SECTION 9 - VEHICULAR TRAFFIC ANALYSIS

VEHICULAR TRAFFIC MODEL

OVERVIEW

The IHNC vehicular traffic model is an analytical methodology for estimating the annual transportation costs to landside traffic transiting the IHNC bridge crossings. It facilitates the comparison of costs of landside traffic under without-project conditions to costs of various with-project conditions. In calculating vehicular transportation costs, the model is able to identify that portion of total costs representing delays caused by bridge openings. These costs can be thought of as navigation dependent costs. Because navigation dependent costs are identifiable, it is possible to determine the change in vehicular traffic costs for a given lock size. It is this transportation cost differential that represents the vehicular benefits. The necessity for the vehicular traffic model to interface directly with deep-draft and shallow-draft model calculations for a specific lock size should be apparent since bridge openings occur to accommodate passage of navigation traffic. Therefore, discussion of landside benefits must take place within the context of a particular lock scenario.

Two analytical techniques were considered in the formulation of the IHNC vehicular traffic model. The first technique was based on the more complex queuing methodology and the second on the simpler differential running speed approach. Each will be described in detail and the basis for selection presented.

DEFINITIONS

The following terms are defined to facilitate understanding of subsequent discussion of the techniques considered.

Analysis Section--length in miles over which costs are calculated including bridge span and ramps and, in some cases, level ground approach sections.

Costs--bridge user costs are the sum of (1) auto, truck, and bus vehicle running costs and (2) the value of vehicle user travel time.

a. Vehicle running costs--mileage-dependent costs of operating autos, trucks, and busses on the analysis section including expenses for fuel, tires, oil and maintenance, and mileage-dependent depreciation.

b. Value of travel time--a dollar value of an individual's time while in transit. This value can be differentiated by trip purpose to reflect, at a minimum, the difference between commercial traffic (truck driver's time) and auto user time.

Traffic characteristics--as defined below it includes factors that determine the incidence and magnitudes of user costs associated with vehicle trips which cross the IHNC.

a. Highway capacity--the maximum number of vehicles that can pass over a section of roadway during a given time period under specified roadway and traffic conditions.

b. Traffic volume--the actual number of vehicles that pass over a roadway section during a given time period.

c. Running speed--the speed over a specified section of roadway determined by dividing the distance travelled by the time required to transit the section.

d. Peak-Hour--peak-hour periods refer to those times corresponding to rush hour at which time the traffic flow consists primarily of commuters.

e. Level of Service--a qualitative measure of the traffic flow conditions on a highway section determined by the relationship between traffic volume (V) and highway capacity (C) during the roadway's peak period. If the V/C ratio equals 1.0, a level F condition exists which means that the traffic flow is congested and unable to run freely, resulting in slowdowns and traffic delays. Such a condition would also result from the blockage of traffic flow due to the raising of a bridge's draw span.

QUEUING METHODOLOGY

Level of service F describes a forced flow condition in which the highway stores vehicles backing up from a downstream bottleneck. In other words, physical lines of waiting vehicles (queues) occur upstream from the bottleneck section. Causes of such queues usually involve intersection signalization at near capacity peak-hours, roadway constrictions, or traffic volumes exceeding roadway capacity.

The costs to the highway user are greatly increased when there is queuing due to the additional time delays encountered during such conditions. If queuing occurs at peak-hour periods, when a roadway is carrying heavy volumes, the queues will be lengthy and the time it takes to dissipate them will be long in contrast to periods of low traffic flows.

