CONCURRENT SESSION 5B - DATA ISSUES

Presented at
National Traffic Data Acquisition Conference
Albuquerque, New Mexico

May 5-9, 1996

VARIABILITY IN CONTINUOUS TRAFFIC MONITORING DATA
(A PRELIMINARY REPORT)

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(A Preliminary Report)

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Abstract

Each state in the United States can be viewed as a universe of road segments. For each road segment in each state, it is desired to know various traffic characteristics based on count data, classification count data, and weigh-in-motion data.

These data are absolutely essential for highway maintenance and planning. Given no cost constraints, each road segment would be continuously monitored every day of the year. However, in practice, a few (sample of) road segments are monitored continuously every day **of the year to produce** annual characteristics of traffic flow. The remaining road segments are monitored for one or two days each year, and this resulting data are "adjusted" (using factors based on data collected from the continuously monitored road segments) to produce estimates of annual characteristics. With this general approach, each state strives to provide (or help provide) estimates of annual characteristics for each road segment within its boundaries. In 1992, the Federal Highway Administration (FHWA) published *the Traffic Monitoring Guide* to assist states in achieving this end.

As with almostany data collection effort, the monitoring data suffers from errors from many sources. In this paper, we report some empirical findings in a research project sponsored by the FHWA. This research project studied the variability in the traffic data from the continuously monitored road segments from state(s) and, the extent to which this variability is transferred to and affects the precision of the data produced from the road segments which are monitored only one or two days each year. The ultimate hope **is** that states will eventually be able to not only publish an estimate of a characteristic such as AADT for each road segment, but also that each estimate will be accompanied by a statement expressing how good the estimate is in terms of its estimated variability or precision, which will likely be expressed as a coefficient of variation.

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[1] Currently with the U.S. Bureau of the Census.

1. INTRODUCTION

Each state in the United States can be viewed as a universe of state road segments. A state road segment is a definite section of a state road. For each road segment in each state, it is desired to know various traffic characteristics including:

Count Data

-Annual Average Daily Traffic (AADT)

Classification Count Data

-AADT for Each Vehicle Class

Weigh-In-Motion Data

-Annual Average Daily Equivalent Single Axle Loadings (ESAL) per Vehicle for Each Vehicle Class

-Annual Average Daily Weight per Vehicle for Each Vehicle Class

These data are absolutely essential for highway maintenance and planning. Given no cost constraints, each road segment would be continuously monitored every day of the year to determine values of the four traffic characteristics just noted as well as many others. However, in practice, a few (sample of) road segments are monitored continuously every day of the year to produce annual characteristics of traffic flow. The remaining road segments are monitored for one or two days each year, and this resulting data are "adjusted" (using factors based on data collected from the continuously monitored road segments) to produce estimates of annual average daily characteristics. With this general approach, each state strives to provide (or help provide) estimates of annual characteristics for each road segment within its boundaries. In 1992, the Federal Highway Administration published its latest edition of the *Traffic Monitoring Guide* to assist states in achieving this end.

Objective of Research Study

As with almost any data collection effort, the monitoring data suffers from errors from many *sources. The objective* of this two year research effort, which is sponsored by the Federal Highway Administration, is (i) to study and characterize *the variability* in the traffic data from the continuously monitored road segments and (ii) to study the extent to which this variability is transferred to and affects *the precision* of the data produced from the road segments **which are** monitored only one or two days each year. The ultimate hope is that states will eventually be able to not only publish an estimate of a characteristic such as AADT for each road segment but also that each estimate will be accompanied by a statement of how good the estimate is in terms of its estimated variability or precision which will likely be expressed as a coefficient of variation (i.e., the quotient of a standard deviation and a mean). While variability is indeed the main objective, other objectives include data analysis of traffic data from continuously monitored sites, data utility to the transportation community, developing data analysis capability, and support highway information needs.

Overall Research Approach

The approach being followed for this research study can be viewed in four major steps.

Step 1: Initial Methodology Development for Data Collected from Continuously Monitored Sites

Using 1994 data from continuously monitored sites in Florida and Washington and elementary statistical methods, it was decided to fust develop a methodology for estimating variability in data from a few sites as follows:

(a) Count Data

We used the 1994 traffic count data from 2 1 of Florida's continuously monitored count sites. Details are given in *Variability in Continuously Traffic Monitoring Data-Task II Report: Pilot Methodology Development and Estimates of Variability from Continuous Traffic Count Data* (October 1995), unpublished report of Oak Ridge National Laboratory's Center for Transportation Analysis.

(b) Classification Count Data

We used the 1994 traffic classification count data from 8 of Florida's continuously monitored classification sites. Details *are* given *in Variability in Continuous Traffic Monitoring Data-Task V Report: Pilot Methodology Development and Estimates of Variability from Continuous Classofication Count Data* (January 1996), unpublished report of Oak Ridge National Laboratory's Center for Transportation Analysis.

(c) Weigh-In-Motion Data

We used the 1994 traffic ES&L and weight data from 6 of Washington's continuously monitored weigh-in-motion sites. Details are given *in Variability in Continuous Traffic Monitoring Data-Task VIII Report: Pilot Methodology Development and Estimates of Variability from Continuous Traffic Weigh-In-Motion Data* (April 1996), unpublished report of Oak Ridge National Laboratory's Center for Transportation Analysis.

Step 2: Extension of Initial Methodology for Continuously Monitored Sites

Methods developed for the few sites under Step 1 are applied to a larger collection of continuously monitored sites from Florida and Washington. Estimates of variability associated with continuously monitored sites would be computed.

Step 3: Variability at Short-Term Monitored Sites

We, will study how and to what extent variability in data obtained from continuously monitored sites is transferred to estimates based on data from short-term monitored sites.

Step 4: Guidance for States

Based on results from Steps 1,2, and 3, we will write a report which provides guidance to states for report *variability* in estimates for continuously monitored sites and *precision in* estimates for short-term monitored sites.

2. DESCRIPTION OF SITES USED IN PILOT STUDY

Data used in the pilot study discussed in this paper come from the sites as described in Table I. Note that what may appear to be some inconsistencies in Table 1 actually are not. For example, for Site 9925, we show 308 days of count data with an AADT value of 12,661 vehicles. However, for Site 9925, we also show only 307 days of classification count data. Using only 307 days of data, we get an AADT value of 12,909 vehicles. Thus the difference in reported AADT for site 9925 is because a different number of days of data are used. In general, we attempted to select sites for the pilot study which had at least 200 days of 1994 data in all directions (usually two) of traffic at the site.

3. SELECTED PRELIMINARY RESULTS FROM THE PILOT STUDY

The reader is reminded that every result or remark in this paper is *preliminary* and based only on a few selected continuously monitored sites from Florida and Washington. We have yet to analyze data from all sites in these two states. Even after analyses of data from these two states, generalization to all states should be done with great care, if at all.

3.1 Differences in Direction of Travel

3.1.1 Investigation of Differences in Count Data by Traffic Direction

For each of Florida's 21 count sites and each "day of the week," we want to know if there was a difference between the mean daily traffic volume in direction 1 and the mean traffic volume in direction 2. To answer this question, we used *a paired t test* for each site and each day of the week as follows. Our discussion focuses on Site 119 and Sunday as the "day of the week."

Step I. For site 119 and for all Sundays in 1994, we paired all daily traffic **counts in** one direction with the daily traffic counts in another direction.

Table 1
Continuously Monitored Sites Used in Pilot Study

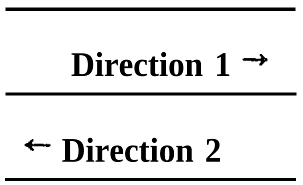
	State	Data Type	Site	Functional Class	Number of Days of Available Data	Approximate 1994 AADT
1.	Florida	Count	119	Rural Principal Arterial Interstate [Ol]	212	30,180
2.	Florida	Count	223	Rural Principal Arterial Other [02]	231	4,474
3.	Florida	Count	65	Rural Principal Arterial Other [02]	322	7,382
4.	Florida	Count	9925	Rural Principal Arterial Other [02]	308	12,661
5.	Florida	Count	104	Rural Principal Arterial Other [02]	347	22,098
6.	Florida	Count	118	Rural Principal Arterial Other [02]	345	22,262
7.	Florid?	Count	170	Rural Minor Arterial [06]	353	5,284
8.	Florida	Count	136	Rural Major Collector [07]	263	6,336
9.	Florida	Count	133	Urban Principal Arterial Interstate [1l]	283	28,026
10.	Florida	Count	179	Urban Principal Arterial Interstate [11]	210	54,599
11..	Florida	Count	130	Urban Principal Arterial Interstate [11]	341	110,865
12.	Florida	Count	196	Urban Principal Arterial Interstate [11]	252	154,304
13.	Florida	count	204	Urban Principal Arterial Other Freeway/ Expressway [12]	212	28,294
14.	Florida	Count	114	Urban Principal Arterial Other [14]	267	14,436
15.	Florida	Count	177	Urban Principal Arterial Other [14]	333	33,290
16.	Florida	Count	102	Urban Principal Arterial Other [14]	278	40,753
17.	Florida	Count	154	Urban Principal Arterial Other [14]	220	44,030
18.	Florida	Count	113	Urban Principal Arterial Other [14]	326	45,825
19.	Florida	Count	197	Urban Principal Arterial Other [14]	212	47,270
20.	Florida	Count	246	Urban Minor Arterial [1 6]	278	7,681
2 1.	Florida	Count	175	Urban Minor Arterial [16]	342	39,920
1.	Florida	Classification	9925	Rural Principal Arterial Other [02]	307	12,909
2.	Florida	Classification	170	Rural Minor Arterial [06]	353	5,284
3.	Florida	Classification	114	Urban Principal Arterial Other [14]	266	14,447
4.	Florida	Classification	177	Urban Principal Arterial Other [14]	284	33,540
5.	Florida	Classification	113	Urban Principal Arterial Other [14]	323	45,867
6.	Florida	Classifkation	197	Urban Principal Arterial Other [14]	212	47,270
7.	Florida	Classification	246	Urban Minor Arterial [16]	277	7,686
8.	Florida	Classification	175	Urban Minor Arterial [16]	342	39,920
1.	Washington	Weigh-In-Motion	PlO	Rural Principal Arterial Interstate [0 l] .	282	1653*
2.	Washington	Weigh-In-Motion	PO5	Rural Principal Arterial Other [02]	346	377*
3.	Washington	Weigh-In-Motion	P17	Rural Minor Arterial [06]	364	425*
4.	Washington	Weigh-In-Motion	P29	Urban Principal Arterial Interstate [1 1]	365	4,180*
5.	Washington	Weigh-In-Motion	P19	Urban Principal Arterial Other Freeway/ Expressway [12]	365	2314*
6.	Washington	Weigh-In-Motion	PO7	Urban Principal Arterial Other [14]	334	281*

*Estimate of AADT excludes vehicle classes 1 and 2.

Step 2. In one direction for the 28 Sundays of available data, we computed an average value of 14,878 vehicles per Sunday. For the other direction, we computed an average value of 16,58 1 vehicles per Sunday.

Step 3. Using a *paired* t test, the Sunday average for the two directions at Site 119 were found to be statistically different at the .05 level of significance.

The complete results are given in Table 2 for the 21 count sites from which we observe that the majority of the average daily traffic counts by direction at a site for each day of the week are statistically different at level .05.



The analysis of count data by direction of travel shows that traffic differs significantly by direction. The preliminary finding confirms the known fact that in order to adequately quantify traffic at the specific location, both directions of travel need to be monitored. Monitoring in onIy one direction and multiplying by two is inadequate.

3.1.2 Investigation of Differences in Classification Count Data by Traffic Direction

For each of Florida's 8 classification sites, each "day of the week," and each vehicle class, we wanted to know if there was a difference between the mean daily traffic volume for a specific vehicle type in direction 1 and the mean daily traffic volume for the same specific type in direction 2. A summary of the results over the 7 days of the week at the 8 sites for the vehicle classes is given in Table 3. Thus by vehicle type, we also -see significant differences in traffic volume by direction of travel.

Table 2
Results of Paired f Tests Comparing the Average Counts in Both Directions by Site and Day of the Week

Site	Day of the Week						
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
119	*					*	
223	*	*	*	*	*	*	*
65	*	*	*	*	*	*	
9925	*					*	*
104		*	*	*	*	*	*
118	*						
170	*	*	*	*	*	*	
136	*	*	*	*	*	*	*
133	*	*		*	*	*	*
179	*				*		*
130	*	*	*	*	*	*	*
196	*	*	*	*	*	*	
204	*	*	*	*	*	*	*
114	*	*	*		*		*
177	*	*	*	*	*	*	*
102	*	*	*	*	*	*	*
154	*	*	*	*	*	*	*
113	*	*	*	*	*	*	*
197	*	*	*	*	*	*	*
246	*	*	*	*	*	*	*
175	*		*	*	*	*	*

Note: The * means the averages were found to be statistically different at α=.05 level of significance.
A blank means the averages were not found to be statistically different at α=.05 level of significance.

Table 3
General Test Results by Vehicle Class

Vehicle Class		Statistically Different at a=.05 (Paired t Test)
(1)	Motorcycles	Yes
(2)	Passenger Cars	Yes
(3)	Other 2 Axle, 4 Tire Single Unit Vehicles	Yes
(4)	Buses	Yes
(5)	2 Axle, 6 Tire, Single Unit S Trucks	Yes
(6)	3 Axle, Single Unit Trucks	Yes
(7)	4 or More Axle, Single Unit Trucks	Yes
(8)	4 or Less Axle, Single Unit Trucks	Yes
(9)	5 Axle, Single Trailer Trucks	Yes
(10)	6 or More Axle, Single Trailer Trucks	Yes
(11)	5 or Less Axle, Multi-Trailers Trucks	No*
(12)	6 Axle, Multi-Trailers Trucks	No*
(13)	7 or More Axle, Multi-Trailers Trucks	Yes
(14)	Unclassified/Other	Yes

* Though not statistically different, the mean daily number of vehicles counted in these classes at each of the sites tended to be less that “1 vehicle”!

3.2 Missing Data

Continuous traffic monitoring is plagued by missing (i) count data, (ii) classification count data, and (iii) weigh-in-motion data. Data are missing for several reasons including (i) equipment failure, (ii) construction, (iii) removal of data during the editing process, and (iv) the time of equipment installation. Tables 4,5, and 6 show graphics which show the level of missing 1994 days of data at the sites for the different types of data.

Table 4
Graphic of Missing Days for the 21 Selected Sites from Florida's District 5
(Block Means Missing Day)

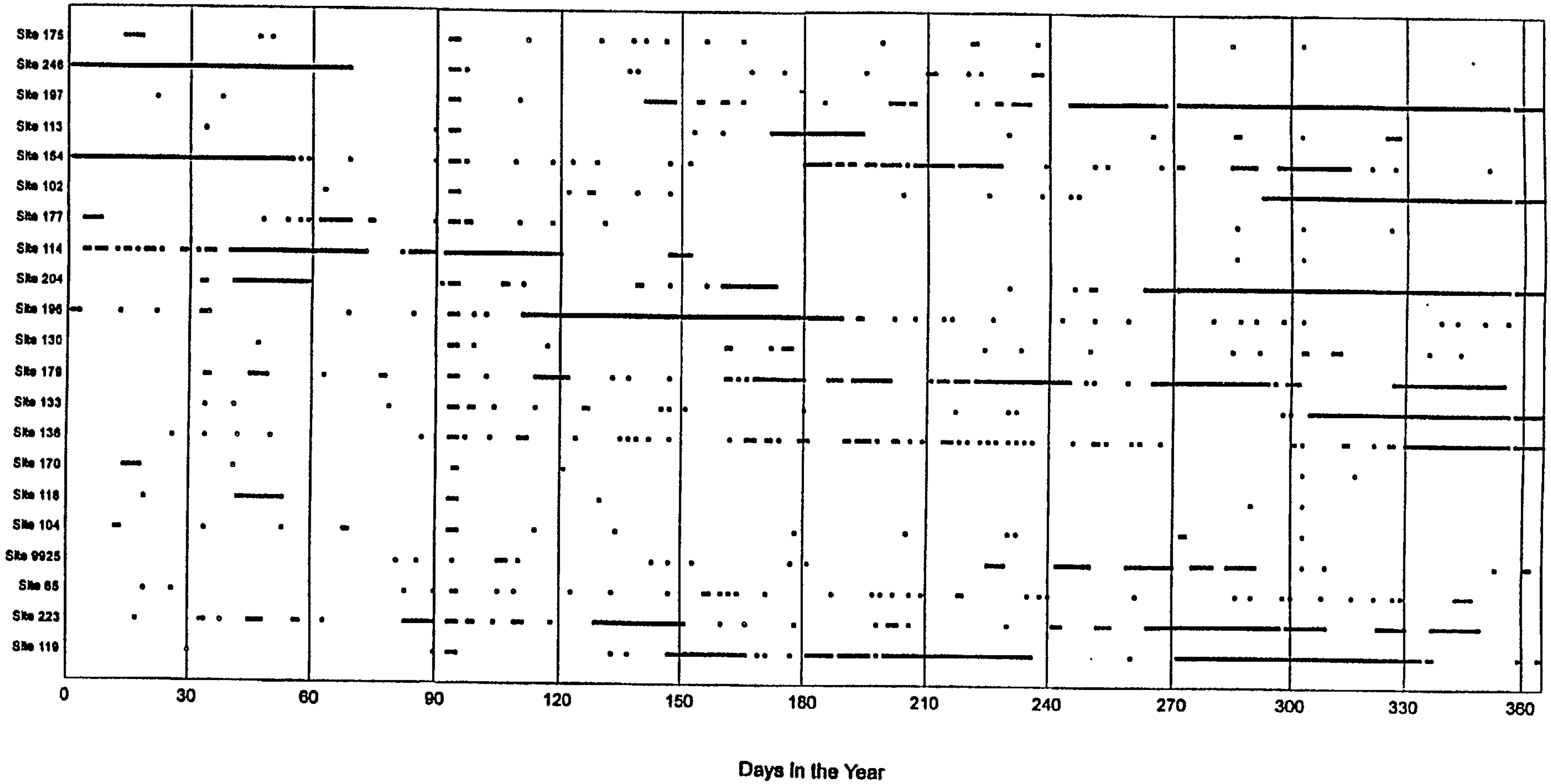


Table 5
Graphic of Missing Days for the 8 Selected Classification Sites from Florida's District 5
(Block Means Missing Day)

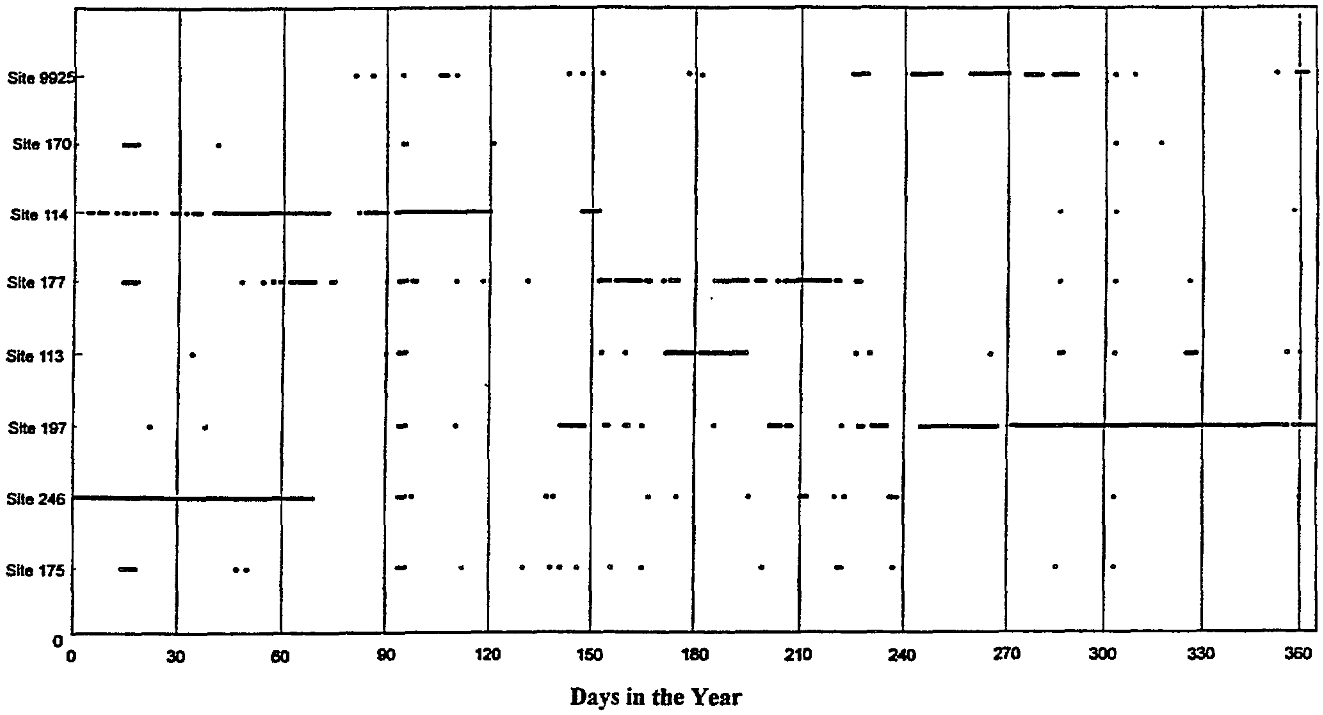
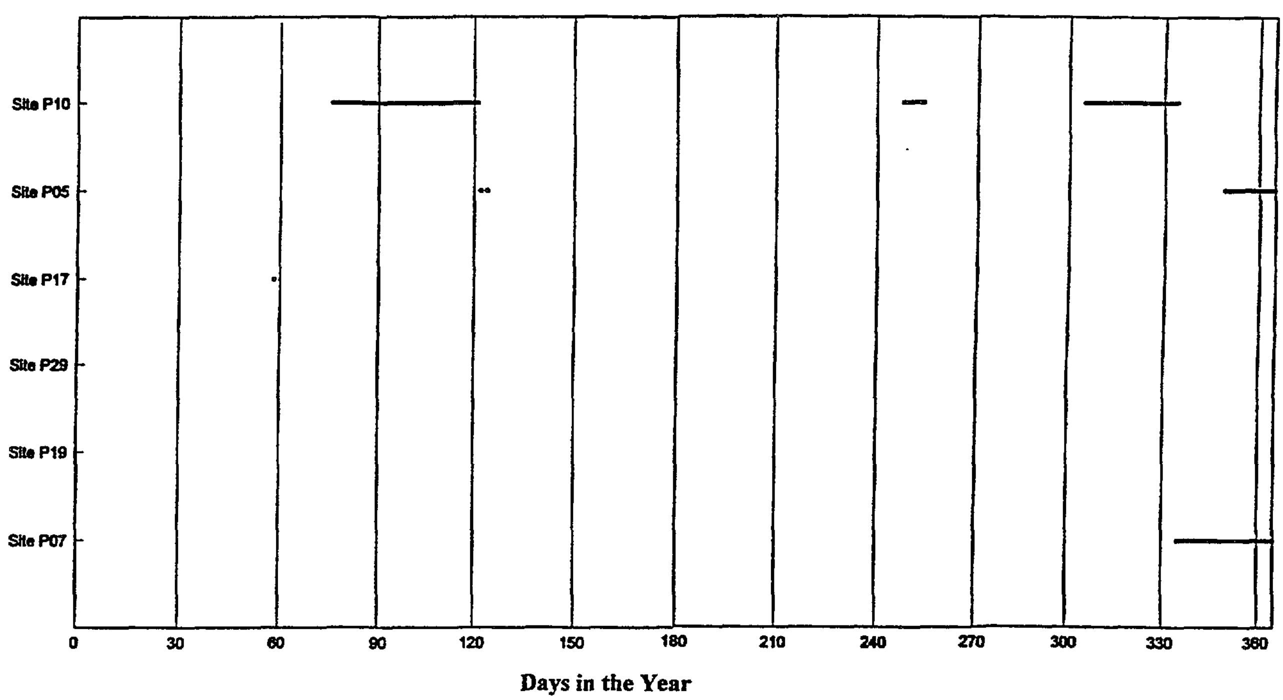


Table 6
Graphic of Missing Days for the 6 Selected WIM Sites from Washington
(Block Means Missing Day)



For the sites considered, relatively few days of weigh-in-motion data are missing. A real close examination of the three tables (graphics) would reveal that missing data for a given site are roughly uniformly distributed over the days of the week, but not roughly uniformly distributed over the months of the year. For example, by looking at the 8 classification sites, we show the 1994 missing days by days of week and by month of year.

