the users will have ETC with a coin drop (this scenario is similar to 40% of the vehicles with unlimited stickers, and 10% of the vehicles using coin drop stickers.) ETC users who must stop for the gates to raise will have similar transaction times as current full discount sticker users, and will be modeled as such. Similarly, in the models without gates, it has been assumed that 40% of the traffic will be traditional, nonstop, ETC vehicles and 10% of the traffic will be coin drop ETC users. The following table shows the proportions of vehicles using various toll payment options. However, for Sanibel bridge, different proportions of participation rates have been assumed. This has been done keeping in mind the existing high participation rates of sticker patrons. The payment options modeled and their proportions have been shown in **Table 2**.

Table 2: Percentage Users with Various Toll Payment Options

Payment Option	**Percentage**	
With Gates	***Cape Coral and Midpoint***	***Sanibel***
Vehicles using unlimited stickers	40.00%	50.00%
Vehicles using coin drop stickers	10.00%	10.00%
Vehicles with correct change	30.00%	5.00%
Vehicles using ETC tags	0.00%	0.00%
Vehicles needing change	20.00%	35.00%
Without Gates	***Cape Coral and Midpoint***	***Sanibel***
Vehicles using unlimited stickers	0.00%	0.00%
Vehicles using coin drop stickers	10.00%	10.00%
Vehicles with correct change	30.00%	5.00%
Vehicles using ETC tags	40.00%	50.00%
Vehicles needing change	20.00%	35.00%

Simulation Models

To examine the impact of several factors on traffic conditions, five basic simulation models have been developed representing five different scenarios. They are:

- **Model 1:** Simulation model with 50%[2] ETC patronage, with gates in the toll lanes, without reversible lanes, and without dedicated ETC lanes
- **Model 2:** Simulation model with 50% ETC patronage, with gates in the toll lanes, with one reversible lane, and without dedicated ETC lanes

2 60% for Sanibel bridge in all cases

- **Model 3:** Simulation model with 50% ETC patronage, without gates in the toll lanes, without reversible lanes, and without dedicated ETC lanes
- **Model 4:** Simulation model with 50% ETC patronage, without gates in the toll lanes, with one reversible lane, and without dedicated ETC lanes
- **Model 5:** Simulation model with 50% ETC patronage, without gates in the toll lanes, without reversible lanes, and with one dedicated ETC lane

On the Sanibel bridge, tolls are charged going onto the island only, eliminating the potential for reversible lanes. Hence the Sanibel bridge has not been modeled with scenarios 2 and 4. The dedicated ETC models are developed in such a way that the ETC vehicles use the dedicated lane until that lane becomes full, and then the ETC vehicles will use the mixed-use lanes. This is an important assumption, as all the ETC vehicles may not always opt for the dedicated lane in the real life. This may further reduce the benefits of having a dedicated ETC lane, over what is modeled here.

Lane Arrangements

The lane arrangements modeled in this study are shown in **Figures 2, 3, and 4**.