The method employed in this model for determining queuing time delay and dissipation time delay is the deterministic method for interrupted flow. This method is appropriate for studying intersection delays where signalization cycles result in queuing at peak periods. It is not designed for a bridge opening scenario. However, the deterministic method can be modified to accomplish its principal purpose: to determine average queue length, average queue duration, and average vehicle delay due to the queue--all necessary to assign costs to queuing. The deterministic method described below reflects a simplifying assumption--uniform flow of vehicles rather than random traffic movements--and therefore, tends to underestimate queue buildup. Therefore, the time delay estimates resulting from the analysis should be considered somewhat understated. It also does not account for the possibility that the duration of the queue occurring during a peak-hour period may extend into a non-peak hour while the queue is dissipating. Rather, the peak hour and non-peak hour periods are considered fixed in length and the condition of the queue at the end of one period does not carry over to the start of the next period.

Deterministic queuing has two formulations, one for application where delay is due to demand exceeding capacity, and the other in which delay is caused by signal cycling. This latter approach has been modified by substituting the bridge opening time for the signal cycle time, and assumes that the hourly volume on the roadway is restricted in proportion to the average percent of each hour that the traffic flow is broken by a bridge opening.

In this method, traffic is thought of as a continuous flow arriving at a uniform rate (q), it is released at a rate (q_m), and builds a queue while the arrival rate exceeds the departure rate. At a later point, arrival rates become less than departure rates and the queue dissipates. The vehicle arrival rate is proportional to the density and speed of the arriving vehicles. The back of the queue is extending while demand exceeds capacity. Thus, the relative speed with which arriving vehicles approach the queue is greater than their speed over the ground, and therefore, the maximum density per lane (km) is assumed for all queued vehicles and is based on a spacing of 22 ft/vehicle or 240 veh/mi/lane.

The following equations describe the basic relationships required to calculate delay time to vehicles.

The rate of vehicles arriving in the queue is:

$q = \quad q_1 [1 + (q_1 - q_m) / (NL \times SPD_u \times k_m - q_1)]$, where

q_1 = arrival rate (demand volume)

q_m = release rate (capacity)

NL = number of lanes

SPD_u = average speed of vehicles approaching from upstream

k_m = density of vehicles per lane

Average delay due to the queue is:

$AD = \quad [T (q/q_m - 1) + R] *2$, where

T = duration of analysis time period in minutes

R = average time of bridge opening per hour in minutes

Period Definition

For purposes of user cost calculations on urban highways where hourly travel flows are uneven, it is necessary to evaluate these flows on a separate peak and off-peak hour basis. User costs can be derived for each separate representative hour and factored to the full day according to the hourly distribution of traffic volume. Where such differentiation is unnecessary, (traffic flow is uniform) a representative hour can be analyzed and factored up to the full day without differentiation. As the IHNC bridge crossings are all affected by peak-hour traffic flows, these must be evaluated independently. As the AM peak-hour period is reversed in the PM peak-hour period, the analysis does not have to reflect directional traffic flow differences.

In order to model all-day traffic with peak and off-peak periods, the traffic in the midnight to 6 AM hours is added to the off-peak total, but the hours are excluded from the day leaving an 18-hour period; 4 hours being peak hours and 14 hours being off-peak. On an annual basis, these hours would break down as follows:

4 peak hours x 249 (365 days - 104 weekend days - 12 holidays = 249 weekdays)	=	996 hrs
14 off-peak hours x 249 weekdays	=	3,486 hrs
18 off-peak hours x 104 weekend days	=	1,872 hrs

18 off-peak hours x 12 holidays = 216 hrs

Total off-peak hours per year = 5,574 hrs

Total hours (18 x 365) = 6,570 hrs

In addition to being calculated on a peak and off-peak period basis, costs are also classified as being either navigation independent or navigation dependent. This basic classification facilitates the following discussion of specific cost calculation routines.

Navigation Independent Costs

Navigation independent costs represent those costs associated with free-flow transit of the analysis section. These costs include running costs of the vehicle and the value of passenger time. To calculate navigation independent costs, the following procedure is employed.

Step 1: Calculate the hourly flow of each vehicle type for peak and off-peak periods. To calculate these flows, the following values must be specified: total daily vehicles for all bridge crossings; each bridge's share of total vehicles; the percent of a bridge's daily volume that represents a single hour of peak and off-peak traffic; and the percentage of each vehicle type for peak and off-peak periods. The product of these values yields hourly flows for each bridge (see tables 9-1 and 9-2).