Table 7
1994 Missing Days of Classification Data by Days of Week

Site	Sun	Mon	Tue	Wed	Thu	Fri	Sat
9925	10	10	10	8	6	7	7
170	4	3	2	0	1	1	1
114	14	12	12	15	13	16	17
177	10	14	11	13	14	10	9
113	6	6	6	5	12	4	3
197	20	23	22	21	20	23	24
246	13	13	12	11	16	12	11
175	4	3	5	4	2	2	3

Table 8
1994 Missing Days of Classification Data by Months of Year

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9925	0	0	2	5	2	3	0	7	19	15	1	4
170	5	1	0	2	1	0	0	1	0	1	1	0
114	15	24	22	29	5	1	0	0	0	2	0	1
177	5	4	11	7	1	18	22	10	0	2	1	0
113	0	1	1	3	0	12	13	2	1	3	4	2
197	1	1	0	4	8	5	7	8	27	31	30	31
246	31	28	10	4	2	2	4	5	0	1	0	1
175	5	2	0	4	4	2	1	3	0	2	0	0

It is clear from Tables 4, 5, and 6 that the missing days of traffic monitoring data occur in *single isolated days* as well as in *consecutive days*.

3.3 Annual Estimates and Associated Coefficients of Variation

3.3.1 AADT and Associated Coefficients of Variation

For each of Florida's 21 count sites and using the days of available 1994 data, we computed AADT by taking the average of the daily count values. We also computed the coeffkient of variation by

$$\textit{coefficient of variation} = \frac{\textit{standard deviation of the daily count values}}{\textit{AADT}}$$

The results are given in Table 9.

Table 9
1994 Estimated AADT and Associated Coefficients of Variation (CV)

	Estimated			Estimated			Estimate	
Site	**AADT**	**CV(%)**	**Site**	**AADT**	**CV(%)**	**Site**	**AADT**	**CV(%)**
119	30,180	21.2	136	6,336	18.6	177	33,290	16.6
223	4,474	16.5	133	28,026	15.4	102	40,753	14.4
65	7,382	11.1	179	54,599	13.7	154	44,030	11.6
9925	12,661	15.0	130	110,865	8.9	113	45,825	14.0
104	22,098	8.0	196	154,304	12.2	197	47,270	16.1
118	22,262	12.6	204	28,294	11.7	246	7,681	10.4
170	5,284	12.3	114	14,436	13.6	175	39,920	22.4

3.3.2 AADT by Vehicle Class and Associated Coefficients of Variation

For each of Florida's 8 classification count sites and using the days of available 1994 data, we computed the 1994 mean daily count by vehicle class and associated coefficients of variation and report results in Table 10.

Table 10
1994 Estimated Mean Daily Count (AADT) by Vehicle Class and Associated Coefficients of Variation (CV)

Vehicle Class		Classification Site 9925	170	114	177	113	197	246	175
(1)	Mean Daily Count	12	7	37	79	23	350	4	38
	CV	249%	129%	179%	125%	52%	181%	79%	101%
(2)	Mean Daily Count	10,538	4,080	12,390	28,66 1	39,755	41,385	5,816	34,830
	c v	21%	11%	12%	15%	13%	15%	11%	22%
(3)	Mean Daily Count	1,737	749	1,533	3,189	4,753	3,853	1,354	2,897
	c v	25%	2 1 %	24%	29%	23%	31%	26%	40%
(4)	Mean Daily Count	8	3	4	22	6	46	36	42
	c v	53%	82%	172%	46%	93%	151%	98%	71%
(5)	Mean Daily Count	176	9	27	53	59	90	54	61
	c v	49%	59%	72%	56%	58%	59%	55%	53%
(6)	Mean Daily Count	59	69	108	93	162	203	40	135
	c v	51%	51%	59%	65%	47%	43%	59%	95%
(7)	Mean Daily Count	8	11	5	18	26	11	3	18
	c v	125%	109%	172%	65%	121%	102%	181%	151%
(8)	Mean Daily Count	71	72	159	331	363	375	122	299
	c v	52%	30%	23%	36%	34%	38%	32%	51%
(9)	Mean Daily Count	96	45	49	215	79	159	113	231
	c v	44%	45%	49%	55%	45%	47%	48%	30%
(10)	Mean Daily Count	2	4	6	10	4	4	1	5
	c v	96%	76%	72%	67%	83%	76%	122%	156%
(11)	Mean Daily Count	1	0	0	4	1	13	0	1
	c v	140%	747%	456%	86%	149%	57%	306%	127%
(12)	Mean Daily Count	0	0	0	1	0	2	0	1
	c v	600%	1,327%	938%	93%	268%	94%	581%	140%
(13)	Mean Daily Count	2	12	0	199	6	0	0	125
	c v	109%	95%	272%	119%	120%	310%	214%	175%
(14)	Mean Daily Count	200	224	129	664	642	782	143	1,241
	c v	64%	78%	49%	54%	21%	55%	37%	126%

3.3.3 Average ESAL per Vehicle by Vehicle Class, Average Weight per Vehicle by Vehicle Class and Associated Coefficients of Variation

For each of Washington's 6 weigh-in-motion sites and using the days of available 1994 data, we computed, by vehicle class, the 1994 mean daily ESAL per vehicle, the 1994 mean daily weight per vehicle and associated coeffkients of variation and report them respectively in Tables 11 and 12.

Table 11
1994 Estimated Average Daily ESAL per Vehicle by Vehicle Class and Associated Coefficients of Variation (CV)

Vehicle Class		Weigh-in-Motion Sites					
		P10	P05	P17	P29	P19	P07
(3)	Mean Daily ESAL per Vehicle	0.01	0.01	0.01	0.12	0.01	0.00
	c v	39.0	139.1	211.8	341.8	54.4	0.0
(4)	Mean Daily ESAL per Vehicle	0.45	0.59	0.12	0.69	0.78	0.46
	c v	36.0	156.0	344.8	47.3	41.8	113.2
(5)	Mean Daily ESAL per Vehicle	0.08	0.13	0.13	0.12	0.10	0.32
	CV	36.1	76.4	139.8	73.1	45.7	72.2
(6)	Mean Daily ESAL per Vehicle	0.25	0.53	0.28	0.45	0.60	0.39
	c v	44.1	103.3	88.3	45.9	32.1	52.4
(7)	Mean Daily ESA per Vehicle	0.22	0.17	0.08	1.02	1.19	0.42
	c v	285.3	294.3	397.0	86.5	52.1	220.5
(8)	Mean Daily ESAL per Vehicle	0.27	0.94	0.95	0.57	0.36	0.87
	c v	32.9	84.1	92.7	50.3	46.2	67.5
(9)	Mean Daily ESAL per Vehicle	0.97	1.34	1.64	1.42	0.97	1.41
	cv	30.2	38.9	25.2	27.1	34.1	26.3
(10)	Mean Daily ESAL per Vehicle	0.84	1.22	0.91	1.09	0.85	1.06
	c v	34.5	75.1	50.8	33.9	37.0	44.6
(11)	Mean Daily ESAL per Vehicle	1.23	1.35	1.95	1.53	0.39	0.77
	c v	35.3	75.3	33.1	37.7	111.1	178.3
(12)	Mean Daily ESAL per Vehicle	0.79	1.19	1.77	1.53	1.76	1.83
	c v	38.3	57.3	43.9	32.7	42.5	68.9
(13)	Mean Daily ESAL per Vehicle	1.16	1.68	1.34	1.56	1.63	1.62
	c v	33.0	52.9	29.2	30.4	27.3	25.0
(14)	Mean Daily ESAL per Vehicle	0.37	0.72	0.47	0.54	0.43	1.27
	c v	289.3	97.3	237.6	109.0	75.7	130.3

Some numbers rounded to zero.

Table 12
1994 Estimated Average Daily Weight per Vehicle by Vehicle Class and Associated Coefficients of Variation (CV)
(Kips)

Vehicle Class		P10	PO5	P17	P29	PI9	PO7
(3)	Mean Daily Weight per Vehicle	11.4	8.4	10.0	14.1	10.9	0.0
	c v	10.2	24.4	30.4	83.5	10.3	0.0
(4)	Mean Daily Weight per Vehicle	30.7	19.3	6.3	29.9	30.3	16.7
	c v	8.7	81.0	200.6	32.2	16.8	94.0
(5)	Mean Daily Weight per Vehicle	10.6	9.2	9.6	10.6	10.4	16.7
	c v	10.7	17.8	20.7	29.8	13.8	16.0
(6)	Mean Daily Weight per Vehicle	23.4	25.4	23.1	28.1	30.7	27.9
	c v	11.0	25.4	28.7	22.9	10.4	19.5
(7)	Mean Daily Weight per Vehicle	12.4	8.0	4.5	36.6	45.8	13.2
	c v	156.7	209.0	306.5	61.3	38.0	188.7
(8)	Mean Daily Weight per Vehicle	24.8	30.2	32.7	28.1	25.0	35.0
	c v	11.8	26.7	33.5	26.3	19.1	31.3
(9)	Mean Daily Weight per Vehicle	54.9	51.1	59.3	59.8	51.3	58.0
	c v	8.5	10.7	8.1	8.7	9.4	7.4
(10)	Mean Daily Weight per Vehicle	59.0	55.1	50.6	61.0	55.3	60.1
	c v	10.8	22.5	18.7	14.7	12.6	19.9
(11)	Mean Daily Weight per Vehicle	51.8	46.4	57.4	52.0	29.0	31.3
	c v	11.2	22.7	12.9	24.0	46.8	81.6
(12)	Mean Daily Weight per Vehicle	55.2	54.5	61.8	65.8	67.0	63.4
	c v	10.4	17.1	14.6	13.8	21.1	31.2
(13)	Mean Daily Weight per Vehicle	76.1	71.8	75.0	78.0	84.5	78.9
	c v	9.7	15.3	9.3	15.1	9.5	10.1
(14)	Mean Daily Weight per Vehicle	19.0	23.8	20.1	14.9	16.5	27.2
	c v	31.2	42.4	61.6	58.1	36.4	39.1

Weigh-in-Motion Sites: P10, PO5, P17, P29, PI9, PO7

3.3.4 Remarks

From Table 9, the coefficients of variation associated with AADT for the 21 sites range from 10% to 20%.

From Table 10, the coefficients of variation associated with AADT by vehicle class for the 8 sites range from 11% to 22% for vehicles in Vehicle Class 2 to a range from 93% to 1,327% for vehicles in Vehicle Class 12. For each classification site, higher mean daily traffic counts for a vehicle class tended to have the lower coefficients of variation.

From Tables 11 and 12, we tended to see lower coefficients of variation for the weight per vehicle estimates than for the ESAL per vehicle estimates.

In general and not surprising, the coefficients of variation by vehicle class tended to be larger than the coefficients of variation for the classes combined (Table 9).

3.4 Coefficients of Variation (CV) by "Day of Week"

3.4.1 Coefficients of Variation (CV) for AADT by "Day of Week"

The range of the coefficients of variation for AADT by "day of week" for each of Florida's 21 sites are given in Table 13. Thus for example, for Sunday and for AADT, the lowest CV among the 21 sites was 4% and the highest CV among 21 sites was 18%. We observe similar ranges of CV for each day of the week.

Table 13
CV Ranges Over Days of Week for AADT Over Florida's 21 Count Sites

	Days of Week						
	sun	Mon	Tue	Wed	Thu	Fri	Sat
Combined Vehicles	4-18	4-18	2-18	2-17	2-18	3-20	4-21

3.4.2 Coefficients of Variation (CV) for AADT by Vehicle Class by "Day of Week"

For the 8 classification sites, we see "day of week" coefficients of variation that range over the seven days of the week as shown in Table 14. The lowest ranges exist for "Passenger Cars" (Class 2). The next lowest range exists for "Other Two-Axle, Four Tire, Single Unit Vehicles" (Class 3). By far, the highest ranges exist for vehicle classes 11, 12, and 13, but the absolute mean daily traffic volumes in each of these classes is quite low.

Table 14
CV Ranges Over Days of Week for Each Vehicle Class at Each of the 8 Classification Sites

	Classification Sites							
Vehicle Class	9925	170	114	177	113	197	246	175
(1) Motorcycles	100-300	112-155	121-193	100-134	32-89	161-206	51-102	75-108
(2) Passenger Cars	6-37	5-8	5-8	5-10	4-9	3-8	7-10	7-14
(3) Other 2 Axle, 4 Tire, S Unit	9-39	11-15	9-16	1 l-26	6-13	8-15	19-25	23-30
(4) Buses	30-80	55-108	62-236	34-50	73-106	134-161	86-111	35-68
(5) 2 Axle, 6 Tire, S Unit	11-47	29-94	35-65	22-49	23-56	18-98	28-106	16-81
(6) 3 Axle, S Unit	19-57	38-71	23-115	24-138	28-44	1 l-27	24-60	61-177
(7) 4+ Axle, S Unit	91-230	86-137	121-346	36-101	93-111	54-174	113-436	129-295
(8) 4- Axle, S Trailer	20-49	25-38	1 l-38	12-30	17-27	10-24	15-32	29-45
(9) 5 Axle, S Trailer	15-43	23-36	14-35	28-56	13-30	13-26	14-37	19-23
(10) 6+ Axle, S Trailer	66-164	54-115	32-200	36-100	57-158	46-133	94-232	119-339
(11) 5- Axle, M Trailers	96-474	O-721	O-633	69-121	91-349	16-566	O-648	86-485
(12) 6 Axle, M Trailers	O-678	O-72 1	O-632	72-121	209-495	56-316	O-640	93-3 14
(13) 7+ Axle, M Trailers	71-175	75-164	O-351	61-161	94-171	182-566	143-351	144-215
(14) Unclassified/Others	19-101	71-81	29-88	23-69	10-14	46-55	31-37	101-153

It is clear that some vehicle classes, the coefficients of variation are quite high (e.g., CV=721 for day of week for Vehicle Class 12 at Site 170 for 1994). These high coefficients of variation tend to occur with vehicle classes that have extremely low mean daily traffic volumes. To lower these high coefficients of variation, one might consider reducing the number of vehicle classes. This reduction may also lead to *better quality* classification data where one class is difficult to be distinguished from another using current monitoring classification equipment.

3.4.3 Coefficients of Variation (CV) for ESAL per Vehicle by Vehicle Class by "Day of Week"

For the 6 weigh-in-motion sites, we see "' day of week" coefficients of variation for ESAL that range over the seven days of the week as shown in Table 15. The lowest and shortest ranges appear to exist for "5 Axle, S Trailer" (Class 9). We also observe relatively low and short ranges for Classes 10, 12, and 13. The highest and longest ranges appear to exist for Vehicle Classes 7 and 14.

Table 15
CV Ranges over Days of Week for "ESAL" for Each Vehicle Class at Each of the 6 Weigh-In-Motion Sites from Washington

Vehicle Class	Weigh-In-Motion Sites					
	P10	P05	P17	P29	P19	P07
(3) Other 2 Axle, 4 Tire, S Unit	30-53	61-235	69-253	268-555	43-67	
(4) Buses	32-42	118-168	208-393	37-60	27-57	78-224
(5) 2 Axle, 6 Tire, S Unit	26-35	54-137	84-260	23-196	23-40	31-157
(6) 3 Axle, S Unit	34-57	62-194	45-163	27-63	22-49	33-85
(7) 4+ Axle, S Unit	181-343	213-707	325-714	55-190	29-237	156-672
(8) 4- Axle, S Trailer	23-45	55-110	58-151	22-116	24-64	35-120
(9) 5 Axle, S Trailer	28-32	34-43	21-28	24-28	28-43	22-27
(10) 6+ Axle, S Trailer	29-40	58-95	41-70	29-38	29-61	25-87
(1l) 5- Axle, M Trailers	28-38	45-97	27-42	26-50	82-209	118-287
(12) 6 Axle, M Trailers	34-46	44-75	32-60	29-39	29-71	41-129
(13) 7+ Axle, M Trailers	31-34	45-55	22-36	26-40	24-31	20-34
14) Unclassified Vehicles	79-346	65-187	142-341	91-137	44-150	69-242

3.4.4 Coefficients of Variation (CV) for Weight per Vehicle by Vehicle Class by "Day of Week"

For the 6 weigh-in-motion sites, we see "day of week" coefficients of variation for weight that range over the seven days of the week as shown in Table 16. The lowest and shortest ranges appear to exist for "5 Axle, S Trailer" (Class 9). By far, the highest and longest ranges appear to exist for Vehicle Class 7.

Table 16
CV Ranges over Days of Week for "Weight" for Each Vehicle Class at Each of the 6 Weigh-In-Motion Sites from Washington

Vehicle Class	Weigh-In-Motion Sites					
	PlO	PO5	P17	P29	P19	PO7
(3) Other 2 Axle, 4 Tire, S Unit	8-12	18-31	27-36	57-91	8-18	
(4) Buses	8-9	51-113	151-233	21-47	7-29	59-163
(5) 2 Axle, 6 Tie, S Unit	8-11	14-21	14-26	7-70	7-10	9-25
(6) 3 Axle, S Unit	8-14	13-37	11-51	8-34	6-12	7-43
(7) 4+ Axle, S Unit	120-202	158-527	247-714	37-122	8-175	129-452
(8) 4- Axle, S Trailer	7-16	15-28	20-55	6-50	6-15	14-49
(9) 5 Axle, S Trailer	7-9	9-12	6-9	6-13	8-11	7-8
(10) 6' Axle, S Trailer	9-13	15-36	15-27	9-17	10-19	8-39
(11) 5- Axle, M Trailers	6-18	16-32	9-20	1 l-39	34-82	52-225
(12) 6 Axle, M Trailers	9-13	14-22	1 O-24	8-22	10-45	12-58
(13) 7' Axle, M Trailers	9-10	1 o-22	7-10	7-29	8-l 1	6-16
(14) Unclassified Vehicles	21-36	32-63	38-70	34-74	22-36	17-60

3.5 Coefficients of Variation (CV) by "Month of Year"

3.5.1 Coefficients of Variation (CV) for AADT by "Month of Year"

We observe similar ranges of CV for each month of the year. Comparing Tables 13 and 17, we observe slightly higher CV's for the month of the year than for the day of the week.

Table 17
CV Ranges Over Months of Year for AADT over Florida's 21 Count Sites

	Month of Year											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Combined Vehicles	6-25	6-23	6-20	7-24	5-26	5-19	6-25	5-21	2-24	7-22	9-25	8-27

3.5.2 Coeffkients of Variation (CV) for AADT by Vehicle Class by "Month of Year"

For the 8 classification sites, we see "month of year" coefficients of variation that range over the twelve months of the year as shown in Table 18. As in Table 14, the lowest and shortest ranges are for "Passenger Cars" (Class 2) and the next lowest ranges are for **Class 3** "Other Two-Axle, Four Tire, Single Unit Vehicles." Also as h Table 14, the highest and longest ranges are for Vehicle Classes 11, 12, and 13, mainly because of the low mean daily traffic volumes.