Figure 2. Lane Arrangement on Midpoint Bridge

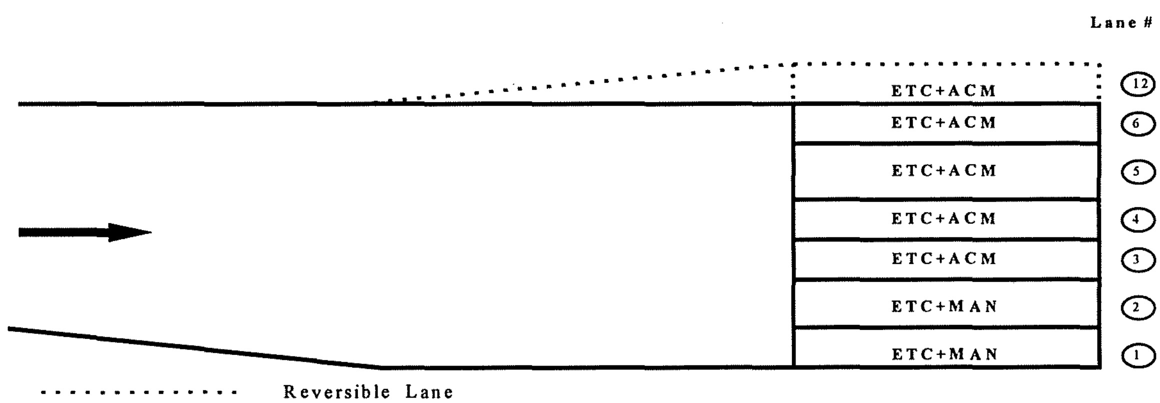


Figure 3. Lane Arrangement on Sanibel Bridge

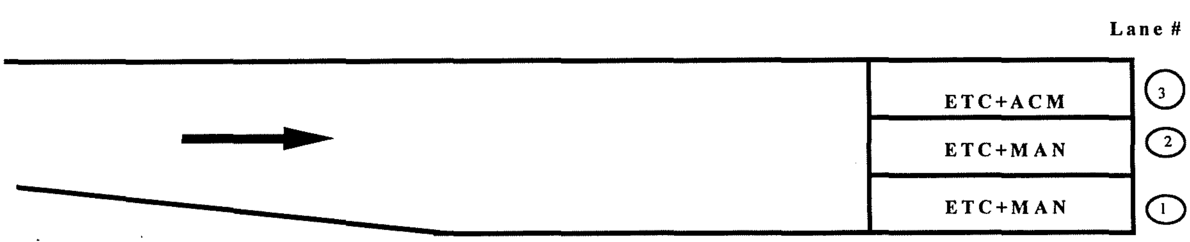
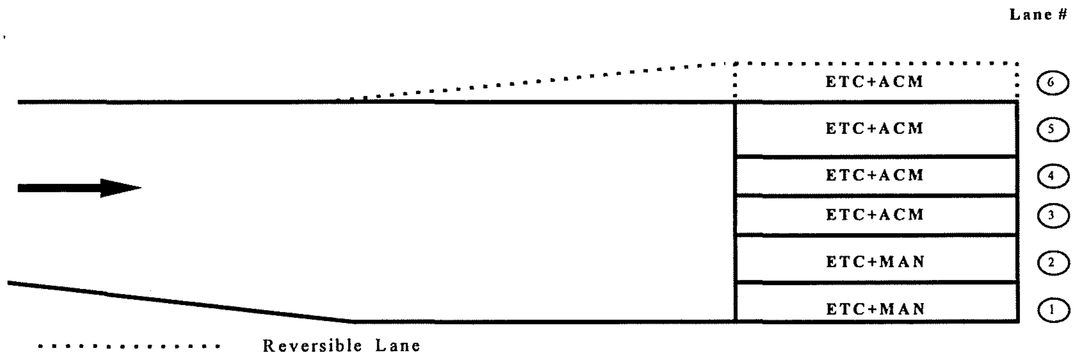


Figure 4. Lane Arrangement on Cape Coral Bridge



Simulation Modeling Results

This section summarizes results from the five models created and they are presented in **Table 3** (Sanibel bridge **), Table 4** (Cape Coral bridge), and **Table 5** (Midpoint bridge). A number of model runs have been performed with current and future traffic volumes. Vehicles have been generated with five different arrival streams, and their output statistics have been averaged to ensure random arrival results.

Table 3: Simulation Model Run Results For Sanibel Bridge

	Model 1	**Model 3**	**Model 5**
Average Number of Vehicles in the Queue			
• 1997	4.910	4.540	5.420
• 2001	5.880	5.400	7.800
• 2011	10.00	8.790	37.60
Average Time (Sec) Spent by a Vehicle at:			
The Plaza			
• 1997	17.52	16.17	19.30
• 2001	19.02	17.46	25.16
• 2011	27.14	23.83	37.64
Lane 1			
• 1997	22.25	24.85	30.23
• 2001	24.33	27.38	43.19
• 2011	35.63	39.04	120.7
Lane 2			
• 1997	21.43	18.01	29.72
• 2001	23.45	20.44	40.19
• 2011	34.21	30.87	114.37
Lane 3			
• 1997	13.21	10.98	7.27
• 2001	14.08	11.21	7.32
• 2011	18.84	13.23	7.40

Table 4: Simulation Model Run Results For Cape Coral Bridge

	Model 1	Model 2	Model 3	Model 4	Model 5
Average Number of Vehicles in the Queue					
• 1997	15	13	13	12	18
• 2001	16	13	14	13	21
• 2011	20	15	16	15	45
Average Time (Sec) Spent by a Vehicle at:					
The Plaza					
• 1997	22.84	20.28	20.56	19.14	27.45
• 2001	23.56	20.08	20.85	19.31	31.24
• 2011	27.99	21.19	22.40	20.12	61.78
Lane 1					
• 1997	31.96	29.74	27.66	27.88	29.55
• 2001	32.60	31.04	28.47	28.29	30.25
• 2011	40.03	34.44	31.22	30.59	31.16
Lane 2					
• 1997	25.52	25.00	21.94	21.81	25.90
• 2001	26.75	25.31	22.24	22.20	25.91
• 2011	32.54	28.65	24.24	23.62	27.44
Lane 3					
• 1997	19.56	17.53	17.96	16.81	41.33
• 2001	20.18	17.66	18.14	16.72	50.56
• 2011	23.72	18.20	19.28	17.22	118.33
Lane 4					
• 1997	19.54	17.33	18.17	15.51	39.65
• 2001	20.03	17.59	18.41	15.72	48.51
• 2011	23.47	17.66	19.52	16.34	116.79
Lane 5					
• 1997	20.57	17.44	19.21	16.64	13.98
• 2001	21.32	17.13	19.30	16.70	14.10
• 2011	25.04	17.71	20.63	16.92	14.27
Lane 6					
• 1997	N/A	16.24	N/A	17.70	N/A
• 2001	N/A	14.50	N/A	17.84	N/A
• 2011	N/A	14.80	N/A	18.25	N/A