Step 2: Calculate the running cost per trip for each vehicle type for peak and off-peak periods. To calculate trip running cost, the bridge length, bridge grade, vehicle speed for peak and off-peak periods, and a cost/speed/grade matrix per 1,000 vehicle-miles for each vehicle type is required. When necessary the cost/speed/grade matrix is interpolated to find the appropriate cost for the specified bridge grade and vehicle speed. The length of the analysis section is coterminous with the length of the high-rise bridge. For the lower-level bridges which span shorter distances than the high-rise bridge, level running costs are used for the portion of the analysis section not involving the ramps or span and running costs associated with a given grade (positive grade on the upstroke and negative grade on the downstroke) are used over the actual length of the bridge (see tables 9-3 through 9-7).

Running cost per trip is calculated as the sum of approach cost (cost on level grade x distance) plus positive grade cost (cost on positive grade x distance) plus negative

Table 9-1

Average Daily Traffic and Traffic Splits
Selected Years

Condition	1990 Number	1990 %	2000 Number	2000 %	2020 Number	2020 %
Without-Project						
St.Claude (low)	29,875	35	30,851	33	32,334	34
Claiborne (mid)	43,531	51	42,070	45	39,941	42
Florida (low)	11,950	14	--	--	--	--
(high)	--	--	20,567	22	22,824	24
Total	85,356	100	93,488	100	95,099	100
With-Project						
St.Claude (low)	28,177	28	28,319	28	28,770	28
Claiborne (mid)	34,216	34	34,387	34	34,935	34
Florida (high)	38,241	38	38,432	38	39,044	38
Total	100,634	100	101,138	100	102,749	100
With-Project						
St.Claude (mid)	33,290	39	36,460	39	37,090	39
Claiborne (mid)	33,290	39	36,460	39	37,090	39
Florida (high)	18,776	22	20,568	22	20,919	22
Total	85,356	100	93,488	100	95,099	100

Source: Regional Planning Commission for Jefferson, Orleans, St. Bernard and St. Tammany Parishes, Inner Harbor Navigation Canal. Lock Replacement Project. Traffic Impact Analysis, September 1993.

Notes: Exclusive of busses

Estimates for 2010 were made by interpolating between traffic volume in the years 2000 and 2020, and by using 2020 roadway splits.

The 2020 estimates were held constant for 2030, 2040, and 2060.

The with-project condition that involves a low-mid-high bridge configuration also includes permanent Florida Avenue access road improvements. The with-project condition that involves a mid-mid-high bridge configuration does not include permanent Florida Avenue access roads.

Table 9-2

Distribution of Hourly Traffic Volume
By Bridge, Vehicle Type and Period

(in percent)

Vehicle Type	St. Claude		Claiborne		Florida	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Pea
Automobiles	70	90	70	80	70	
Single Unit Trucks	20	7	15	10	15	
Large Trucks	10	3	15	10	15	.
	100	100	100	100	100	10
Busses	19	8	14	9	0	

Sources: EDAW Inc., "Transportation, Volume 5" of the Ninth Ward Study.

EDAW Inc., "Highway User Cost Analysis Methodology for IHNC Bridge Crossings" of the Ninth Ward Study, May 1982.

Regional Transit Authority (number of busses).

Notes: Busses are shown as actual vehicles, not in percent.

The Regional Planning Commission estimates that 12 percent of each bridge's average daily traffic volume occurs during each peak hour.