Table 18
CV Ranges Over Months of Year for Each Vehicle Class at Each of the 8 Classification Sites

	Classification Sites							II
Vehicle Class	9925	170	114	177	113	197	246	175
(1) Motorcycles	53-287	33-108	O-64	43-113	26-95	44-77	**42-95**	38-108
(2) Passenger Cars	IO-48	9-13	O-16	12-16	l0-16	1-17	7-12	19-26
(3) Other 2 Axle, 4 Tire, S Unit	15-55	16-30	O-30	25-43	19-26	4-34	17-33	27-36
(4) Buses	35-65	61-109	O-163	26-6 1	49-140	5-84	40-71	25-53
(5) 2 Axle, 6 Tire, S Unit	38-75	49-62	o-79	49-76	45-67	5-65	38-69	45-59
(6) 3 Axle, S Unit	39-75	26-71	O-63	40-94	35-51	20-50	54-63	48-l 13
(7) 4+ Axle, S Unit	51-194	58-184	O-208	48-75	65-127	67-105	112-200	67-175
(8) 4- Axle, S Trailer	35-83	18-33	O-36	30-46	27-36	11-45	21-42	33-52
(9) 5 Axle, S Trailer	29-70	36-47	O-52	44-74	39-49	5-56	44-53	21-30
(10) 6+ Axle, S Trailer	66-103	58-127	O-78	54-83	64-122	48-87	97-134	70-145
(l 1) 5- Axle, M Trailers	58-288	O-556	o-539	41-150	11 l-280	35-67	O-548	78-177
(12) 6 Axle, M Trailers	o-557	O-548	O-305	63-164	O-424	63-131	O-548	79-195
(13) 7+ Axle, M Trailers	60-156	48-374	O-409	36-176	65-154	o-331	135-421	99-328
(14) Unclassified/Others	23-123	21-38	o-43	28-62	17-23	4-36	20-38	42-181

3.5.3 Coeffkients of Variation (CV) for ESAL per Vehicle by Vehicle Class by "Month of Year"

For the 6 weigh-in-motion sites, we see "month of year" coefficients of variation for ESAL, that range over the twelve months of the year as shown in Table 19. The lowest and shortest ranges appear to exist for "5 Axle, S Trailer" (Class 9) and "7+ Axle, M Trailers," (Class 13). As in Table 15 for "days of week" for ESAL, we observe the highest and longest ranges for Vehicle Classes 7 and 14.

Table 19
CV Ranges over Months of Year for "ESAL" for Each Vehicle Class at Each of the 6 Weigh-In-Motion Sites from Washington

Vehicle Class	Weigh-In-Motion Sites					
	PlO	PO5	PI7	P29	P19	PO7
(3) Other 2 Axle, 4 Tire, S Unit	15-61	40-288	41-315	3 l-469	31-66	
(4) Buses	12-32	108-179	178-557	21-67	22-49	50-254
(5) 2 Axle, 6 Tire, S Unit	22-37	40-98	43-156	29-174	33-49	32-115
(6) 3Axle, S Unit	27-47	56-l 19	48-98	17-51	18-32	35-94
(7) 4+Axle, S Unit	158-394	169-548	178-548	60-144	28-63	138-453
(8) 4-Axle, S Trailer	18-30	45-78	55-100	27-69	29-53	46-83
(9) 5 Axle, S Trailer	8-24	16-54	1 l-34	7-29	12-32	13-32
(1O) 6+ Axle, S Trailer	16-32	42-90	19-61	1 l-35	19-33	24-7 1
(11) 5- Axle, M Trailers	15-38	41-128	17-42	19-47	SO-199	95-277
(1 2 6 Axle, M Trailers	11-41	28-66	20-55	1 l-35	26-52	48-86
(13) 7' Axle, M Trailers	8-24	21-62	16-45	7-29	8-33	15-30
(14) Unclassified Vehicles	32-338	51-114	82-303	47-131	55-80	76-175

3.5.4 Coefficients of Variation (CV) for Weight per Vehicle by Vehicle Class by "Month of Year" .

For the 6 weigh-in-motion sites, we see "month of year" coefficients of variation for weight that range over the twelve months of the year as shown in Table 20. We continue to see that the lowest and shortest ranges appear to occur for "5 Axle, S Trailer" (Class 9) and that the highest and longest ranges appear to exist for vehicles in Class 7.

Table 20
CV Ranges over Months of Year for "Weight" for Each Vehicle Class at Each of the 6 Weigh-In-Motion Sites from Washington

Vehicle Class	Weigh-In-Motion Sites					
	PlO	PO5	P17	P29	P19	PO7
(3) Other 2 Axle, 4 Tire, S Unit	4-11	11-46	11-52	20-99	6-21	
(4) Buses	3-8	66-116	144-557	5-59	6-35	36-237
(5) 2 Axle, 6 Tire, S Unit	5-l 1	9-21	9-28	6-80	10-15	8-28
(6) 3 Axle, S Unit	6-12	15-34	15-42	6-42	6-11	9-36
(7) 4+Axle, S Unit	116-247	140-504	144-548	36-109	20-47	126-385
(8) 4- Axle, S Trailer	6-12	17-31	21-40	15-49	12-22	21-43
(9) 5 Axle, S Trailer	3-7	5-23	5-12	2-17	4-8	4-8
(10) 6' Axle, S Trailer	5-10	15-31	7-24	3-29	6-14	7-32
(11) 5- Axle, M Trailers	5-21	13-35	7-22	10-41	35-78	58-107
(12) 6 Axle, M Trailers	3-10	7-24	5-24	3-23	11-41	25-37
(13) 7+ Axle, M Trailers	3-7	7-23	5-15	3-22	3-10	4-20
(14) Unclassified Vehicles	946	16-42	33-86	12-81	25-45	24-58

3.6 Daily Vehicle Mix

Averaging over the 8 classification sites, we obtain the following ranking for the average daily traffic percent mix for 1994 at each classification site (Table 21). (All percents are rounded).

At almost every one of the 8 classification sites, the level of unclassified/other vehicles is quite high relative to what is captured in Classes 1,4,5,6,7,8,9,10,11,12, and 13. If a large percentage of vehicles in Class 14 is due to unclassified, this may signal some cause for concern for the reported counts in the other classes. It may also signal the need to consider decreasing the number of classes until technology can be improved to distinguish better between similar type vehicles. This decrease in the number of classes may also lead to a significant decrease in the level of unclassifieds. One such grouping is given in Table 22.

Table 21
1994 Daily Vehicle Mix Based on Florida's 8 Classification Sites

	Percent	Vehicle Class
Highest Ranked Class	83.39	(2) Passenger Cars
	11.39	(3) Other 2 Axle, 4 Tire, S Unit Vehicles
	2.09	(14) Unclassified/Others
	0.99	(8) 4- Axle, S Trailer Trucks
	0.64	(9) 5 Axle, S Trailer Trucks
	0.55	(6) 3 Axle, S Unit Trucks
	0.38	(5) 2 Axle, 6 Tire, S Unit Trucks
	0.21	(1) Motorcycles
	0.15	(13) 7' Axle, M Trailers Trucks
	0.11	(4) Buses
	0.06	(7) 4' Axle, S Unit Trucks
	0.03	(10) 6' Axle, S Trailer Trucks
	0.01	(11) 5- Axle, M Trailers Trucks
Lowest Ranked Class	0.00	(12) 6 Axle, M Trailers Trucks
Total	100.00	

Table 22
Potential Grouping Scheme of Vehicles

Potential Group Class	Vehicle Classes
Gl Motorcycles	1 Motorcycles
G2 Passenger Vehicles - 1	2 Passenger Cars
G3 Passenger Vehicles - 2	3 Other 2 Axle, 4 Tire, Single Unit
G4 Single Unit Trucks	4 Buses
	5 2 Axle, 6 Tire, Single Unit
	6 3 Axle, Single Unit
	7 4 or More Axle, Single Unit
G5 Single Trailer Trucks	8 4 or Less Axle, Single Trailer
	9 5 Axle, Single Trailer
	10 6 or More Axle, Single Trailer
G6 Twin Trailer Trucks	11 5 or Less Axle, Multi-Trailer
	12 6 Axle, Multi-Trailer
G7 Very Large Trucks	13 7 or More Axle, Multi-Trailers
G8 Unknown Vehicle	14 Unclassified/Other Vehicles

Averaging over the 6 weigh-in-motion sites, we obtain the following ranking for the average daily traffic percent mix for 1994 at each Washington weigh-in-motion site. We also note a relatively high level of unclassified vehicles among these sites (Table 23).

Table 23
1994 Daily Vehicle Ml Based on Washington's 6 Weigh-In-Motion Sites

	Percent	Vehicle Class
Highest Ranked Class	35.6	(9) 5 Axle, S Trailer
	24.3	(5) 2 Axle, 6 Tire, S Unit
	12.2	(13) 7+ Axle, M Trailers
	6.4	(6) 3 Axle, S Trailer
	5.7	(10) 6+ Axle, S Trailer
	5.2	(8) 4-Axle, S Trailer
	3.7	(12) 6 Axle, M Trailers
	2.7	(14) Unclassified Vehicles
	1.8	(11) 5 Axle, M Trailers
	1.4	(3) Other 2 Axle, 4 Tire, S Unit
	0.7	(4) Buses
Lowest Ranked Class	0.3	(7) 4+ Axle, S Unit
Total	100.00	

3.7. Examination of Different Methods for Computing AADT

3.7.1 Five Methods for Computing AADT

For a given road segment or site on a given road segment, **the aim** of **annual average daily traffic (AADT)** is to characterize ". ..typical daily traffic (count) on (the) road segment for all days of the week, Sunday through Saturday, over the period of one year." [Reference: AASHTO *Guidelines for Traffic Data Programs (1992), American* Association of State Highway and Transportation Officials, Washington, DC, p. 108.] Depending on the amount and quality of available data, it appears that there are several methods to compute a quantity to pursue this aim as discussed in Sections 3.7.2-3.7.6.

3.7.2 Method 1: Average of All Days (Standard Method)

If X_i is the total daily traffic count on a given road segment for the ith day, where i=l, 2, ... N, define AADT to be

$$AADT_1 = \frac{\sum_{i=1}^{N} x_i}{N}$$

Ideally, N=365 (or 366). In practice, N, which is the number of days with available "edited" counts during a year, is often less than 365 (or 366). If N=365 (or 366), all would likely use AADT, .

3.7.3 Method 2: Average of "Monthly" Averages

If certain months of the year (e.g. winter months) have more days with missing data than other months of the year (e.g. summer months), then the definition in Method 1 tends to give a number $AADT_1$ which is influenced more than it should be by the summer months and influenced less than it should be by the winter months. ‘Ibis seems undesirable, and in an attempt to overcome or guard against this and to give equal influence to the months of the year, $AADT_2$ is proposed.

Step 1. For month i, let

$\bar{x}_i$ be the average of the total daily traffic counts.

Note that $\bar{x}_i$ is based on the number of days of available counts for month i.

Step 2. Then AADT can be taken as

$$AADT_2 = \frac{\sum_{i=1}^{M} \bar{x}_i}{M}$$

where M is the number of months with sufficient data to compute a value $\bar{x}_i$. Ideally M=12. However, in practice, M is often less than 12 as revealed by Table 2.1 for the sites in Florida’s District 5.

3.7.4 Method 3: Average of “Day of Week” Averages

If certain days of the week (say Tuesdays and Wednesdays) tend to have missing days of data while other days of the week tend to not have missing days of data, the definition in Method 1 tends to give a number $AADT_1$ which is overly influenced by counts from days other than Tuesdays and Wednesdays. This seems undesirable because the traffic volume is clearly different among the different days of the week, particularly between weekdays and weekend days. In an attempt to overcome this and to give equal influence to the days of the week, $AADT_3$ is proposed.

Step 1. For the ith day of the week, let

$\bar{Y}_i$ be the average of the total daily traffic counts for all of the ith days of the week during the year for which there are available "edited" counts.

Step 2. Then AADT can be taken as

$$AADT_3 = \frac{\sum_{i=1}^{W} \bar{Y}_i}{W}$$

where W is the number of days of the week with sufficient data to compute a value $\bar{Y}_i$. Ideally W=7.

Method 4 is a combination of Methods 2 and 3 and it attempts to simultaneously equalize the effect of the months of the year and days of the week on AADT.

3.7.5 Method 4: Average of "Monthly" and "Day of Week" Averages (AASHTO Method)

Step 1. For the ith day of the week in month j, let

$\bar{x}_{ij}$ be the average of the total daily traffic counts.

Then we have

$$\text{for Sunday, } \bar{x}_{1.} = \frac{\bar{x}_{11} + \bar{x}_{12} + \cdots + \bar{x}_{1,M_1}}{M_1};$$

$$\text{for Monday, } \bar{x}_{2.} = \frac{\bar{x}_{21} + \bar{x}_{22} + \cdots + \bar{x}_{2,M_2}}{M_2};$$

$$\text{for Monday, } \bar{x}_{2.} = \frac{\bar{x}_{21} + \bar{x}_{22} + \cdots + \bar{x}_{2,M_2}}{M_2},$$

$$\vdots$$

$$\text{for Saturday, } \bar{x}_{7} = \frac{\bar{x}_{71} + \bar{x}_{72} + \cdots + \bar{x}_{7,M_7}}{M_7},$$

where M_i is the number of months with an average for day of week i for i=l, ... 7. Ideally each M_i=12.

Step 2. Then AADT can be taken as

$$AADT_4 = \frac{\bar{x}_{1.} + \bar{x}_{2.} + \bar{x}_{3.} + \bar{x}_{4.} + \bar{x}_{5.} + \bar{x}_{6.} + \bar{x}_{7.}}{7}$$

Method 4 is recommended by *AASHTO*. *(AASHTO Guidelines for Traffic Data Program,* p. 52)

3.7.6 Method 5: Weighted Average of Average of Monthly "Weekday" and Weekend Day" Averages

To ensure appropriate contributions to annual average daily traffic of weekdays and weekend days, Method 5 is considered.

Step 1. For weekdays in month j, let

$\bar{Y}_{wj}$ be the average of the total daily traffic count.

Then for weekdays,

$$AADT_{weekday} = \frac{\bar{Y}_{w1} + \bar{Y}_{w2} + \ldots + \bar{Y}_{w,M_w}}{M_w}$$

where M_W is the number of months with a weekday average. Ideally M_W=12.

Step 2. For *weekend days in* month j, let

$\bar{x}_{ej}$ be the average of the total daily traffic count.

Then for weekend days,

$$AADT_{weekend} = \frac{\bar{x}_{e1} + \bar{x}_{e2} + \ldots + \bar{x}_{e,M_e}}{M_e}$$

where M_e is the number of months with a *weekend* average. Ideally M_e=12.

Step 3. Then AADT can be taken as

$$AADT_5 = \frac{5}{7} AADT_{weekday} + \frac{2}{7} AADT_{weekend}$$

Note under Method 5 that we are taking the weekend days to be Saturday and Sunday.

For the 21 Florida selected sites, and using the available 1994 data, the AADT for the different methods are given in Table 24.

3.7.7 Preliminary Comments Based on the Empirical Comparison

From the last column of Table 24, note that for each site, all of the 5 estimates of AADT are within 2.5% or less of each other. Actually, for 15 out of the 2 1 sites, the 5 estimates of AADT are within less than 1% of each other. For example with site 170, the percent closeness (maximum ratio) of the 5 estimates is computed by

Table 24
A Comparison of the Computed AADTs for the Five Different Methods

'unc 'lass	Site	No. of Days	No. of Weekdays	No. of Weekend Days	Number of Sun	Mon	Tue	Wed	Thu	Fri	Sat	No. of Mos	AADT - Methods 1	2	3	4	5	How Clos Are Methods'
01	119	212	153	59	28	31	30	31	33	28	31	10	30,180	29,592	30,282	29,587	29,613	2.35%
02	223	231	160	71	36	30	35	32	29	34	35	12	4,474	4,427	4,479	4,492	4,439	1.47%
02	65	322	227	95	47	44	46	48	45	44	48	12	7,382	7,375	7,383	7,385	7,373	0.16%
02	9925	308	219	89	43	42	42	44	46	45	46	12	12,661	12,670	12,654	12,653	12,672	0.15%
02	104	347	248	99	48	50	50	50	47	51	51	12	22,098	22,122	22,084	22,118	22,139	0.25%
02	118	345	246	99	48	48	48	50	50	50	51	12	22,262	22,269	22,238	22,234	22,281	0.21%
06	170	353	253	100	48	49	50	52	51	51	52	12	5,284	5,284	5,275	5,277	5,283	0.17%
07	136	263	185	78	40	39	40	37	32	37	38	11	6,336	6,294	6,372	6,329	6,314	1.24%
11	133	283	201	82	41	43	40	41	38	39	41	10	28,026	28,058	28,062	28,097	28,085	0.25%
11	179	210	144	66	33	30	29	29	32	24	33	12	54,599	54,259	54,801	54,432	54,154	1.19%
11	130	341	244	97	48	49	49	46	52	48	49	12	110,865	110,819	110,846	110,677	110,781	0.17%
11	196	252	177	75	37	38	34	38	33	34	38	10	154,304	154,480	154,764	154,899	155,022	0.47%
12	204	212	151	61	30	32	32	31	27	29	31	9	28,294	28,047	28,354	28,131	28,046	1.10%
14	114	267	192	75	38	40	40	37	39	36	37	12	14,436	14,695	14,437	14,581	14,578	1.80%
14	177	333	235	98	48	48	46	47	45	49	50	12	33,290	33,428	33,341	33,486	33,524	0.70%
14	102	278	200	78	39	40	41	42	40	37	39	10	40,753	40,737	40,775	40,768	40,708	0.17%
14	154	220	154	66	33	31	31	32		263433		11	44,030	43,851	44,143	43,923	44,265	0.95%
14	113	326	229	97	47	47	46	47	41	48	50	12	45,825	45,793	45,900	45,874	45,943	0.33%
14	197	212	151	61	32	29	30	31	32	29	29	9	47,270	47,716	47,374	47,412	47,325	0.94%
16	246	278	197	81	39	40	40	41	36	40	42	10	7,681	7,706	7,686	7,710	7,713	0.41%
16	175	342	244	98	48	49	47	48	50	50	50	12	39,920	39,922	39,905	39,891	39,945	0.14%

* How close are the methods7 The 5 estimates are within X% of each other, See Section 3.7.7 for more details.

$$\textit{Percent Closeness} = \textit{Maximum Ratio}$$

$$= \frac{\textit{Max Estimate} - \textit{Min Estimate}}{\textit{Min Estimate}} \times 100\%$$

$$= \frac{5{,}284 - 5{,}275}{5{,}275} \times 100\%$$

$$\approx 0.17\%.$$

For practical purposes, it can be argued that this preliminary result shows no real differences among the estimates produced by the five different methods for the sites which all suffer from various patterns of missing data.

To conclude, based on preliminary evidence, that the 5 estimates are essentially the same for each of the sites seems reasonable. However, to conclude that the 5 estimates for a given site are at or near the "true" AADT (based on measurement error free data from 365 or 366 days) would be incorrect. In fact, we may never know whether or not we have the true AADT for any given site.

If no practical difference in the estimates continues to hold for the additional sites to be analyzed in later Tasks, we recommend use of Method One for simplicity!

By using the same five methods, similar results were observed for the classification data (Task V Report, Chapter 7) and for the weigh-in-motion (Task VIII Report, Chapter 7).

3.8 Effect of Holidays and Special Days

3.8.1 Effect of Holidays and Special Days on AADT and CV

The table below gives 1994 holidays and "holiday period" as defined by the Florida DOT. For each of the 21 selected sites, Table 25 presents computations of AADT, and CV under these conditions:

Condition 1: All days of data used

Condition 2: Data with all specific holidays removed

Condition 3: Data with all "holiday period" days removed

where

Holiday	Specific Date	"Holiday Period"
New Year's	January 1, 1994	January 1,2,3,4,1994
Martin Luther King B-Day	January 17, 1994	January 14,15,16,17,18, 1994
Memorial Day	May 30, 1994	May 27,28,29,30,3 1, 1994
Independence Day	July 4, 1994	July 1,2,3,4,5,6,7, 1994
Labor Day	September 5, 1994	September 2,3,4,5,6, 1994
Veterans Day	November 11, 1994	November 10, 11,12, 1994
Thanksgiving	November 24, 1994	November 21,22,23,24,25, 26,27,28, 1994
Christmas	December 25, 1994	December 18, 19,20,21,22, 23,24,25,26,27,28,29,3-O, 31, 1994

3.8.2 Preliminary Comments

From Table 25, the AADT *increases* at 18 of the 21 sites from Condition 1 (all available days) to Condition 2 (all days except specific holidays). Also, the AADT *increases* at 15 of the 21 sites from Condition 1 (all available days) to Condition 3 (all days except those in holiday periods). However, in both cases, the increases (and decreases) are relatively small amounts. The closeness of the AADT values under the 3 different conditions is reflected in the sixth and seventh columns with percents.

Based on these preliminaty results, and assuming a minimum number of days of available edited data, the effect of holidays and holiday periods on overall AADT is negligible.

From Table 25, the (rounded) CV *decreases* at 16 of the 21 sites from Condition 1 (all available days) to Condition 2 (all days except specific holidays). Also the (rounded) CV *decreases* at 20 of the 21 sites from Condition 1 (all available days) to Condition 3 (all days except those in holiday periods). However, in both cases these decreases are small. Moreover, these decreases in CV are not surprising when one considers that the daily traffic on these holiday period days gives smaller values than for the rest of the days.