Table 5: Simulation Model Run Results For Midpoint Bridge

	Model 1	Model 2	Model 3	Model 4	Model 5
Average Number of Vehicles in the Queue					
• 1997	12	12	10	10	11
• 2001	15	15	13	13	13
• 2011	31	28	25	23	23
Average Time (Sec) Spent by a Vehicle at:					
The Plaza					
• 1997	25.68	25.48	22.00	21.97	22.68
• 2001	26.39	26.11	22.64	22.55	23.07
• 2011	35.91	32.36	28.86	27.26	27.42
Lane 1					
• 1997	29.87	30.30	28.03	28.25	30.54
• 2001	32.28	32.10	30.57	30.68	31.74
• 2011	65.20	59.05	49.84	49.69	44.90
Lane 2					
• 1997	27.52	27.21	26.09	26.04	30.76
• 2001	29.04	29.05	26.80	27.03	31.55
• 2011	54.53	52.28	41.87	40.03	42.63
Lane 3					
• 1997	24.22	24.12	15.24	15.27	26.84
• 2001	24.42	24.40	15.33	15.20	27.17
• 2011	28.45	25.69	19.75	10.42	32.39
Lane 4					
• 1997	23.24	23.20	20.65	19.70	25.19
• 2001	23.54	23.49	21.27	20.70	25.44
• 2011	27.34	24.49	24.41	22.84	28.98
Lane 5					
• 1997	24.30	23.93	23.52	23.44	25.21
• 2001	24.34	23.96	23.81	23.44	25.56
• 2011	27.87	24.95	24.99	23.89	27.93
Lane 6					
• 1997	24.50	24.00	23.38	22.61	15.62
• 2001	24.84	23.95	23.61	22.92	15.83
• 2011	28.37	24.82	25.04	23.42	17.09
Lane 12					
• 1997	N/A	23.90	N/A	23.41	N/A
• 2001	N/A	24.02	N/A	23.20	N/A
• 2011	N/A	24.93	N/A	23.70	N/A

Summary of Findings

Simulation results indicate that there are no significant reductions in either queue lengths or delays due to the presence of reversible lanes in all the three years for which simulation models have been developed on all three bridges.

ETC participation rates assumed in the study (50% for Cape Coral and Midpoint, 60% for Sanibel bridges,) will be a critical factor to analyze traffic conditions at toll plazas. This particular ETC participation rate has been assumed to make the simulation modeling easily understandable. However, because of the uncertainty over ETC participation rate, the results for current year may not represent the real situation accurately as it is possible that 50% of the total users will not be equipped with electronic tags in the current year.

The results show that the queue lengths, transaction times, and delays increase slightly due to the presence of gates in the toll lanes. The queue lengths and transaction times have increased by about 10-20% for models without reversible lanes and by about 3-8% for models with reversible lanes.

The results from models with dedicated ETC lane (Model #5), indicate that for the Cape Coral bridge, both queue length and delays will increase slightly. These overall increases are due to increased queues and delays for those vehicles using the ETC/ACM lanes (lanes 3 and 4). The vehicles, which use these lanes, are the ETC with coin drop and the ACM vehicles. However, the availability of ACMs in lanes 1 and 2 might alleviate the delays, as there is some spare capacity in these lanes. Once ETC is up and running and both a percentage of ETC users and ETC users with coin drop is better known, CUTR can refine this model. Until then CUTR recommends continuing to leave the option of a dedicated ETC lane on Cape Coral Bridge open.

Having a dedicated ETC lane on the Midpoint bridge produced good results as the increase in delay and queues was observed to be insignificant (3.2% in 1997 and 2% in 2001). It could be due to the availability of an extra lane (the Midpoint bridge has six lanes in each direction) for ETC coin drop vehicles and vehicles using exact change. Therefore, based on delay times and queue lengths alone, it is beneficial to place a dedicated ETC lane on the Midpoint Bridge. For marketing purposes the existence of a dedicated ETC lane is extremely valuable and could entice a significant number of patrons to use ETC.

The traffic conditions in the two future years modeled, 2001 and 2011, do not cause any significant increase in queues or delays as long as the assumed 50% ETC participation rate is maintained. The extremely high delays in model #5 for Cape Coral and Sanibel bridges is caused by increased traffic in future years and having the dedicated ETC lane with 50% ETC patronage. If the ETC patronage rises above 50% in the future (year 2011) then this dedicated ETC lane may be beneficial.

Conclusions and Recommendations

- No reversible lanes are required for the current year and the two future years modeled, as they are not found to cause any significant reductions in either the queue lengths or delays.
- CUTR recommends having a dedicated ETC lane on the Midpoint Bridge, but further research is necessary to determine the impacts of having a dedicated ETC lane on Cape Coral Bridge, so that it does not result in any undue delays in the lanes used by ACM/ETC with coin drop vehicles. CUTR recommends not having a dedicated ETC lane on the Sanibel Bridge.