Table 9-3

Bridge Grades and Lengths
By Bridge Crossing

Condition	Grade (in percent)	Length (in miles)
Existing		
St. Claude (low)	3	0.32
Claiborne (mid)	5	0.59
Florida (low)	3	0.05
Without-Project		
St. Claude (low)	3	0.32
Claiborne (mid)	5	0.59
Florida (high)	5	1.59
With-Project		
St. Claude (low)	3	0.32
Claiborne (mid)	5	0.59
Florida (high)	5	1.59
With-Project		
St. Claude (mid)	4	0.71
Claiborne (mid)	5	0.59
Florida (high)	5	1.59

Table 9-4

Peak Free-Flow
Vehicle Speeds

(in mph)

Condition	1990	2000	2020
Without-Project			
St. Claude (low)	17.0	15.5	14.0
Claiborne (mid)	13.0	12.7	14.0
Florida (low)	17.0	--	--
(high)	--	55.0	55.0
With-Project			
St. Claude (low)	16.5	16.5	16.5
Claiborne (mid)	19.0.	19.0	19.0
Florida (high)	54.0	54.0	54.0
With-Project			
St. Claude (mid)	20.0	15.0	15.0
Claiborne (mid)	20.0	15.0	15.0
Florida (high)	55.0	55.0	55.0

Source: Regional Planning Commission, Inner Harbor Navigation Canal. Lock Replacement Project. Traffic Impact Analysis, September 1993.

USACE (1990 without-project).

Notes: Speeds in the year 2010 use the 2020 estimates.

The 2020 speed estimates were also used for 2030, 2040, and 2060.

Table 9-5

Average Running Costs at Uniform Speeds on Level Tangents and Grades for Passenger Cars
(1992 Costs in Dollars per 1,000 Vehicle Miles)

Speed	-5%Grade	Level	+2%Grade	+4%Grade	+6%Grade
5	183.80	250.59	266.68	290.05	308.20
10	148.41	186.94	201.37	219.88	240.74
15	135.72	168.89	188.15	206.63	226.00
20	129.45	162.66	181.64	199.58	219.58
25	126.24	161.00	177.68	196.78	217.59
30	125.24	161.14	176.19	196.37	216.73
35	125.75	162.86	177.39	196.57	216.82
40	127.62	165.67	180.24	198.04	217.77
45	130.28	168.36	183.24	199.60	219.67
50	133.84	171.35	187.15	202.79	223.20
55	138.19	175.33	191.47	207.58	228.51

Sources: American Association of State Highway and Transportation Officials, _A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements_, 1977.

USACE Update using U.S. Dept. of Commerce, Bureau of Labor Statistics, 1992 _Consumer Price Index_ and _Producer Price Index_.

Note: Passenger car idling cost is $728.45 per 1,000 vehicle miles.

Table 9-6

Average Running Costs at Uniform Speeds on Level Tangents and Grades for Single Unit Trucks

(1992 Costs in Dollars per 1,000 Vehicle Miles)

Speed	-5%Grade	Level	+2%Grade	+4%Grade	+6%Grade
5	265.46	307.17	369.71	466.98	526.60
10	234.73	281.11	348.18	434.51	515.33
15	211.31	262.38	334.05	408.56	509.16
20	198.54	259.14	339.00	436.32	526.42
25	165.62	268.36	354.39	459.62	566.56
30	170.75	281.64	373.78	492.18	623.15
35	204.09	301.62	401.47	540.95	623.15
40	217.89	321.03	432.93	606.20	623.155
45	217.89	344.45	466.78	606.20	623.15
50	217.89	370.60	502.10	606.20	623.15
55	217.89	395.65	502.10	606.20	623.15

Sources: American Association of State Highway and Transportation Officials, A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977.

USACE Update using U.S. Dept. of Commerce, Bureau of Labor Statistics, 1992 Consumer Price Index and Producer Price Index.

Note: Single unit truck idling cost per 1,000 vehicle miles is $646.44.