While the effect of holiday and holiday periods on overall AADT appears negligible, the effect on CV, i.e., variability, is small but not negligible.

Similar results were observed for the classification data (Task V Report) and for the weigh-in-motion data (Task VIII).

Table 25
Effect of Holidays and Special Days on AADT and CV (%)

Func Clas	Site	AADT Condition 1	AADT Condition 2	AADT Condition 3	How Close Are The AADTs?*	CV Condition 1	CV Condition 2	CV Condition 3	How Close Are The CV's?*
01	119	30,180	30,111	29,681	1.68%	21.2	21.3	20.5	3.71%
02	223	4,474	4,486	4,447	0.88%	16.5	16.5	15.7	5.16%
02	65	7,382	7,370	7,330	0.70%	11.1	11.0	11.0	0.45%
02	9925	12,661	12,741	12,785	0.98%	15.0	14.2	13.9	7.63%
02	104	22,098	22,145	22,229	0.59%	8.0	7.8	7.8	3.09%
02	118	22,262	22,322	22,110	0.96%	12.6	12.5	10.9	15.96%
06	170	5,284	5,303	5,308	0.46%	12.3	11.9	11.7	5.04%
07	136	6,336	6,376	6,434	1.55%	18.6	18.0	17.5	6.23%
11	133	28,026	28,008	27,968	0.21%	15.4	15.5	15.1	2.45%
11	179	54,599	54,753	54,866	0.49%	13.7	13.7	13.8	0.95%
11	130	110,865	110,998	110,777	0.20%	8.9	8.9	8.8	1.36%
11	196	154,304	154,805	155,392	0.71%	12.2	11.8	11.4	6.84%
12	204	28,294	28,414	28,542	0.88%	11.7	11.5	11.3	3.89%
14	114	14,436	14,5 19	14,533	0.68%	13.6	12.8	12.6	8.10%
14	177	33,290	33,502	33,534	0.73%	16.6	15.9	15.7	5.86%
14	102	40,753	40,993	41,177	1.04%	14.4	13.8	13.5	6.89%
14	154	44,030	44,251	44,372	0.78%	11.6	11.0	10.3	12.33%
14	113	45,825	46,035	46,165	0.74%	14.0	13.3	13.1	6.64%
14	197	47,270	47,449	47,742	1.00%	16.1	15.6	15.2	5.86%
16	246	7,681	7,712	7,745	0.83%	10.4	10.0	9.8	5.82%
16	175	39,926	40,255	40,537	1.54%	22.4	21.4	20.9	7.32%

* How close are the 3 estimates? The 3 estimates are within X% of each other.

3.9 Simulations with Randomly Missing Count Data

3.9.1 Simulations with Randomly Missing Days: Effect on AADT

In this section, we investigate the effect on AADT when individual days of data are missing at random. Throughout all simulations in this section, AADT is the mean of the available data. We do this for three levels of missing data:

- (i) 5% of Days of Data Missing at Random,
- *(ii)* 20% of Days of Data Missing at Random, and
- *(iii)* 50% of Days of Data Missing at Random.

3.9.1.1 Five Percent of Days of Count Data Missing at Random

For a specific one of Florida's 2 1 selected sites, let N be its number of days of available "edited" count data. Let d_1 = .05N, and round to the nearest integer. Next, randomly select and remove d_1 days of count data from the given site. For the N-d, remaining days of count data., compute the average daily traffic and the associated coefficient of variation. Replace the d, days and repeat the above steps 999 additional times. Thus for the given site, we have 1000 different values of average daily traffic and 1000 different coefficients of variation. Compute the average of the 1000 values of average daily traffic and denote this by SADT, for "simulated average daily traffic" without 5% of days of count data. This process was repeated for each of the 21 Florida selected sites.

3.9.1.2 Twenty Percent of Days of Count Data Missing at Random

For each of Florida's 21 selected sites, repeat the steps of Section 3.9.1.1 except here, the remaining days are N - d_2 where d_2= .2N and $SADT_2$ is the "simulated average daily traffic" without 20% of days of count data.

3.9.1.3 Fifty Percent of Days of Count Data Missing at Random

For each of Florida's 21 selected sites, repeat the steps of Section 3.9.1.1 except here, the remaining days are $N - d_3 = .5N$ and $SADT_3$ is the "simulated average daily traffic" without 50% of days of count data.

The results of the simulations are described in Table 26.

3.9.1.4 Preliminary Comments

From columns 5,6 and 7 of Table 26, if 5% or 20% of the days' data are missing at random, the simulated average values of SADT, and $SADT_2$ are essentially the same as AADT, for each site. Though the simulated average value $SADT_3$ (column 7 of Table 26) is also close to AADT,, it does not tend to be as close as $SADT_1$ and $SADT_2$. Note also from the values in parentheses in columns 5, 6 and 7 that the simulated standard errors increase from $SADT_1$ to $SADT_2$ to $SADT_3$.

Under random sampling, sampling theory tells us that the expected values of SADT,, SADT, and $SADT_3$ will all be AADT and that the standard errors will increase from $SADT_1$ to $SADT_2$ to $SADT_3$. That is, the more (randomly) missing data, the more unreliable the result even though it is on target (on the average).

For these 21 preliminary sites, one might argue that even with 50% of the count data missing at random, the reliability of the estimate is quite high. In fact, if equipment failure due to use is the chief cause for missing data, then a more efficient approach for collecting traffic data might be to abandon continuous monitoring. Rather than attempt to employ the equipment at a single site for each and every day of the year, it might be better to employ the equipment only on randomly selected days, hence decreasing its use while extending its life. Preliminary results suggest that the loss in AADT reliability due to missing data might very well be tolerable. More research is needed, which is beyond the scope of this research study. The use of sampling with continuously monitored sites should likely permit more resources for the short term monitoring sites.

These preliminary simulations suggest that randomly missing days of count data have little effect on the average value of the coefficient of variation with AADT based on the non-missing days of count data.

4. CONCLUDING COMMENT

The empirical results and comments in this paper are all based on observations for a small set of continuously monitored sites from Florida and Washington using 1994 data. More details and other empirical results are given in the reports for Tasks II, V, and VIII. The validity of most of these empirical results will likely be increased only as additional data are analyzed from other sites, including sites from other states.

Table 26
Simulation Results for $AADT_1$ with Randomly Missing Days of Count Data* *

Func . Class	Site	N	$AADT_1$	Amount of Randomly Missing Data: 5% $SADT_1$*	20% $SADT_2$*	50% $SADT_3$*	How Close are $SADT_i$ and AADT,? The 2 estimates are within X% of each other. SADT,	$SADT_2$	SADT,
01	119	212	30,180	30,185	30,179	30,207	0.02%	0.00%	0.09%
				(101)	(215)	(445)			
02	223	231	4,474	4,474	4,475	4,475	0.01%	0.02%	0.02%
				(12)	(24)	(46)			
02	65	322	7,382	7,381	7,383	7,385	0.01%	0.01%	0.04%
				(11)	(22)	(45)			
02	9925	308	12,661	12,661	12,661	12,657	0.00%	0.00%	0.03%
				(25)	(55)	(109)			
02	104	347	22,098	22,099	22,101	22,091	0.00%	0.02%	0.03%
				(21)	(48)	(95)			
02	118	345	22,262	22,264	22,263	22,256	0.01%	0.00%	0.03%
				(34)	(75)	(156)			
06	170	353	5,284	5,283	5,285	5,285	0.01%	0.03%	0.01%
				(8)	(17)	(36)			
07	136	263	6,336	6,336	6,336	6,336	0.01%	0.00%	0.00%
				(17)	(37)	(71)			
11	133	283	28,026	28,028	28,031	28,016	0.01%	0.02%	0.04%
				(58)	(128)	(261)			
11	179	210	54,599	54,599	54,592	54,603	0.00%	0.01%	0.01%
				(121)	(264)	(523)			
11	130	341	110,865	110,863	110,861	110,847	0.00%	0.00%	0.02%
				(124)	(254)	(529)			

* The numbers in parenthesis are the standard deviations of the 1,000 simulated values $SADT_i$ for each site.
** Simulated results are rounded. Some percents rounded to zero.

Table 26 (continued)
Simulation Results for $AADT_1$ with Randomly Missing Days of Count Data**

Func Class	Site	N	$AADT_1$	Amount of Randomly Missing Data: 5% $SADT_1$*	20% $SADT_2$*	50% $SADT_3$*	How Close are $SADT_i$ and $AADT_1$? The 2 estimates are within X% of each other. $SADT_1$	$SADT_2$	$SADT_3$
11	196	252	154,304	154,308	154,318	154,339	0.00%	0.01%	0.02%
				(265)	(590)	(1,175)			
12	204	212	28,294	28,293	28,287	28,301	0.01%	0.03%	0.02%
				(54)	(113)	(228)			
14	114	267	14,436	14,436	14,436	14,429	0.00%	0.01%	0.05%
				(28)	(58)	(126)			
14	177	333	33,290	33,292	33,282	33,303	0.01%	0.02%	0.04%
				(69)	(155)	(314)			
14	102	278	40,753	40,756	40,753	40,755	0.01%	0.00%	0.00%
				(83)	(170)	(343)			
14	154	220	44,030	44,031	44,030	44,035	0.00%	0.00%	0.01%
				(77)	(176)	(338)			
14	113	326	45,825	45,826	45,829	45,820	0.00%	0.01%	0.01%
				(82)	(173)	(369)			
14	197	212	47,270	47,272	47,278	47,270	0.01%	0.02%	0.00%
				(120)	(263)	(527)			
16	246	278	7,681	7,681	7,682	7,682	0.00%	0.01%	0.01%
				(11)	(23)	(49)			
16	175	342	39,920	39,917	39,917	39,927	0.01%	0.01%	0.02%
				(113)	(238)	(485)			

* The numbers in parenthesis are the standard deviations of the 1,000 simulated values $SADT_i$ for each site.

** Simulated results are rounded. Some percents rounded to zero.

5. REFERENCES

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5. *Variability in Continuous Traffic Monitoring Data Task V Report: Pilot Methodology Development and Estimates of Variability from Continuous Traffic Classification Count Data,* (January 1996), unpublished report of the Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, Tennessee 3783 1.

6. *Variability in Continuous Traffic Monitoring Data Task VIII Report: Pilot Methodology Development and Estimates of Variability from Continuous Traffic Weigh-In-Motion Data,* (April 1996), unpublished report of the Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, Tennessee 3783 1.

TRAFFIC MONITORING SYSTEM

Speaker: Christopher Huvig
Societe des Autoroutes Paris Rhin Rhône
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Presented at
National Traffic Data Acquisition Conference
Albuquerque, New Mexico

May 5-9, 1996

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The Societe des Autoroutes Paris Rhin Rhône operates a 1,500 km highway network situated at the crossing of West European main routes. Located in the East of France, this network is directly connected with the highways of North, Central and Eastern Europe, forming as a whole the framework of a reunified continent.

Acting as concessionary of the State, the SAPRR has three main functions :

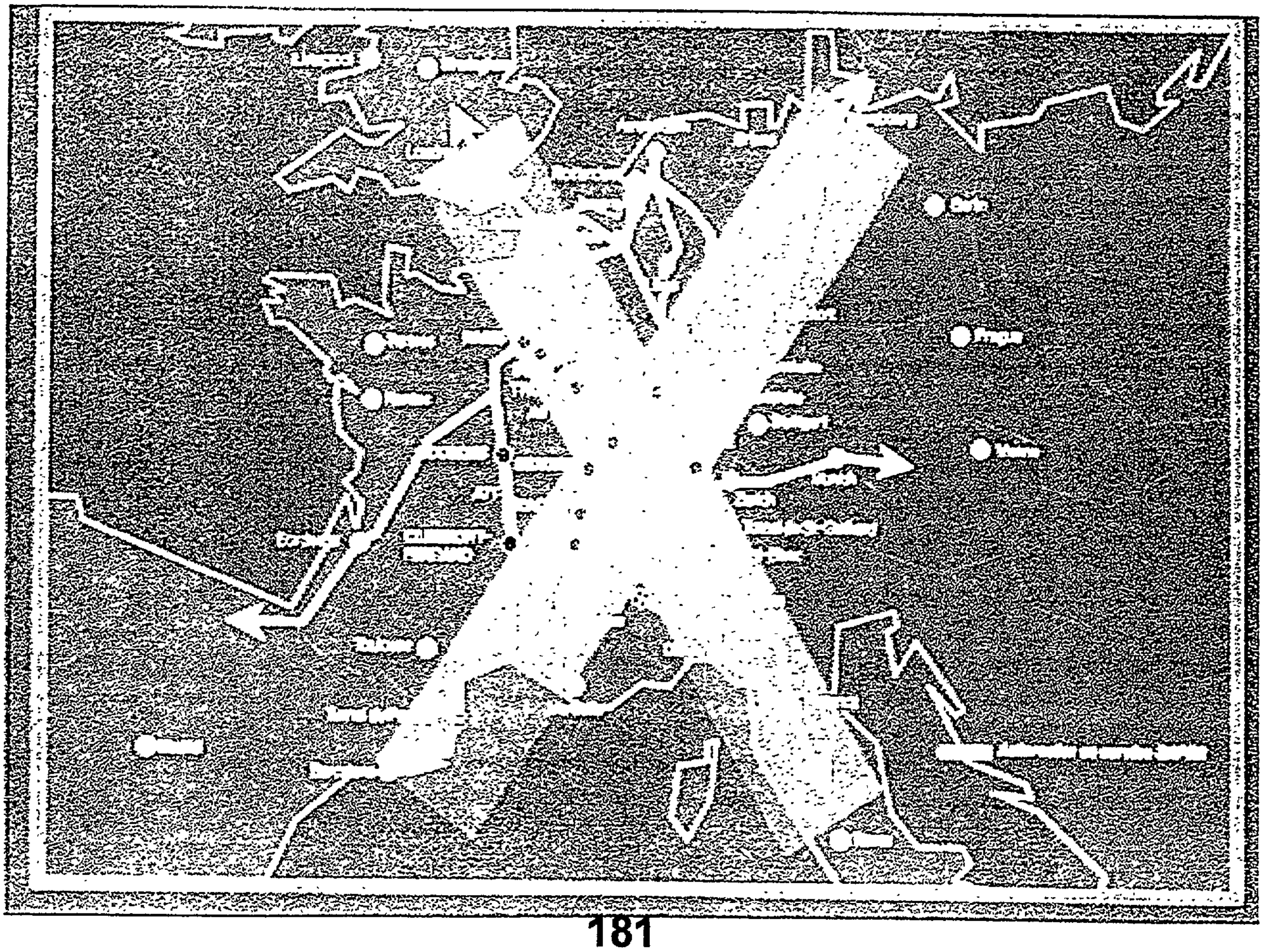
- the construction of highways, designed and realized with consideration for the operator's point of view and for the environment ;

- the operation of the network, with the help of the most efficient devices, to ensure the safety and information of the clients, and the fluidity of the traffic ;

- improve the level of services to the clients, who wish to travel rapidly from one point to the other, with constantly increased safety and comfort.

The traffic on our network is constantly growing Eleven billion Kilometers were traveled in 1995 by more than 94 million vehicles. Some sections reach up to 160 000 vehicles per day during the summer. This traffic undergoes seasonal variations ranging from 1 to 6, with an average of 25 to 30% trucks.

The operating needs for this network have impelled the SAPRR to obtain traffic knowledge in matters of counting, classification and dynamic weighing. In the context of a national project called « Weigh In Motion », the SAPRR has used and developed, in cooperation with a well known manufacturer of traffic monitoring equipment, specific equipment and softwares to satisfy these traffic data needs.



1 - THE NEEDS OF THE OPERATOR

To improve the management of the infrastructure in terms of design, construction and operation, any manager of a road network (highways, national roads or city roads) must have knowledge of his traffic in terms of:

- vehicle classification,
- speeds,
- loads.

- **CLASSIFICATION**

Knowledge of the composition of the traffic is an essential element for :
- the safety of the clients (appreciation of the risks of incidents in view of the various categories of vehicles that drive alongside the highway at the same time),
- the improvement of the protection devices such as retainers,
- the level of services, that depends on the number and the type of vehicles,
- the dimensioning of the rest and service areas.

- **SPEED**

- detection of slowdowns or traffic incidents,
- better understanding of the drivers behavior, of the speeds of the different categories of vehicles and their evolution in time,
- control of the respect of the speed regulation by the drivers,
- verification of the impact of the safety programs and of the traffic control system.

- **DETAILLED KNOWLEDGE OF WEIGHTS AND LOADS**

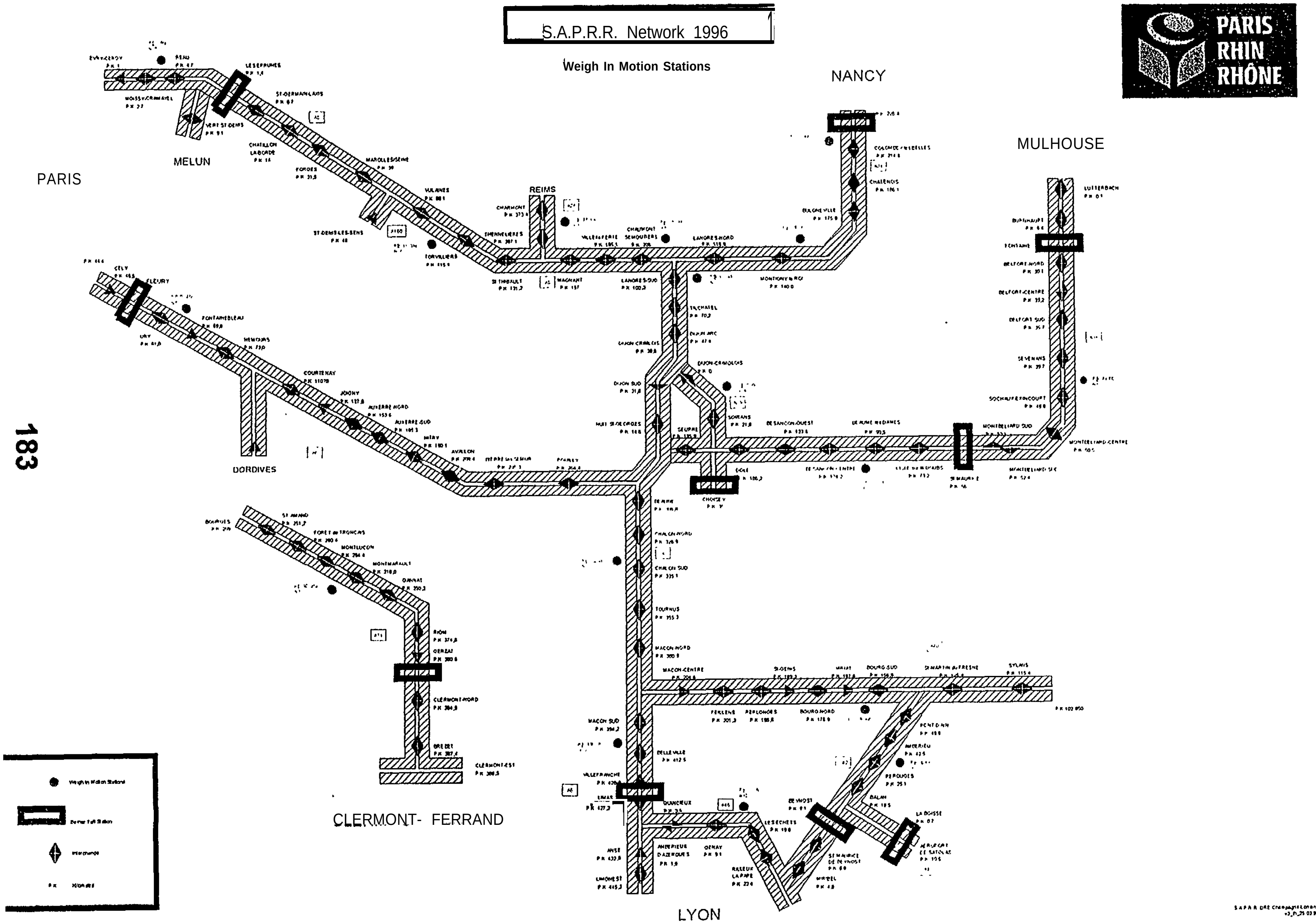
- calculation of the damage caused by heavy loads on the infrastructure,
- anticipated life of the engineering structures,
- control of the respect of the loads regulation by the drivers,
- improvement of the safety (for example lanes width),
- evaluation of the economic role of the infrastructure.

– CLASSIFICATION FOR HIGH SPEED TOLL

Beyond the immediate operating needs, it is in anticipation of the future evolution of Toll Systems that the SAPRR has decided to implement detailed traffic analysis stations.
In the context of High Speed To11 Systems, only the automatic detection and classification of vehicles passing by will ensure correct calculation and collection of the fare. The technology that has been developed for the Traffic Monitoring System meets the requirements Toll System applications, which need both a great accuracy and reliability.

S.A.P.R.R. Network 1996

Weigh In Motion Stations



2 - THE WIM STATIONS

To date, 17 WIM stations have been installed along the highway network of the SAPRR. Others are currently planned. They ensure the analysis of the traffic for counting, classification and dynamic weighing.

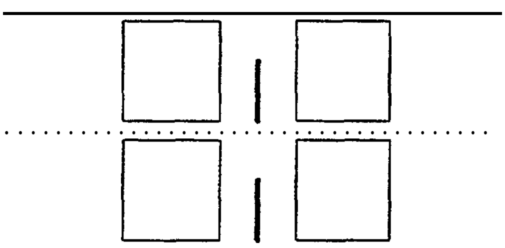
The WIM traffic analysis stations make use of the principle of one intelligent detector for each traffic lane.