Table 9-7

Average Running Costs at Uniform Speeds on Level Tangents and Grades for Large Diesel Trucks

(1992 Costs in Dollars per 1,000 Vehicle Miles)

Speed	-5%Grade	Level	+2%Grade	+4%Grade	+6%Grade
5	201.03	621.97	669.68	726.52	780.76
10	192.72	420.19	537.11	656.64	773.71
15	190.64	358.85	502.17	649.91	794.84
20	191.29	335.23	494.01	666.09	848.56
25	196.86	329.41	501.86	701.35	937.92
30	205.65	335.02	521.79	758.12	937.92
35	205.65	348.06	550.74	837.38	937.92
40	205.65	368.00	589.63	837.38	937.92
45	205.65	395.26	641.25	837.38	937.92
50	205.65	436.79	641.25	837.38	937.92
55	205.65	469.64	641.25	837.38	937.92

Sources: American Association of State Highway and Transportation Officials, A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977.

USACE Update using U.S. Dept. of Commerce, Bureau of Labor Statistics, 1992 Consumer Price Index and Producer Price Index.

Note: Large truck idling cost is $449.85 per 1,000 vehicle miles.

grade cost (cost on negative grade x distance) divided by 1,000. Division by 1,000 converts the costs in the cost/speed/grade matrix which are per 1,000 miles to a per trip basis.

Step 3: Calculate the value of time per vehicle crossing for each vehicle type for peak and off-peak periods. The value of time per vehicle crossing is equal to [length of analysis section/vehicle speed] times value of passenger time times number of passengers per vehicle (see table 9-8).

Step 4: Calculate navigation independent costs on an hourly and annual basis for each vehicle type for peak and off-peak periods. Navigation independent costs are composed of the relevant running costs plus user costs. Running costs for a representative hour are equal to the number of vehicles times the cost per trip. User costs for a representative hour are equal to the number of vehicles times the value of time per vehicle crossing. Hourly running costs and user costs are summed and converted to an annual basis by multiplying the peak hourly costs by 996 and the off-peak hourly costs by 5,574. (The numbers 996 and 5,574 represent total peak and off-peak hours in a year, respectively.)

Navigation Dependent Costs

Navigation dependent costs represent those costs imposed on vehicular traffic as the result of navigation induced bridge raisings. Unlike the calculation of navigation independent costs, the computation of navigation dependent costs requires an interface with the level of navigation activity. The calculation of navigation dependent costs is as described in the following procedure.

Step 1: Calculate the hourly bridge openings required to serve navigation traffic for peak and off-peak periods. For the peak period, when constraints created by curfews are placed on bridge openings, desired openings per hour are compared to maximum allowable openings. Desired openings are equal to annual barge lockages divided by annual hours available for barge service. Desired openings represent barge lockages per hour assuming a uniform flow of barge traffic. Maximum allowable openings are equal to a specified percentage of a peak hour that a bridge is allowed to be open, as controlled by the curfew, times sixty minutes and divided by the average bridge open time per lockage. The lesser of desired openings and maximum allowable openings is the value used for the peak period. If maximum allowable openings is used during the peak period, then off-peak period openings due to barge traffic

Table 9-8

Vehicle Occupancy, Value of Time,
And Bus Operating Costs

(1992 Costs in Dollars)

Item	Auto	Small Truck	Large Truck	Bus Peak	Bus Off-Peak
Persons per vehicle	1.3	1.0	1.0	40.0	10.0
Hourly Value of Occupant Time	$4.00	$10.00	$12.75	$4.00	
Hourly Operating Cost	(1)	(1)	(1)	$56.00	

Sources: EDAW Inc., "Highway User Cost Analysis Methodology for IHNC Bridge Crossings" of the Ninth Ward Study, May 1982 (occupancy levels and passenger time values).

Regional Transit Authority (bus operating cost).

Teamster's Local Union Number 270, 1992 (truck driver hourly earnings).

(1) Operating costs for autos, small trucks, and large trucks are described in tables 9-5, 9-6, and 9-7.

are equal to annual barge lockages minus annual peak hour barge lockages divided by annual off-peak barge hours. If, however, desired openings are used for the peak period, then desired openings are also used for the off-peak period. In addition to bridge openings due to barge traffic, bridge openings due to ship traffic must also be considered. For bridge opening purposes, all ship traffic is assumed to occur during the off-peak period (see tables 9-9 through 9-11).

Step 2: Calculate the percentage of an hour the bridge is in the open condition for peak and off-peak periods. For the peak period, the percentage of an hour a bridge is open is equal to openings per hour times the time that the bridge is open per raising, divided by sixty minutes. For the off-peak period, minutes open per hour due to barge traffic is calculated in the same manner as for the peak period. In addition, open time for ships must be included. Time open per ship lockage is equal to a specified bridge open time times a specified percentage of off-peak period. Thus, the percent of an hour that the bridge is open can now be calculated. It is composed of a weighted average of open time per barge lockage and open time per ship lockage weighted by the percent of annual off-peak hours attributed to barge traffic and ship traffic, respectively.

Table 9-9

Average Bridge Open Time
(in minutes)

Condition	Single Tow	Additional Tow Increment	Deep Draft Vessel
Existing			
St. Claude (low)	7.1	1.6	10.7
Claiborne (mid)	6.2	0.0	8.5
Florida (low)	5.2	3.6	8.4
Future Without-Project			
St. Claude (low)	7.1	1.6	10.7
Claiborne (mid)	6.2	0.0	8.5
Florida (high)	0.0	0.0	0.0
With-Project			
St. Claude (low)	7.1	1.6	10.7
Claiborne (mid)	6.5	0.0	9.1
Florida (high)	0.0	0.0	0.0
With-Project			
St. Claude (mid)	6.5	0.0	9.1
Claiborne (mid)	6.5	0.0	9.1
Florida (high)	0.0	0.0	0.0

Sources: USACE from Louisiana Department of Transportation and Development bridge log data (existing condition and without-project).

USACE from USACE river stage data and WCSC towboat height data (with-project).

Table 9-10

Percent of Vessel Requiring
Bridges to Open

Condition	Shallow Draft	Deep Draft
<u>Existing</u>		
St. Claude (low)	100.0	100.0
Claiborne (mid)	14.2	100.0
Florida (low)	100.0	100.0
<u>Without-Project</u>		
St. Claude (low)	100.0	100.0
Claiborne (mid)	14.2	100.0
Florida (high)	0.0	0.0
<u>With-Project</u>		
St. Claude (low)	100.0	100.0
Claiborne (mid)	25.8	100.0
Florida (high)	0.0	0.0
<u>With-Project</u>		
St. Claude (mid)	25.8	100.0
Claiborne (mid)	25.8	100.0
Florida (high)	0.0	0.0

Sources: USACE from Louisiana Department of Transportation and Development bridge log data (existing condition and without-project)

USACE from USACE river stage data and WCSC towboat height data (with-project).

Table 9-11

Percent of Time Bridge Are Allowed Open

During Peak Hours With Curfews

(in percent)

Condition	1990	2000	2020
Without-Project			
St. Claude (low)	10.5	10.5	10.5
Claiborne (mid)	0.9	0.9	0.9
Florida (low)	11.5	--	--
(high)	--	--	--
Without-Project			
St. Claude (low)	10.5	10.5	10.5
Claiborne (mid)	0.9	0.9	0.9
Florida (high)	--	--	--
With-Project			
St. Claude (mid)	0.9	0.9	0.9
Claiborne (mid)	0.9	0.9	0.9
Florida (high)	--	--	--

SOURCE: USACE from Louisiana Department of Transportation and Development bridge log data.

Note: Percentages represent actual portions of the peak period that bridges are open. While Claiborne is allowed open a much lower percent of time compared to St. Claude, it does not represent a binding constraint on navigation traffic through the Inner Harbor Navigation Canal, since a large portion of navigation traffic does not require the Claiborne Bridge to be raised.