2.1- THE INTELLIGENT DETECTORS

Each detector is connected either to :

- 2 loops and a half length piezo sensor for simple classification, (fig I),
- one loop and two full length piezo-electric sensors for dynamic weighing (fig 2).

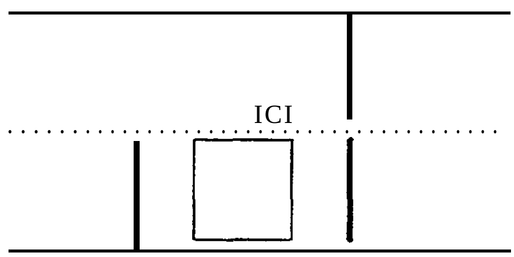
fig. 1



lane I

lane 2

fig. 2



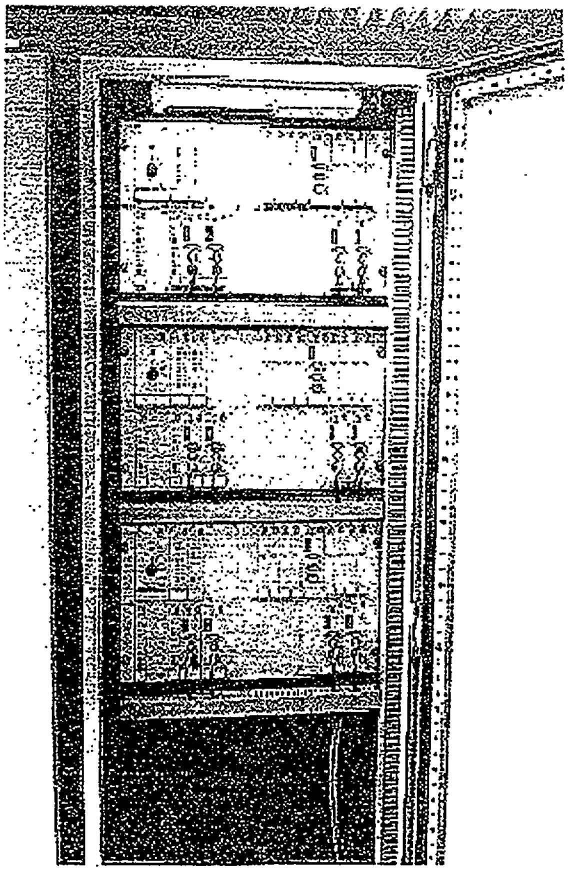
The piezo sensors employed are encapsulated 3 mm ceramic elements, manufactured and installed according to techniques which have been in permanent evolution for more than 15 years, and which are the subject of numerous patents. The electronic piezo sensors, and installation is provided by a single manufacturer to ensure a consistent product.

The WIM (Weigh In Motion) and AVC (Automatic Vehicle Classification) intelligent detectors collect the information from the sensors and determine all the geometric measurements of the longitudinal axis of the vehicles. The following data is obtained :

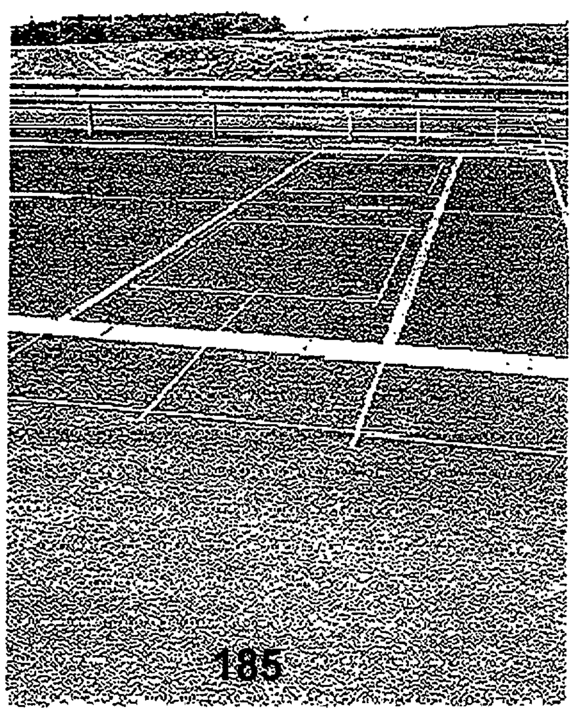
- date and time,
- lane number,
- classification,
- speed,
- time of presence on the loop,
- distance between the axles,
- time gap with the previous vehicle.

The WIM intelligent detector adds to the preceding data the measurement of dynamic weight for each axle as well as the total dynamic weight. It also provides greater accuracy in speed and measurement of the distance between the axles.

WIM Electronics
(three 4-lane systems)

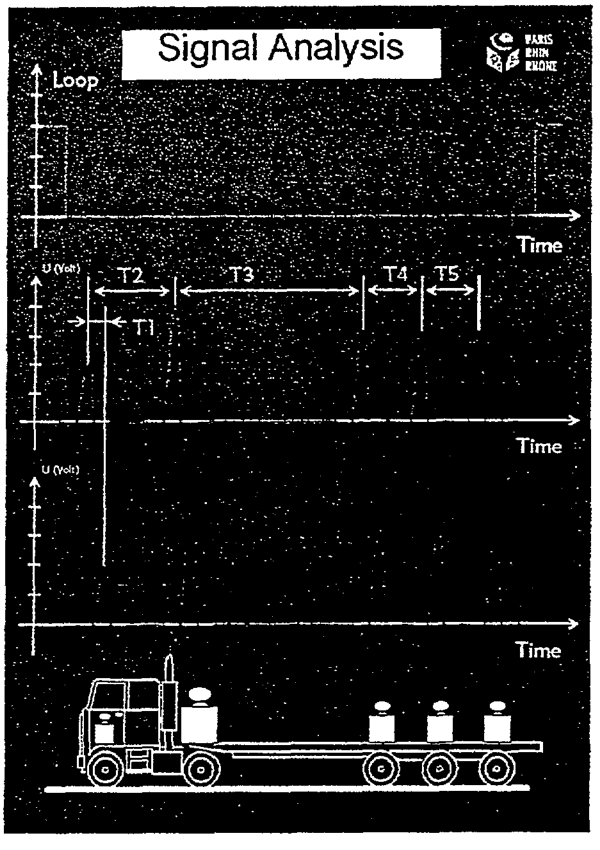


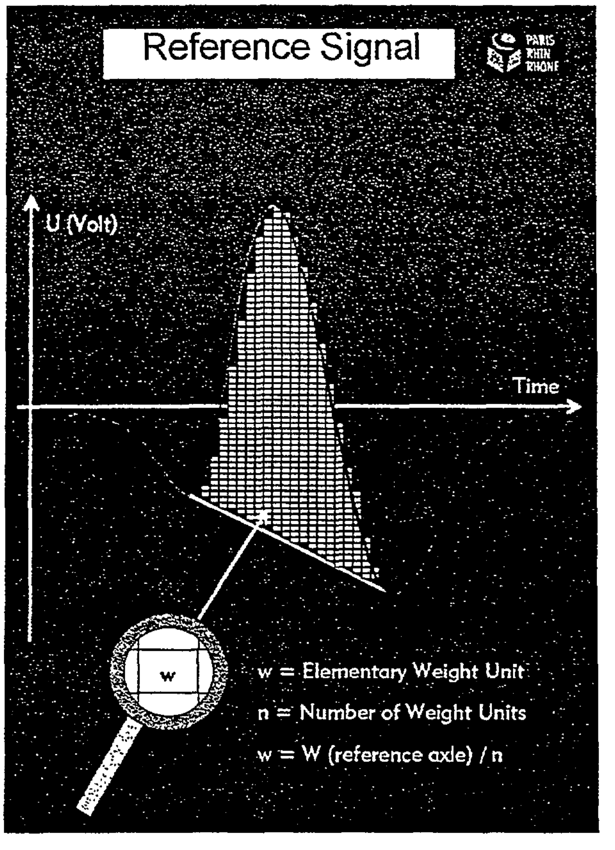
WIM sensor layout



2.1.1- SIGNAL PROCESSING

The WIM intelligent detector processes independently the signals it receives from both piezo-electric sensors. It is thus possible to compare the results obtained by each sensor for the same vehicle, on the condition that the speed has been correctly measured (if not, it will be set to 100 Km/hour by default). In all cases, the use of two sensors optimizes the precision of the system. either by working out the average of the two measures, or by selection of the most accurate sensor.





The signals received by the detector and from sensors installed in the lane are represented in the display above Piezo 1 and piezo 2 send signals in turn. These signals correspond to the axles that pass over the sensors and the size of the signal depends on the dynamic load of the axle.
The speed is calculated with time Tl and the distance between the two piezo sensors.
The distance between the axles is calculated with times T2, T3, etc. and the speed of the vehicle.
The category is determined with the distance between the axles and the weights.

It is worth pointing out that the stations are equipped with a sophisticated anti-coincidence system :
Lane N-l receives from lane N (its neighbor) information regarding the presence of a wheel or axle on one of the sensors at the same time as signals from its own sensors. Comparing the time of presence and the duration of presence on the sensors allows, by means of threshold setting, determination of whether two vehicles are driving side by side on the two lanes or if one single vehicle is overlapping both lanes. In the first case, each detector sends its vehicle data to the central unit. In the second case, only the lane N detector sends data to the central unit and, therefore, only one vehicle is counted along with its category.

2.1.2 - PARAMETERS DEFINITION

The users can define :

- The distance between the sensors ;
- The calibration method :
  - with pre-weighed vehicles,
  - autocalibrationwith standard vehicles and their characteristics ;
- the classification :
  - European table,
  - other classification parameters with customized definition of the classes and sub-classes ;
- the definition of the sensor(s) used for the weighing ;
- the secondary choices, such as the length of the vehicle or the duration of presence on the loop, length of the loop, spacing between the vehicles in seconds or milliseconds.

This approach of parameters definition allows installation of this type of equipment in any country. Vehicle characteristics are different in Asia, North-America and Europe, but with a few statistics about the vehicle population of his country, the operator can calibrate the station on the basis of the characteristic vehicles.

Each category is defined by a certain number of criteria, as is shown in the table hereafter. Up to fifty two different categories can be defined and grouped into 14 statistical categories. It is clear that the categories can differ according to the country where the equipment is in use in order to meet the requirements of local traffic.

In the case of our highway network, the stations are programmed to classify vehicles ino 34 categories and further summarize them into 14 statistical categories.

Modify one class

Veh cls	No. of axles	Cat	Sub cat	Stat cat	Select. TK/CA Wt 1st	Select. TK/CA Tot wt	TK	CA
AH	05	05	34	05		X	X	

Distances between pairs of axles

Axles n / n + 1	Distances Min.	Distances Max.	Axles n / n + 1	Distances Min.	Distances Max.
1 / 2	1000	1500	7 / 8	-	-
2 / 3	0	9999	8 / 9	-	-
3 / 4	150	330	9 / 10	-	-
4 / 5	150	330	10 / 11	-	-
5 / 6	-	-	11 / 12	-	-
6 / 7	-	-	12 / 13	-	-

			Min.	Max.
Total length	(ft/100)	(Min-Max)	-	-
Total weight	(100*1b)	(Min-Max)	100	600
Bumper / 1 st axle length	(ft/100)	(Min-Max)	-	-

Modify : M Exit : Esc

CATEGORIES DETERMINED BY THE WIM STATIONS

	HESTIA	EUROPE	NAME
	01	13	V2
	02	14	V2R1
	03	14	V2R2A
	04	1	C2
	22	(3)	C2R1
	18	(4)	C2R2A
	19	(5)	C2R3A
	09	7	C2R2
	13	8	C2R3
	24	(1)	B2
	26	(3)	B2R1

	HESTIA	EUROPE	NAME
	27	(4)	B2R2A
	28	(5)	B2R3A
	06	3	T2R1
	07	4	T2R2
	10	5	T2R3
	05	2	C3
	23	4	C3R1
	20	6	C3R2A
	21	(11)	C3R3A
	12	9	C3R2
	14	10	C3R3

	HESTIA	EUROPE	NAME
	25	(2)	B3
	29	(4)	B3R1
	30	(6)	B3R2A
	31	(11)	B3R3A
	08	(4)	T3R1
	11	6	T3R2
	15	11	T3R3
	33	(4)	C13
	32	(2)	C21
	16	(7)	C22
	17	(5)	C23

Thirty three categories are represented here. The 34th gathers all vehicles with an exceptional size.

2.2 - THE CENTRAL UNIT

The Central Unit gathers the data collected by all the detectors of the station, processes it according to the needs of the operator and communicates the result to the data acquisition terminals.

The main functions of the Central Unit are :

- communication with the intelligent detectors,
- management of the memory,
- management of the alarms,
- communication with the exterior,
- « real time » display of the traffic characteristics, which gives us the possibility to use the WIM station like a police roadside radar, providing not only the speed for each vehicle but also its weight and headway ;
- collection of the traffic data in the form defined by the operator :
  - vehicle by vehicle,
  - real time, which permits a user to integrate the station into a traffic management system,
  - statistics that can be used with a calculator program.

2.3 - ACCURACY

The controls were achieved after a period of 6 to 36 months of normal work with permanent automatic calibration without any correction.
The last checks made on our stations have taken place in December 1995, and were realized by the CETE de l'Est (Centre d'Etudes Techniques de l'Equipement de l'Est). System accuracy has been checked for the following points :
- traffic counting,
- speed for each traffic lane,
- weight measured by each piezo-electric sensor.

It appeared that :

- Raw counting had an accuracy between -0.28 and 0.46 %,
- Counting of the trucks had an accuracy between -2.43 and 0.88 %,
- Measurement of the speed was equivalent to the «MESTA 208 » police radar,
- The standard deviations of the weights were between 1.85 and 6.6 1 %.

The quality of the results showed that the autocalibration method used in HESTIA works without normal correction or re-calibration.

3 - DATA ACQUISITION AND STORAGE

Our regional data processing system is composed of:

- two data acquisition terminals,
- one NOVELL server for storage,
- one or more workstation(s) for data processing and elaboration of statistics,
- one temporary database.

They are linked together by an Ethernet network.

The two data acquisition terminals ensure communication with the stations and collection of the data through an X25 or dial nehvork. Each of them is equipped with one specific software.

The A26 software has been developed for the stations that generate vehicle by vehicle data. Its role is to :

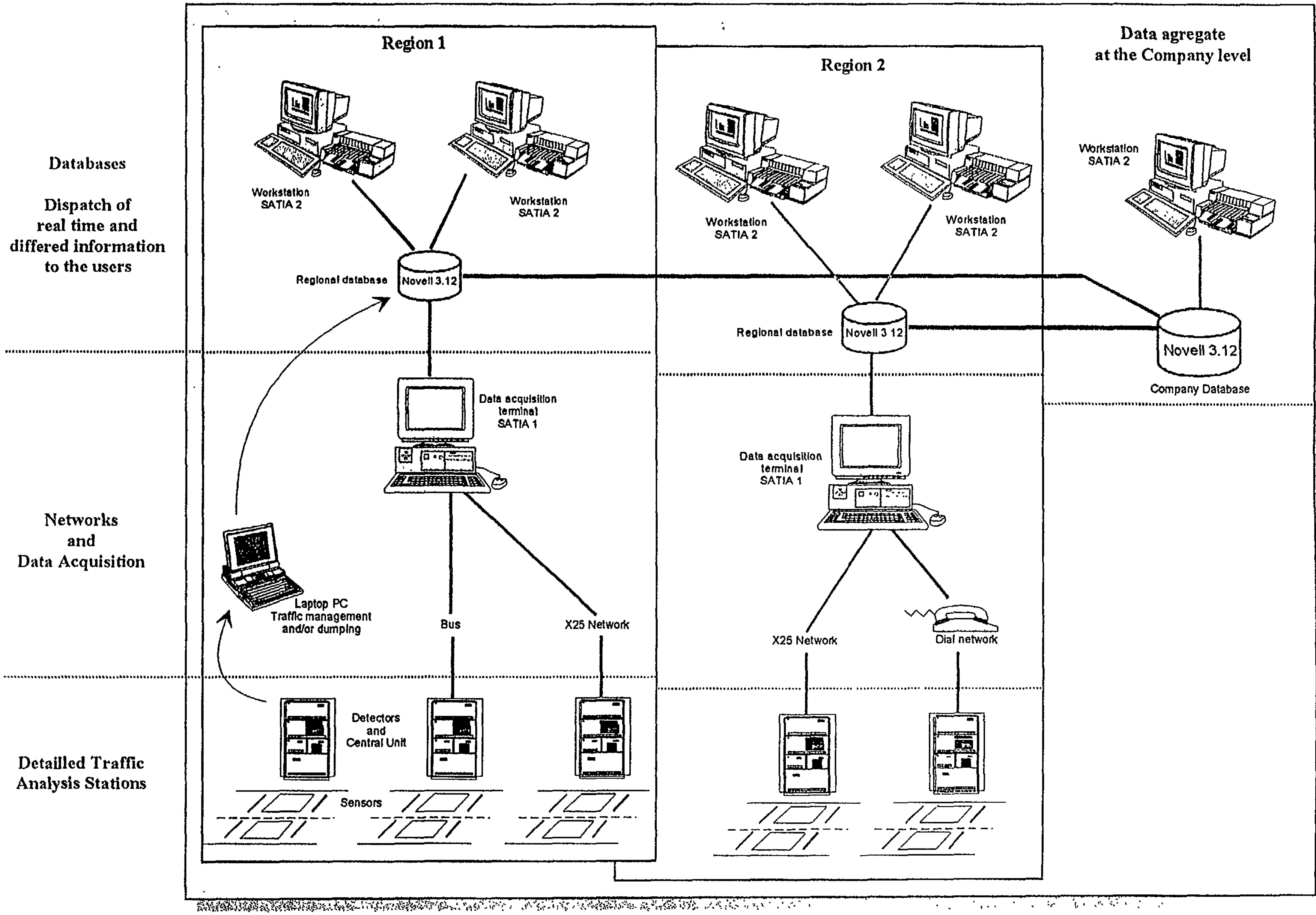
- acquire in real time vehicle by vehicle data,
- synchronize the clocks of the stations,
- constitute data files that can be used with EXCEL,
- transmit data to the NOVELL server.

The SATIA l software collects accumulated data from the other stations. Its role is ***to :***

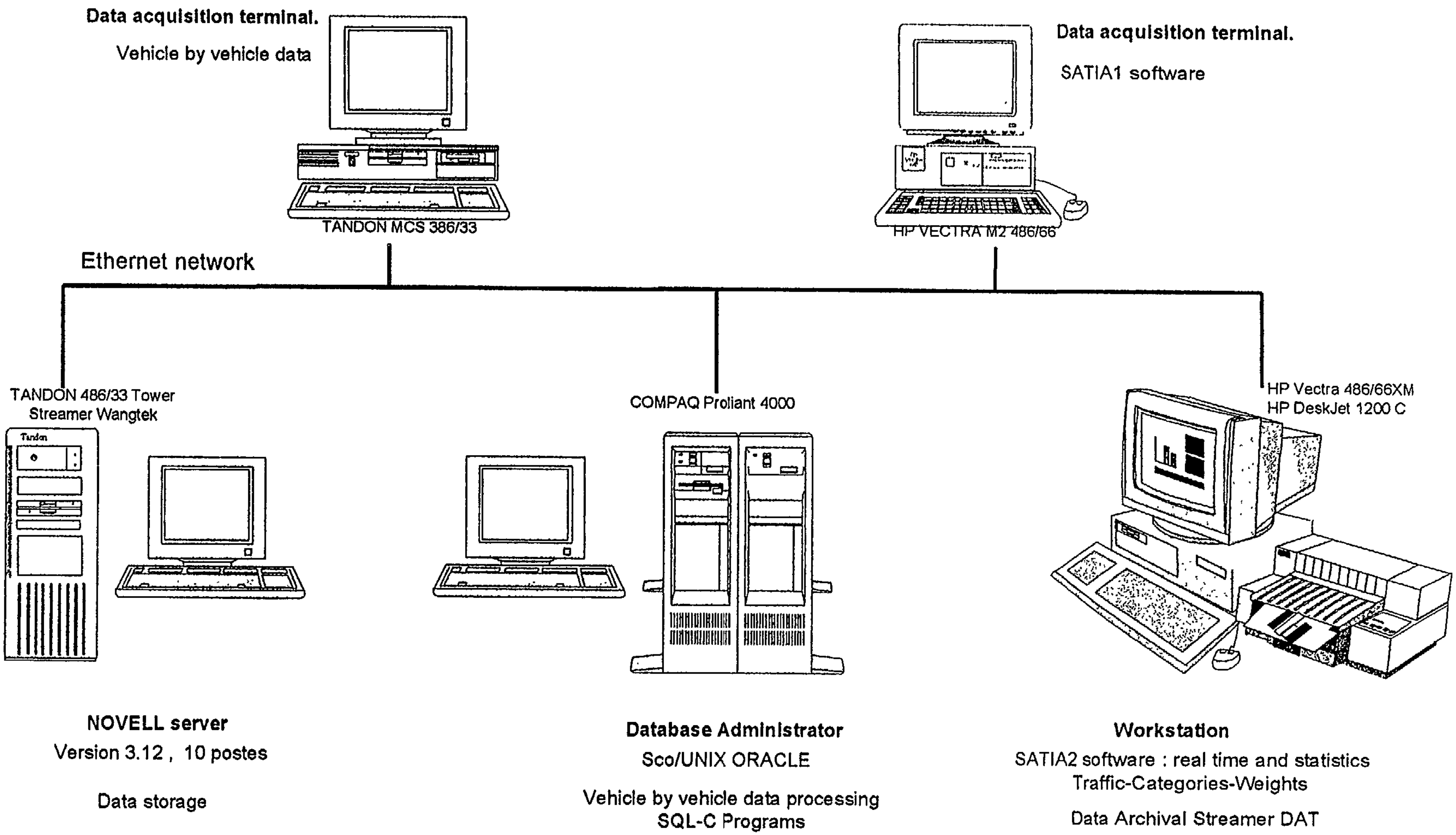
- collect accumulated data every 6 mn,
- define the parameters of communication with the WIM stations,
- define the parameters of data accumulation by the stations,
- transmit data to the NOVELL server.

Some WIM stations are not yet linked to our terminals with the network. Data from these stations is collected by dumping to a laptop personal computer.

A system is currently under development to agregate data from all the different operation regions at the company level.


Databases
Dispatch of real time and differed information to the users
Networks and Data Acquisition
Detailled Traffic Analysis Stations
Region 1
Workstation SATIA 2
Workstation SATIA 2
Regional database
Novell 3.12
Data acquisition terminal SATIA 1
Laptop PC Traffic management and/or dumping
Bus
X25 Network
Detectors and Central Unit
Sensors
Region 2
Workstation SATIA 2
Workstation SATIA 2
Regional database
Novell 3 12
Data acquisition terminal SATIA 1
X25 Network
Dial network
Data agregate at the Company level
Workstation SATIA 2
Novell 3.12
Company Database

REGIONAL DATA ACQUISITION AND PROCESSING SYSTEM
S.A.P.R.R. Région Champagne Lorraine



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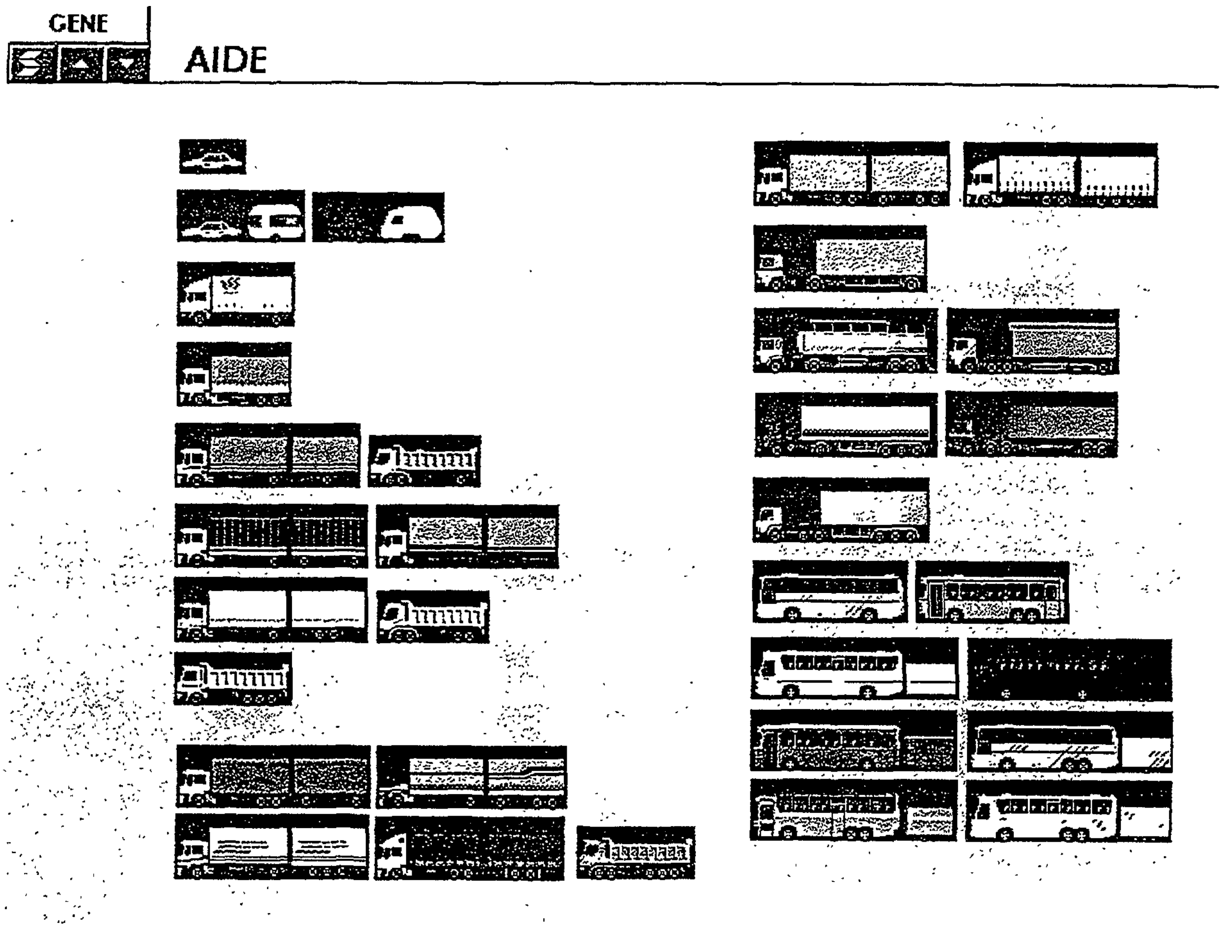
4 - DATA PROCESSING

SATIA2 is a software that has been developed to process the accumulated data generated by the WJM stations and collected by SATIAl. It prepares daily, weekly, monthly and annual statistics. It also displays real time informations about the traffic conditions thanks to the short time period between datadownloads..

The vehicle classification used by SATIA relies on the 14 statistical categories gathered by the WIM stations (13 categories + 1 for the vehicles with an exceptional size).



4.1- REAL TIME DATA

The possibility to display real time data permits us to get a near instant image of the traffic flow conditions. We are thus in possession of elements that enable us to make rapid decisions and to take the adequate actions as soon as needed.

The speed and density of the flow are useful indicators for the detection of traffic incidents. For example we know that a 15% occupation rate signifies that there is an important slowdown. If it reaches 20%, it means saturation.
Equally important is the fact that we can see at a glance the situation in all the stations. We can at the same time localize congested sites and anticipate the number of vehicles that are going towards it. These elements constitute the basis of our traffic management system. The next step is to decide the actions to be taken (information to the drivers, road relieving. etc.), all this leading to an improvement of the traffic conditions.

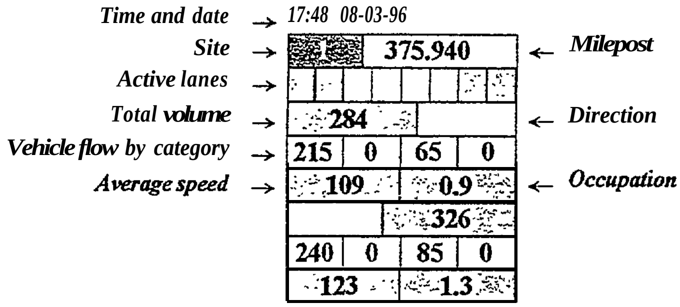
Knowledge of the composition of the traffic in real time is also helpful in the context of traffic management. First of all we gain knowledge and understanding related to the risks of incidents. For example when the traffic **is** composed of a mixture of cars travelling at high speeds and large vehicles travelling at slower speeds, we do know that the risks of incidence is greater, even if the lanes are not saturated.
Furthermore the behavior of a driver is obviously not the same if he **is** a professional driving a truck or a vacationist with a Recreational Vehicle (RV). The information or instructions that we might want to deliver will not be the same according to the proportion of categories.

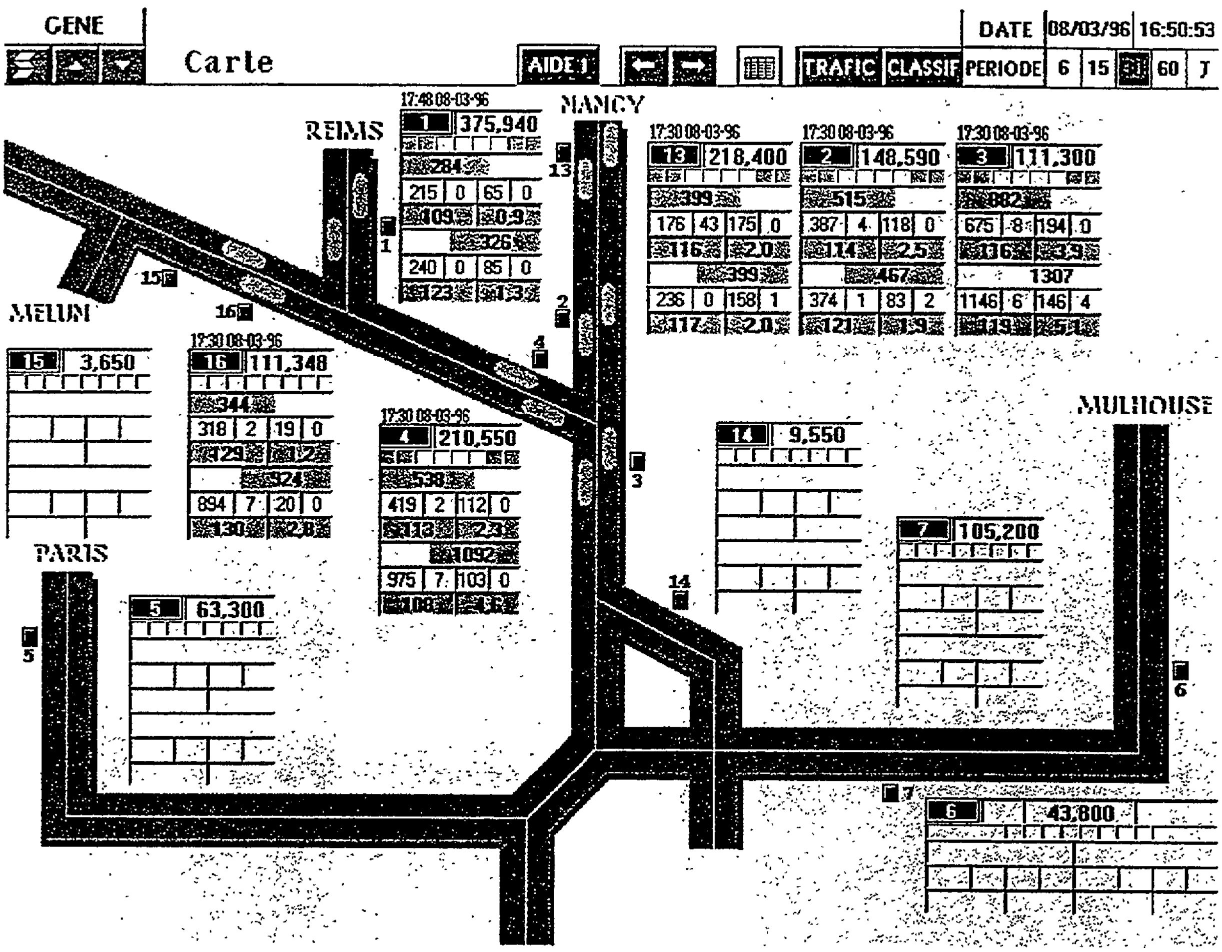
The efficiency of traffic management depends on the quality of the collected information, on the times for response and reaction, and on the proportion of drivers that are acted upon. In all cases, communication of the information to the clients has a positive influence on their behavior by improving the feeling of safety and comfort, even if they do not always modify their habits and itinerary.

Let us finally add that the level of services offered to the clients at one precise moment depends on the number and types of vehicles that are present on the highway at that moment. A family that goes on holiday with an RV has not the same service requirements as a truck driver or a bus with 50 passengers on board. Thanks to real time data collected at frequent intervals, we have the possibility to forecast the needs in terms of cleaning and maintenance of the public conveniences and service areas, or to open further ones.

The main interest for the operator to have at a glance real time data is to be able to act in a timely manner upon the safety level, by traffic control, and upon the level of services.

The main real time data display is a synoptic view of the highway network, with the location of the WIM stations. A table is associated with each station. It permits, for each traffic direction, real time visualization of the following data :





Threshold values of total traffic flow, mean speed and occupation rate are user programable to provide suitable alarms (pre-warning in yellow, warning-in red).

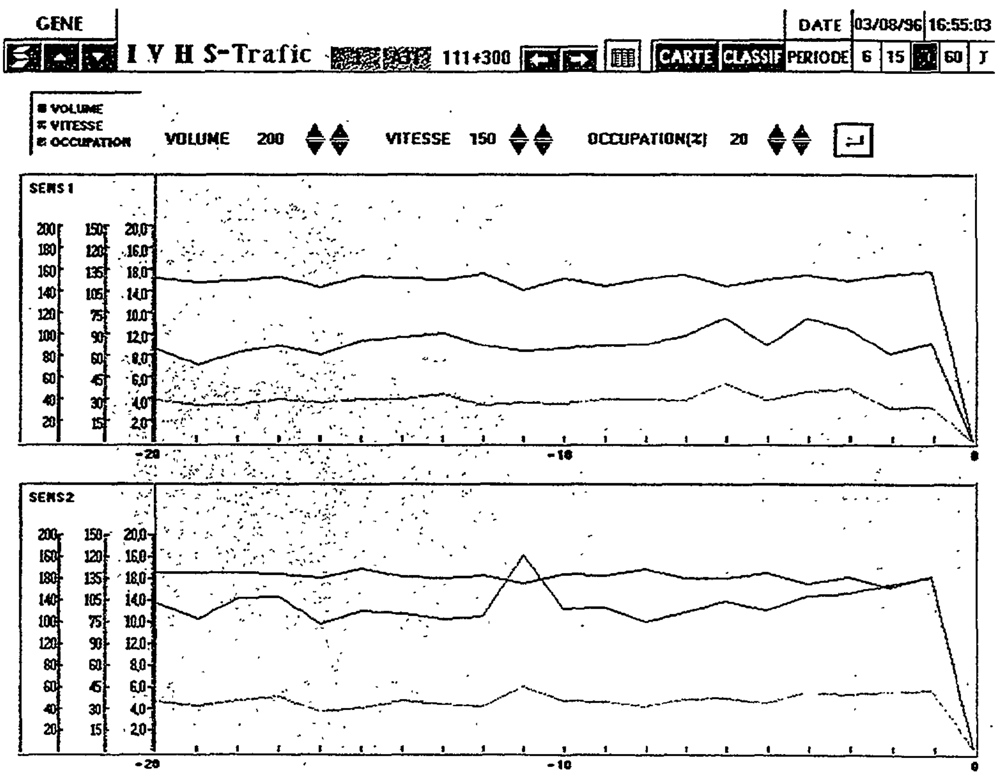
It is possible to connect in real time to the WIM stations that are linked with the X25 or dial network, and see a representation of the vehicles passing at the level of the station with their speed or load.

Review of the last periods received from one station

GENE — Trafic/tableau — CARTE CLASSIF PERIODE 30 D — DATE 08/03/96 16:54:27

A31 111+300

TEMPS	SENS 1			SENS 2		
	Volume	Vitesse	Occupation(%)	Volume	Vitesse	Occupation(%)
17:24	92	120	3,2	162	122	5,6
17:18	83	118	3,1	155	114	5,4
17:12	105	113	4,9	146	121	5,2
17:06	116	118	4,7	144	117	5,4
17:00	90	114	3,8	130	124	4,3
16:54	116	110	5,4	139	120	4,8
16:48	99	118	3,8	128	120	4,7
16:42	91	115	3,9	120	127	3,9
16:36	90	110	3,9	133	122	4,4
16:30	88	115	3,5	132	123	4,5
16:24	85	107	3,6	182	117	5,9
16:18	90	119	3,3	125	122	4,0
16:12	102	114	4,4	122	120	4,2
16:06	98	115	3,9	127	121	4,6
16:00	95	117	3,9	129	127	3,8
15:54	81	109	3,6	118	120	3,5
15:48	90	116	3,9	142	123	4,9
15:42	84	113	3,4	141	124	4,6
15:36	72	112	3,3	122	124	4,1
15:30	86	115	3,8	137	124	4,4



4.2 - TRAFFIC STATISTICS

SATIA 2 retrieves the 6 mn accumulated data from the FOXPRO database of the NOVELL server. It then computes daily, weekly, monthly and annual traffic statistics.

Our first objective when we have decided to install Weigh In Motion stations was to gain better knowledge of the damage the heavy loads have upon the infrastructure. Additional analysis of the traffic, axle weights and distribution permits evaluation of the fatigue of the pavements and engineering structures. We can then, if necessary, modify the frequency of intervention for the routine maintenance, and establish more efficient forward looking plans for the heavy repair work. The definition of the pavement structure also takes into account the volume, load and growth rate of the traffic.

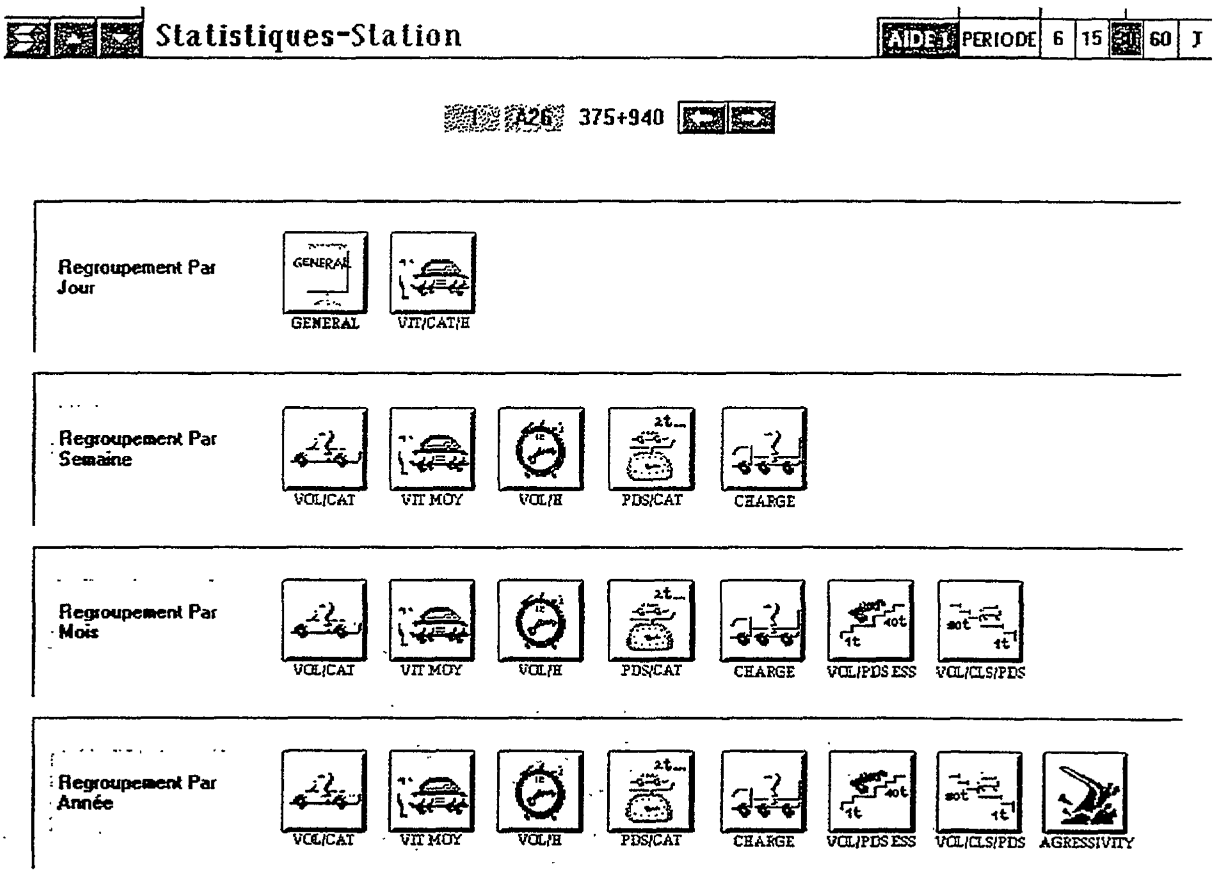
Studying the evolution of the transiting loads and overloads is also an important element for the improvement of safety devices. It can for example lead to the decision to replace a metallic rail retainer with a concrete wall, which is supposed to be impassable even by trucks. The growth of the truck traffic can also lead to increase the width of the lanes.

From the dynamic weighing information supplied by the WIM stations, we have reached better knowledge of the economic role of our infrastructure. For the SAPRR, which network is situated at the heart of the North-South European axis, this point of view is especially interesting. We are now able to measure with precision the volume of goods transportation transiting by our network, and their seasonnal itineraries. These elements have provided us the means to compare the road haulage with goods transportation by train and by inland waterway.

The traffic indicators calculated by SATIA are also involved in our road safety policy. Long term statistical calculations enable us to examine the evolution in time of the behavior of drivers according to the categories of vehicles. (We have for example been able to observe that the speeds are generally higher at night, in spite of the reduced visibility).
We have the means to determine percentages of vehicles that are dangerous or damageable to the infrastructure, because they do not respect the speeds and loads regulations. This helps us to decide when to launch targeted safety campaigns, based on information and advertising, or even to intensify the controls and enforcement in cooperation with the police forces.

For each station. SATIA 2 provides us with tables, diagrams and histograms about the following information :

- the volume of the traffic per category and hour,
- the mean speed per category,
- the mean weight per category (total weight of the vehicles).
- the load per category,
- the volume per axle weight,
- the distribution of the traffic according to its weight,
- the aggressivity of the loads.



Daily reports

General Report

Station A31 111+300 J 09 S 1 M 03 A 1996

Rapport Journalier Général

(1) Volume du trafic, Vitesse moyenne et Charge Par Catégorie

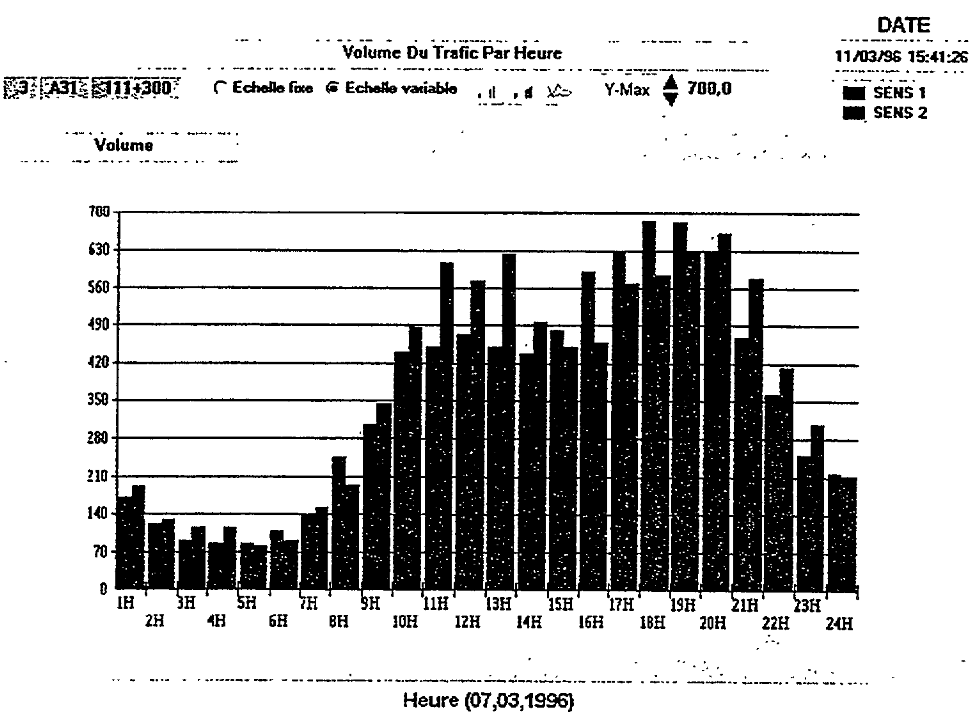
AIDE !

Sens		CAT.01	CAT 02	CAT 03	CAT.04	CAT.05	CAT.06	CAT.07	CAT.08	CAT.09	CAT.10	CAT.11	CAT.12	CAT.13	CAT.14	TOTAL
1	Volume	19874	273	116	7	4	108	350	5	1	140	1746	151	89	1	22365
	Vitesse	120	108	96	93	81	88	88	91	99	88	88	88	99	87	116
	C.Flow	0	0	9628	1127	156	22788	107450	1855	37	28700	543006	47565	0	0	762312
2	Volume	18210	227	112	8	1	81	186	4	3	69	1211	69	176	0	20357
	Vitesse	125	104	85	81	88	86	87	87	83	87	87	87	99	0	121
	C.Flow	0	0	9408	1352	46	18387	56544	1204	387	14628	404474	22701	0	0	529131

(2) Volume Du Trafic Par Heure

Sens	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1	341	281	194	158	140	141	131	187	248	402	677	1026	1430	1635	1966	2285	2204	1926	2234	2172	1313	817	576	379	22365
2	388	277	342	496	506	620	908	1196	1490	1598	1951	2000	1929	1289	1156	1102	915	618	472	402	271	184	134	113	20357

Traffic per Hour



Monthly Reports

Daily Traffic per Category

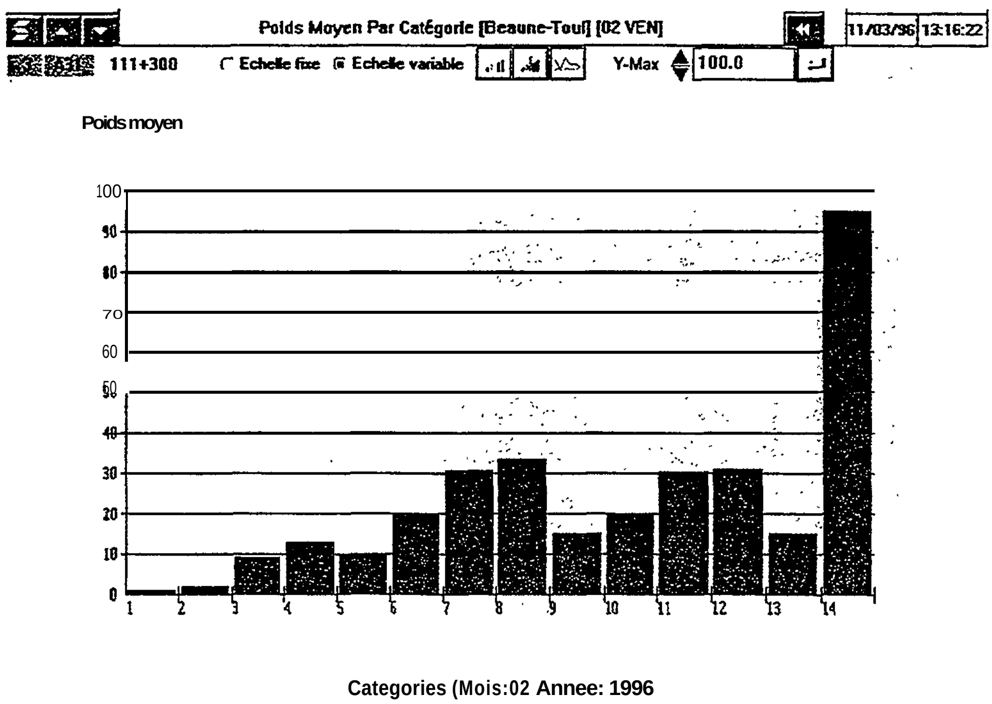
Station [illegible] 111+300 J S 1 M 02 A 1996

AIDE 1

Volume Du Trafic Par Categorie Beaune-Toul

Jour	CAT1	CAT.2	CAT.3	CAT.4	CAT.5	CAT.6	CAT.7	CAT.8	CAT.9	CAT.10	CAT.11	CAT.12	CAT.13	CAT.14	TOTAL
01 JEU	3688	34	202	15	1	183	354	13	16	291	2519	112	25	1	7454
02 VEN	5527	46	157	22	16	162	327	14	16	258	2009	89	32	2	8677
03 SAM	9108	86	118	2	2	117	338	6	1	100	1747	132	119	0	11876
04 DIM	5876	57	48	4	2	28	154	7	1	26	939	71	371	0	7584
05 LUN	4389	47	160	13	3	116	195	9	5	193	1726	30	60	2	6948
06 MAR	3271	27	170	5	4	171	249	7	10	256	1935	46	21	0	6172
07 MER	3192	37	222	31	3	214	379	13	10	318	2960	85	45	1	7510
08 JEU	3549	48	224	21	0	207	345	15	10	295	2700	110	48	0	7572
09 VEN	5372	35	179	6	3	175	352	10	14	259	2166	91	31	1	8694
10 SAM	10927	84	103	5	3	112	359	11	3	121	1762	143	141	2	13776
11 DIM	6529	69	42	5	2	43	165	3	4	38	971	70	340	0	8287
12 LUN	4479	47	162	21	6	122	184	8	9	177	1602	38	34	3	6892
13 MAR	3674	55	198	20	7	169	285	7	5	270	2190	53	37	0	6970
14 MER	3467	33	202	17	4	191	346	13	15	291	2610	86	20	1	7296
15 JEU	3794	50	230	24	16	184	382	15	14	298	2518	110	25	1	7661
16 VEN	6433	56	198	9	1	176	314	12	10	259	2034	107	70	2	9681
17 SAM	13556	141	119	6	0	112	332	7	6	105	1685	168	225	2	16464
18 DIM	6992	68	54	6	0	42	151	4	2	42	877	63	324	0	8625
19 LUN	5175	56	174	13	2	128	203	12	10	172	1591	21	61	1	7619
20 MAR	3973	61	223	20	6	162	264	13	9	281	2028	45	46	0	7131
21 MER	3723	49	220	9	2	173	319	8	13	278	2388	72	30	0	7284
22 JEU	4222	63	199	17	6	183	317	12	19	288	2401	89	33	3	7852
23 VEN	8375	138	184	10	3	158	322	9	24	265	2009	95	47	1	11640
24 SAM	29687	503	143	4	5	106	341	14	4	130	1600	128	277	2	32944
25 DIM	15877	244	75	6	2	24	171	10	1	39	1019	95	605	1	18169
26 LUN	6722	89	189	20	0	120	208	8	17	201	1709	30	32	0	9345
27 MAR	4931	66	205	12	2	159	235	9	8	283	1981	41	20	2	7954
28 MER	4776	67	210	15	4	183	351	10	13	303	2529	78	30	1	8570
29 JEU	5339	93	198	16	3	198	344	14	11	268	2384	96	21	2	8993
TOTAL	196623	2455	4808	374	108	4118	8286	293	280	6105	56589	2394	3170	31	285634

Average Weight of the Categories of Vehicles



Annual Reports

Total Vehicle Load per Category

GENE

Station 111+300 J S 1 M 03 A 1995

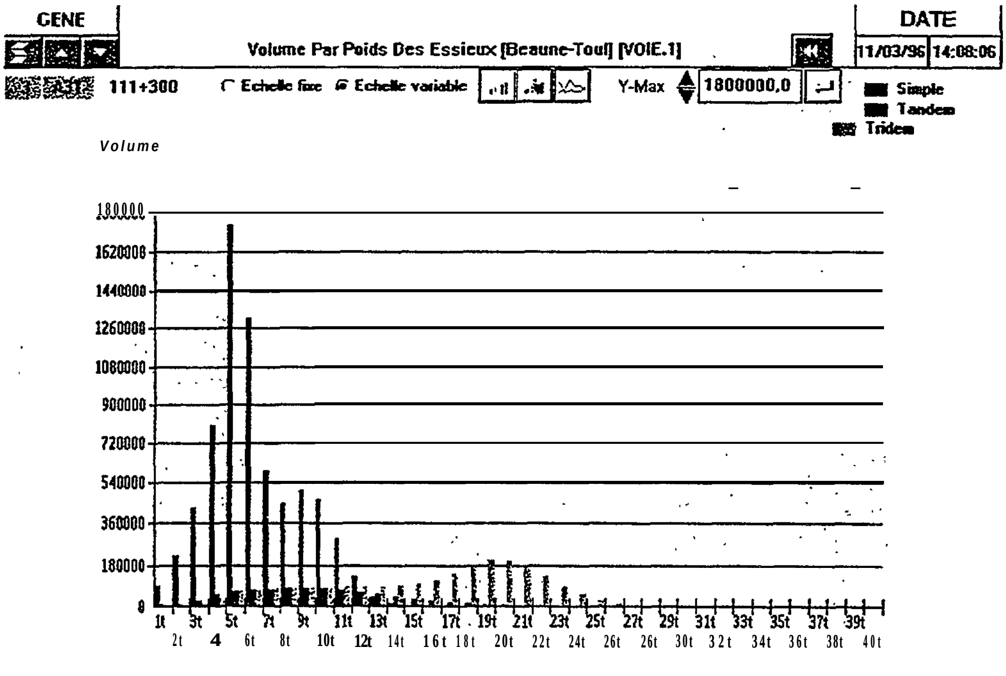
AIDE 1

Charge Par Catégorie Beaune-Toul

Unité : tonne

Mois	CAT.1	CAT.2	CAT.3	CAT.4	CAT.5	CAT.6	CAT.7	CAT.8	CAT.9	CAT.10	CAT.11	CAT.12	CAT.13	CAT.14	Total
02	0	0	42253	5088	913	88831	309831	11627	3698	122345	1550534	61792	0	0	2196912
03	0	0	49882	5314	1424	103768	339300	12634	4875	136941	1680423	72547	0	0	2407608
04	0	0	8158	862	213	17731	64024	2282	929	21240	306270	14085	0	0	435794
05	0	0	40386	5750	1015	82739	292350	9821	3779	106007	1413454	60379	0	0	2015680
06	0	0	51059	7540	1183	91694	388318	11919	4624	120451	1603645	70132	0	0	2280565
07	0	0	50584	5959	1725	90013	321484	9731	4233	126268	1442996	84439	0	0	2137432
08	0	0	4499	547	100	8508	32382	1020	369	11995	134875	5018	0	0	199313
09	0	0	48902	5866	1218	103100	356995	10294	4388	124220	1534988	83790	0	0	2273761
10	0	0	52281	9294	1644	108282	376626	9960	5670	131726	1733530	81970	0	0	2510985
11	0	0	48332	6405	1338	106926	399866	11730	4509	128668	1906476	80352	0	0	2694602
12	0	0	40094	5070	1134	81535	293219	10389	3616	111615	1584859	69062	0	0	2200593
Total	0	0	436430	58195	11907	883127	3104397	101407	40690	1141476	14892050	683566	0	0	21353245

Number of Vehicles and Axle Weight



Classe De Poids (Annee:1995)

Number of Vehicles Classified by Weight

Station A31 111+300 J S M A 1995

Volume Par Classe De Poids

Beaume-Toul

AIDE

Classe De Poids	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
26~28t	0	0	2	156	7	4850	33052	656	61	6086	108410	7455	5	67	160807
28~30t	0	0	0	60	11	3054	32277	762	40	4734	132596	9542	0	98	183174
30~32t	0	0	1	1	26	2001	35548	1213	28	6097	183604	12310	1	71	240901
32~34t	0	0	0	0	0	1589	41635	1062	1	6721	267246	12600	21	25	330900
34~36t	0	0	0	0	1	974	43614	1053	1	5198	260601	11692	0	34	323168
36~38t	0	0	0	1	0	696	35389	1458	0	2301	198239	7643	0	47	246374
38~40t	0	0	0	0	0	423	21956	938	0	389	116131	3414	17	10	143878
40~42t	0	0	0	0	0	173	11857	625	0	207	47943	1201	0	60	62066
42~44t	0	0	0	0	0	61	4526	331	0	75	15872	472	0	67	21404
44~46t	0	0	0	0	0	23	1714	209	0	27	4777	82	0	7	6839
46~48t	0	0	0	0	0	4	448	98	0	13	1963	39	0	47	2612
48~50t	0	0	1	0	0	28	135	66	0	13	1219	65	0	56	1583
50~52t	0	0	0	0	0	1	80	50	0	5	325	36	0	17	514
52~54t	0	0	0	0	0	0	3	35	0	2	163	24	0	12	239
54~56t	0	0	0	0	0	0	2	4	0	0	46	2	0	23	77
56~58t	0	0	0	0	0	4	4	3	0	0	10	3	0	3	27
58~60t	0	0	0	0	0	0	1	34	0	0	6	1	0	29	71
60~62t	0	0	0	0	0	0	1	0	0	0	0	3	0	11	15
62~64t	0	0	0	0	0	0	0	1	0	0	1	0	0	1	3
64~66t	0	0	0	0	0	0	0	0	0	0	1	1	0	1	3
66~68t	0	0	0	0	0	0	2	0	0	0	0	0	0	21	23
68~70t	0	0	0	0	0	0	1	1	0	0	1	0	0	1	4
70~72t	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9
72~74t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74~76t	0	0	0	0	0	0	0	0	0	0	0	1	0	3	4
76~78t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78~80t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
> 80T	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4

Aggressivity of the Heavy Vehicles

GENE

Station A31 111+300 J S M A 1996

Agressivité

Voies lentes

Voie	Voie\Mois	1	2	3	4	5	6	7	8	9	10	11	12
VOIE 0	NEC	50430	48557										
	AXLE	459490	442451										
	AM	0.11	0.11										
	TRUCK	94937	91479										
	CAM	0.53	0.53										
VOIE 1	NEC	36223	36796										
	AXLE	411912	403823										
	AM	0.09	0.09										
	TRUCK	85401	84150										
	CAM	0.42	0.44										
VOIE 2	NEC	1751	1510										
	AXLE	24230	22065										
	AM	0.07	0.07										
	TRUCK	4519	3950										
	CAM	0.39	0.38										
VOIE 3	NEC	1250	1137										
	AXLE	17465	14433										
	AM	0.07	0.08										
	TRUCK	3074	2406										
	CAM	0.41	0.47										

5 - THE DATABASE

The completeness of the WIM messages generated by the stations is what makes their value in the eyes of the operator who wishes to improve his knowledge of the traffic conditions on his network. The data collected by the stations puts at our disposal complete information about the speed, headway, category and weight for the totality of the traffic. The various statistics that are presently calculated by the system are only part of the possibilities, and the SAPRR is presently studying further traffic indicators.

A temporary database has thus been created in our regional operation center in order to store vehicle by vehicle data. It can then be sorted and retrieved according to our needs and wishes. The completeness of the available information gives us the means to analyze detailed periods of traffic, chosen according to any desired criteria (light or heavy traffic, classification, weather conditions, visibility. day or night, etc.).

The traffic indicators which have thus been studied are speed, spacing between the vehicles and weights, according to 3 characteristic categories :

- the light vehicles,
- the tridems (5 axles), which constitute the main part of the truck population in France,
- the buses, which are interesting for the number of passengers they transport.

The volume of the collected data is incompatible with long term storage because we are faced with problems of limitation of the memory. Furthermore the time necessary to their processing upon long periods of time would be considerably increased and would necessitate ultra-powerful computers. This is the reason why the SAPRR has only carried out vehicle by vehicle studies on limited intervals of time.

The final purpose of these detailed analyses of the traffic is to make a choice of the traffic statistics that are the most significant and reliable, apart from the ones already supplied by SATIA. Summary files will then be integrated to the WIM stations in order to directly obtain these statistics,, without having to collect their individual vehicle data. This will on the one hand limit the volume of the data flow, and on the other hand provide us continuously with results that up to now we get blow-by-blow.

6 - CONCLUSION

The quantitative analysis of the road traffic is an important and permanent preoccupation of the constructors and operators of roads and engineering structures. We need :

- to be able to gather a maximum number of traffic characteristics,

- to have detailed knowledge of the composition, load and growth rate of the heavy loads.

Our current state-of-the-art traffic data collection system has now given us the means to implement reliable detailed traffic analysis stations. The Electronic Cdntrol Measure company has also provided us the adequate software means to exploit fully the data they generate. The various trials that have been carried out by different organizations have proven that our objectives in terms of measurement accuracy have been reached.

An effective Traffic Monitoring System is now operational on the SAPRR network.

THE LINK/NODE SYSTEM

Speaker: Dave Hrankowski
Monroe County Department of Transportation
Authors: Alan M. Stiehler
Monroe County Department of Transportation

Presented at
National Traffic Data Acquisition Conference
Albuquerque, New Mexico

May 5-9, 1996

The Link/Node System

Interfacing Information for Accident Reduction

Monroe County Department of Transportation, Rochester, New York

Alan M. Stiehler

"The principal tasks of a community's transportation department are to construct, operate and maintain a safe and efficient highway, bridge and traffic network for moving people and goods, which in turn enhances the growth, economic well-being and the quality of life of the community." This is the formal statement of the mission of the Monroe County Department of Transportation.

Highway safety principles, interwoven with every aspect of the mission, become a prime focus of transportation officials. Traffic accidents draw attention to the shortcomings of the network and prompt officials, and citizens as well, to continually renew their efforts to improve a less-than-perfect system.

Accident surveillance starts the process.

Hand-in-hand with highway safety, an accident monitoring system and its companion, an accident reduction program, can produce a positive effect on the continuing mission. if accidents are occurring, then determining their causes leads to understanding how they can be prevented. Steps can then be taken to remove the causes, wherever possible, of preventable accidents. An effective accident monitoring system can place pertinent accident data in the hands of professional engineers, technicians and police for review, processing and investigation.

Accident surveillance, then, becomes the first Step in the process of accident reduction. Variables associated with each accident, such as location, day, date, time, severity, driver and vehicle attributes, weather, causative factors, lighting, etc. will be systematically documented and made available for retrieval, wholly or in summary, by interested transportation officials. A location index is a primary feature of accident surveillance, and provides the basis for information retrieval. Common examples of locational indices include milepoints, reference markers, map coordinates, and the link/node system. Subsequent discussion will focus on the link/node system as it is implemented in the New York State Centrallized Local Accident Surveillance System and used in the Monroe County High Accident Location Program.

Accidents in New York State are reported to the Department of Motor Vehicles, which files the accident reports and encodes the variables into the accident surveillance system, using links and nodes for location on local, or non-state-highway, roads. For reference, a distinct map position, such as an intersection or bridge, is a node indexed with its own unique 4- or S-digit node number. A road section connecting two adjacent nodes constitutes a link. For indexing, a link is identified by its two adjoining nodes. The NYS Department of Motor Vehicles periodically transfers indexed accident data to the NYS Department of Transportation for distribution to interested localities.

A modest beginning in Monroe County

Monroe County's relationship with the state accident surveillance system began in 1980 through an annual accident summary released by the New York State Centrallized Local Accident Surveillance System. It was a list of nodes and links with five or more accidents, and became the foundation for the first high accident location program in Monroe County.

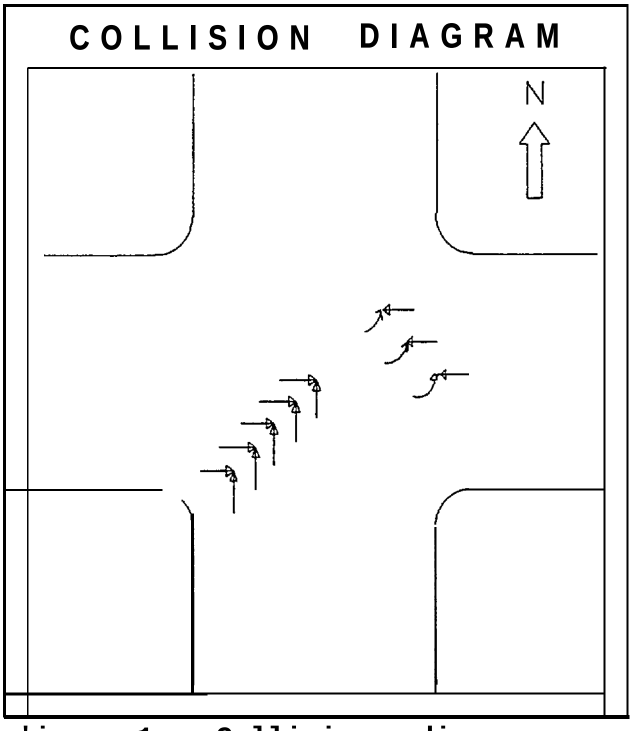
Shortly thereafter, with the help of a new computer system, node numbers became a useful index to store average daily traffic counts in the computer. Counts had been traditionally located from the nearest intersection. So the node number of the intersection became the primary index number. This was subscripted by a single digit to indicate which leg of the intersection was counted, clockwise from north: 1 for north, 2 for east, 3 for south, and 4 for west. Indexing in this way relieved data input personnel from inputting road names multiple times for multiple counts near the same intersection. The subscripted node numbers became a file name for raw count data for processing into an average daily traffic count (ADT). Multiple ADTs at the same location could be reported together, grouped according to node number.

Federal grant to promote highway safety

Accident rates, however, were still hand-calculated to meet the needs of individual projects, and the state accident surveillance system was used only to retrieve hard data when a project required it. The node index remained largely on paper until personal computers became available, along with user-friendly database software. A Federal Highway Safety Grant in 1990 allowed Monroe County to develop the potential of its computers in a highway safety improvement project. Software, specifically techniques using the Paradox database program, was used to allow duplication of the state's link/node system within the county's computer system. In this way, the Monroe County High Accident Location Program used personal computer technology to combine traffic counts with accident data in a single system. Large numbers of traffic counts could now be processed along with large amounts of accident data to yield accident rates at a large number of locations. This was made possible by indexing both accident and traffic data alike to the link/node system.

Monroe County High Accident Location Program
How it works

Monroe County's PC-based replica of the state's link/node system encompasses non-state-highway roads in the county. Accident summaries are periodically transferred from the state system to the county system, and year-to-year accident surveillance proceeds on the basis of traffic and accident totals at each node or link. The accident rates produced serve as a common measure to compare the safety of traffic operations at one location with that of others, independent of pure accident totals. Locations needing attention become obvious when their accident rates have been determined to be exceedingly high. After these high-accident-rate nodes or links are identified, the related hard copies of accident information are obtained with a request to the state accident surveillance system. Printed data on each accident is available along with police reports. Investigating these records provides essential clues, such as recurring accident patterns, and serves to determine accident causes, leading to an assessment of what can be done to remove the causes. Monroe County employs this process in its High Accident Location Program.



'igure 1. Collision diagram.

Essential to the program are certain mathematical concepts and a means to apply them to a large number of locations. Average daily traffic (ADD has to be determined for links. For intersections, entering-vehicles-per-day has to be determined. Accident rates (in accidents per million vehicle-miles or accidents per million entering vehicles) must be calculated, as well as average accident rates for county road facilities of similar type. A statistical process is applied to each county location, based on the overall average accident rate and the traffic exposure at specific sites. It determines a theoretical critical accident rate for each node or link. When the critical rate is exceeded by the computed accident rate, the system identifies it as a high accident candidate. After identification, accident report hard copies must be requested for each selected location. Following this, site-specific investigation and applied remedial treatment must be documented for future reference.

Personal computers reduce the workload.

Monroe County's personal computer system handles all data transfer, computation, reporting, and related record-keeping. Database software exists which allows operation with a minimal amount of formal computer training, and which can virtually eliminate the need to rely on extensive computer programming. A traffic engineering technician familiar with the underlying concepts can easily Operate the system. Indexing on nodes and links allows speedy processing and fast retrieval to take place, even with large data files. the output of this data finds uses not only in the High Accident Location Program, but also in planning and design of transportation projects. Frequent opportunity also arises to enhance site-specific investigations with related computer methods.

Techniques with traffic counts

The program's traffic counts originate primarily with the county mechanical traffic counting program. The climate in Monroe County allows ADT counts to be obtained in spring, summer and fall, near most major intersections, on a four-year rotation schedule. ADTs are preferred to evaluate entering vehicles of intersections, since the counts usually last three full days. However, minor intersections can be evaluated in the absence of ADTs by using peak-hour turning movement counts to estimate daily entering vehicles. Figure 2 illustrates the basic technique employed to determine daily entering vehicles (IntADT) of an intersection using the ADTs of adjacent links.

It is notable that ideal configurations of ADTs about an intersection are not always obtainable in practice. So, with engineering judgement, it becomes necessary to accept less perfect levels of coverage, as illustrated in Figure 3. Certainly, configurations with no ADTs on the cross streets are unacceptable, making turning movement counts preferable.

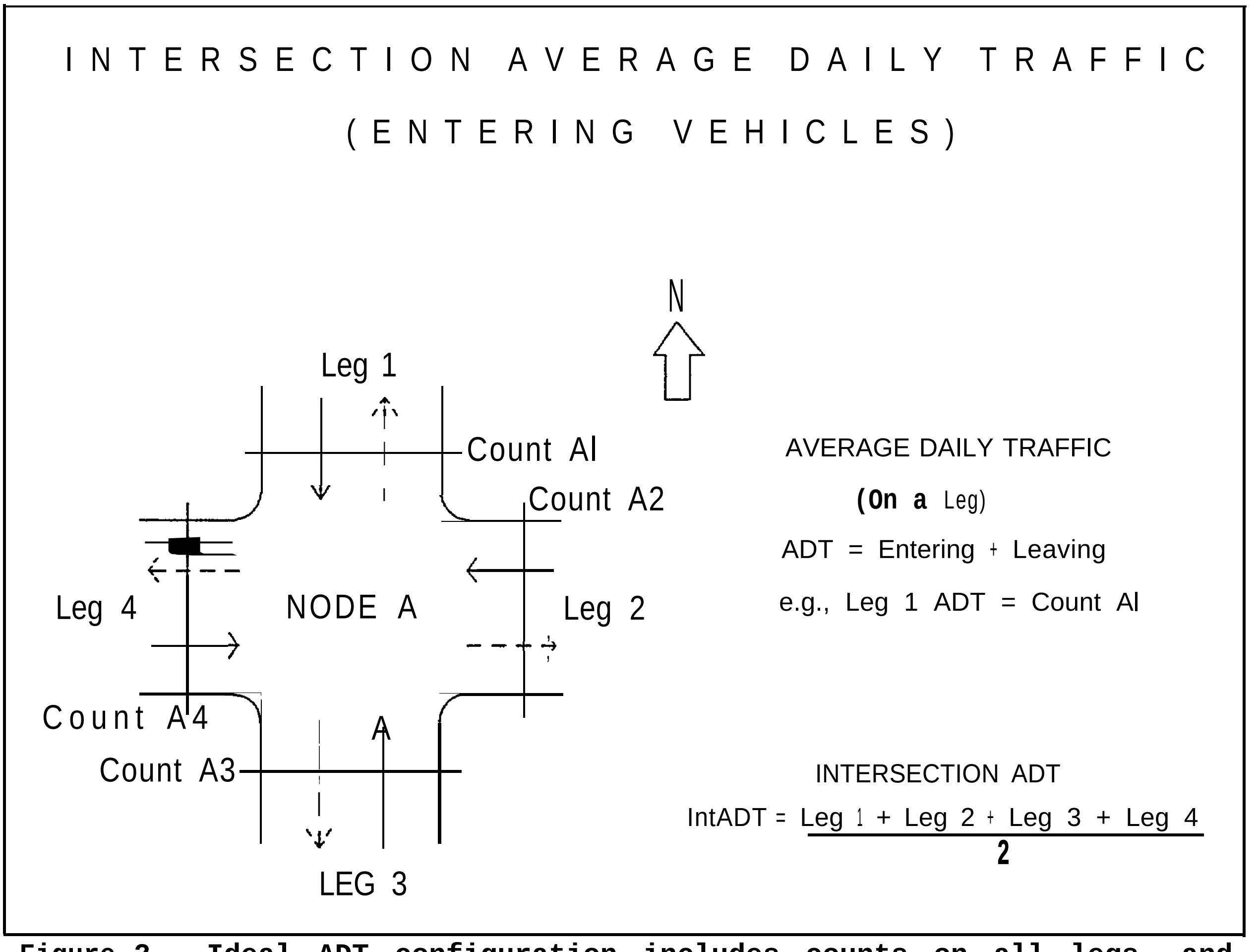


Figure 2. Ideal ADT configuration includes counts on all legs, and n the same date.

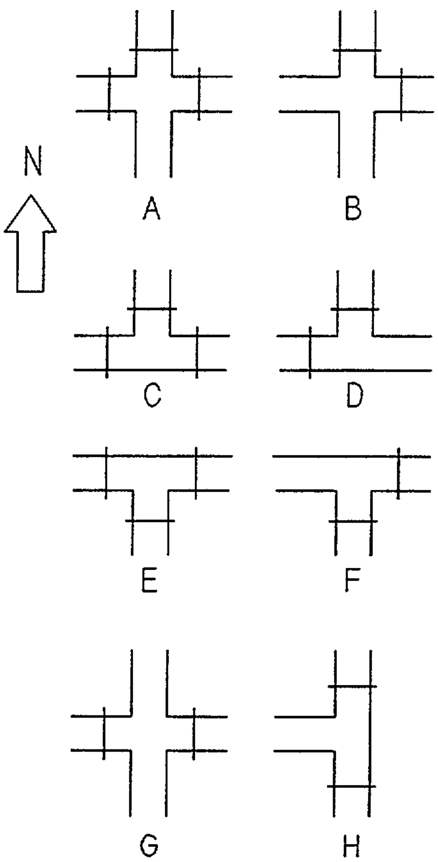
But often, ADTs on only two right-angle legs can provide an acceptable estimate Of intersection ADT, if it is apparent that approximately equal flows exist on ppposite legs.

Peak hour turning movement counts are convertable to intersection ADT (IntADT) by relying on nearby ADTs to provide the relationship of hourly volume to ADT. An example is the K-factor, which is the ratio of the 2-way peak hourly volume to 2-way ADT on a link. Using that method, IntADT can be estimated as the total peak-hour entering vehicles divided by the K-factor of a nearby mechanical count. Again, engineering judgement should decide if this is acceptable.

Straight ADT is used on links. An ADT near a major intersection may apply to a succession of links past several minor side roads, up to the next major intersection.

INTERSECTION AVERAGE DAILY TRAFFIC

(ALTERNATIVE CALCULATIONS)



Node	CalcType	IntADT Formula
A	4Leg124	$\frac{Leg2 + Leg4}{2} + Leg1$
B	4Leg12	$Leg1 + Leg2$
C	3Leg124	$\frac{Leg1 + Leg2 + Leg4}{2}$
D	3LegN14	$\frac{Leg1}{2} + Leg4$
E	3Leg234	$\frac{Leg2 + Leg3 + Leg4}{2}$
F	3LegS23	$\frac{Leg3}{2} + Leg2$
G	null	none possible
H	null	none possible

Figure 3. Alternative ADT configurations are acceptable when not all legs have counts. An appropriate formula determines IntADT.

Accident rates: comparing apples to apples

Accident rates are the number of accidents per **unit of exposure. Exposure on links is measured as millions of vehicle-miles. At intersections, it is millions of entering vehicles. Thus:**

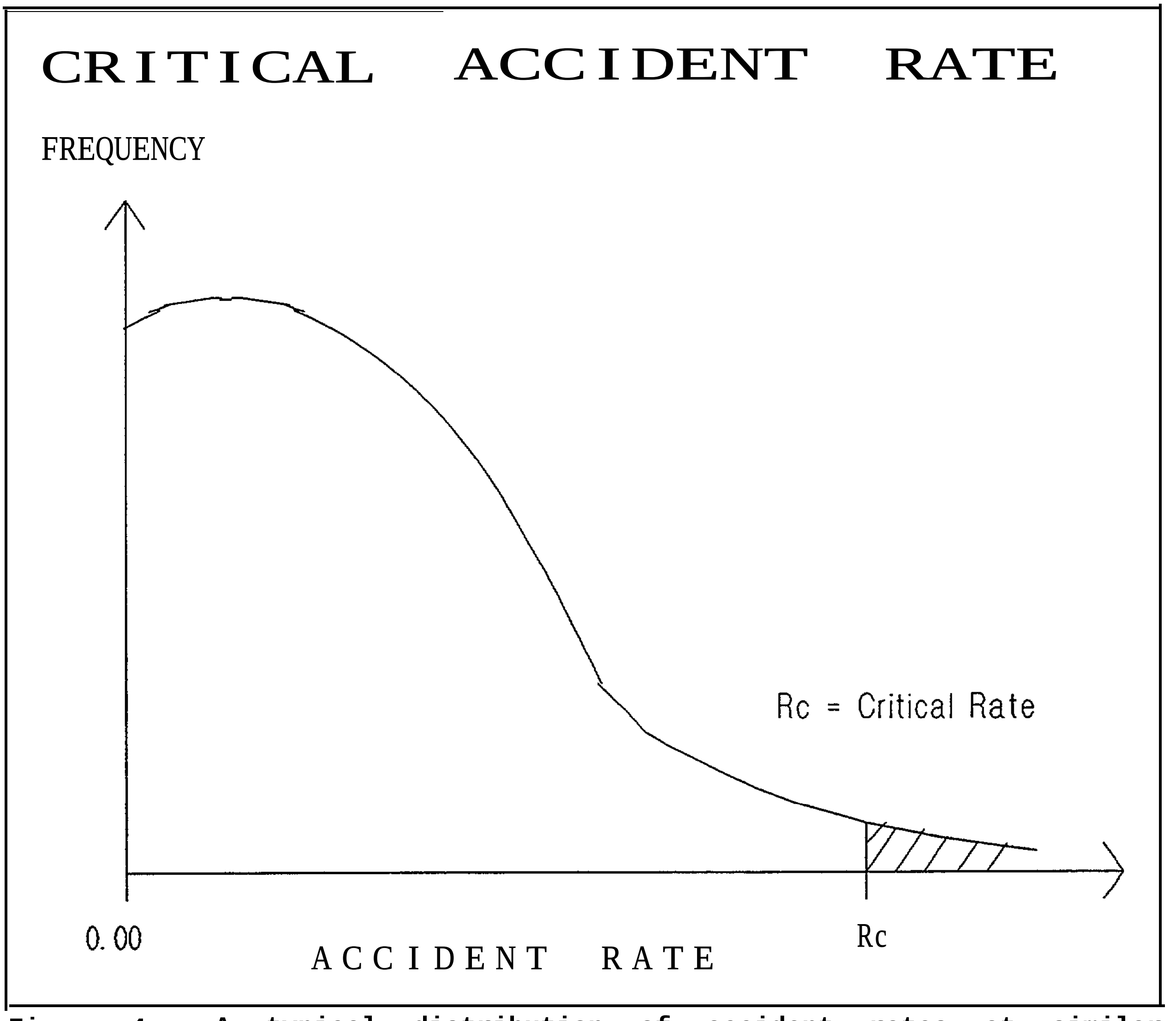


Figure 4. A typical distribution of accident rates at similar facilities. Think of the curve as long-term accident rates at a single location. The shaded area depicts when it should be studied.

for links:

R = [Accidents x 1,000,000]/[ADT x Length x Days]

(in accidents per million vehicle-miles);

and for intersections:

R = [Accidents x 1,000,000]/[IntADT x Days]

(in accidents per million entering vehicles).

Length is measured in miles of centerline. R is the accident rate.

A frequency distribution of accident rates at all similar facilities within the jurisdiction produces a graph highly skewed toward zero, tailing down to very low frequency at higher accident rates. Such a distribution is subject to statistical analysis according to the Poisson distribution. Applying the one-tail Poisson test to such data allows for selecting high accident rate locations. A commonly used level of confidence is 95%, meaning that the test will select a hazardous location with 95 percent certainty. (But roughly 5 percent of the selections will be locations that don't belong among the hazardous locations.) Higher levels of confidence can be used to provide more certainty that selections are indeed high accident locations, but only with more chance that some truly high accident locations will remain undetected when they really should be selected for treatment. This applied statistical test determines the theoretical critical rate, which, when exceeded in reality, identifies a hazardous location. Figure 4 presents a typical accident rate frequency distribution and an illustration of critical rate.

A closed system benefits a unique jurisdiction

It is notable that the critical rate test applies only to locations of similar type within the same jurisdiction. Distinguishing features of different type facilities could be rural, suburban, or urban surroundings; or functional classification; or lane configuration and traffic control; or a combination of these. It is important to differentiate on jurisdiction. Statistically, state road data differs from county road data, which differs from town road data, and so on. The critical rate test is based on a closed system of data points from a particular jurisdiction and is valid only within that system. That means that statewide data from state roads does not apply to counties or towns, who maintain their own systems of jurisdiction. However, within a jurisdiction, the critical rate test adds certainty to selecting high accident locations suitable for treatment, as long as similar facilities are grouped according to suitable distinguishing features.

AVERAGE RATE, LINKS

$$Raf = \frac{\sum_{1}^{n} Acc_i \times 1,000,000}{\sum_{1}^{n} \left[Adt_i \times Length_i \right] \times Days}$$

where: Raf = Average Accident Rate for All Links of Type f

i = Individual Link of Type f

n = Number of Links of Type f

Acc_i = Number of Accidents on Link i

Adt_i = Average Daily Traffic on Link i

$Length_i$ = Length of Link i, in miles

ACCIDENTS PER MILLION VEHICLE-MILES

Figure 5. The equation to calculate the average accident rate of similar facilities (links).

The bases of the critical rate test are traffic exposure at specific sites and the overall jurisdictional averages of accident rates for similar facilities. Traffic counts must exist at specific sites. And only sites with traffic counts are used to compute overall averages. The goal involves applying a statistical test to similar data points to identify high accident locations with some certainty.

The calculation of average rates is illustrated in Figures 5 and 6. Generally, average rates are based on the long term, e.g. three or four years. Figure 7 illustrates the calculation of a specific critical rate. Table 1 illustrates some popular levels of confidence and their corresponding statistical constant, K.

Benefits and Drawbacks

There are advantages to using the outlined techniques. First, it is an active approach

Stiehler

A V E R A G E   R A T E ,   I N T E R S E C T I O N S

$$Ra_f = \frac{\sum_{1}^{n} Acc_i \times 1{,}000{,}000}{\left[\sum_{1}^{n} IntADT_i\right] \times Days}$$

where:
- Ra_f = Average Accident Rate for All Intersections of Type f
- i = Individual Intersection of Type f
- n = Total Number of Intersections of Type f
- Acc_i = Number of Accidents at Intersection i
- $IntAdt_i$ = Entering Vehicles Per Day at Intersection i

ACCIDENTS PER MILLION ENTERING VEHICLES

Figure 6. The equation to calculate the average rate of intersections (nodes) of the same type.

Confidence Level (%)	K
99.9	3.090
99.5	2.576
99.0	2.326
95.0	1.645
90.0	1.282

Table 1. Common values of the statistical constant, K, used to apply the Poisson 1-tail test for critical rate.

to accident reduction that actively furthers the mission of the transportation department. It can be viewed as a "trouble-shooting" technique to detect unnoticed or developing

C R I T I C A L R A T E

$$Rc = Ra + \left[K \times \sqrt{\frac{Ra}{\text{Yearly Millions}}} \right] + \frac{1}{2 \times \text{Yearly Millions}}$$

where: Rc = Critical Accident Rate

Ra = Jurisdiction-wide Average Rate

K = statistical constant

Yearly Millions = millions of entering vehicles per year or millions of vehicle-miles per year

Ref : Traffic Institute, Northwestern University

Figure 7. The critical rate equation for a single location. The average rate, Ra, applies to all facilities of the same type as the location whose critical rate is to be determined.

safety problems. Further, it can free traffic technicians to focus on selected high accident locations with the certainty that their efforts are applied where they are is most needed. A related advantage includes having a current accident summary available whenever needed for planning or designing improvements. Locations need not be high accident locations to benefit concerned citizens, whose safety questions can often be addressed after consulting data in the system. And over time, records will accumulate to determine what engineering techniques are better suited to solve certain types of safely problems.

A disadvantage may be the necessary reliance on traffic counts to produce accident rates. Not every community has a traffic counting program. Also, it is not possible to have traffic counts at all points of the road network, so some gaps can result in network coverage. However, accident rate surveillance provides safety monitoring to whatever extent the traffic count program reaches.

Summary

An active approach to accident reduction makes accident surveillance a necessary step in the process of improving highway safety. An appropriate accident surveillance system makes pertinent accident data available to transportation professionals.

Traffic counts can be related to the geographic location index of the accident surveillance system. Then personal computers can be the tool to compute locational accident rates and apply suitable statistical tests to accident rate data to develop an accident reduction program uniquely suited to the needs of a particular community.

Reference:

Wentification and Treatment of High Hazard Locations", short course, Traffic Institute, Northwestern University.

Centrallized Local Accident Surveillance System, New York State Department of Transportation.

Alan M. Stiehler is a Senior Traffic Engineering Technician in the Monroe County, New York, Department of Transportation, and has worked in highway safety monitoring there since 1986.