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HUMAN FACTORS FOR TRANSITWAY SAFETY IMPROVEMENT

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Human Factors for Transitway Safety Improvement

Final Report for Phase 1

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Table of Contents

List of Tables And Figures

List of Tables

List of Figures

Human Factors for Transitway Safety Improvement

Abstract

A human factors study was performed to identify potential cause of accidents at eight Transitway intersections. Data were collected on bus operators' driving behavior, on motorists' behavior at Transitway intersections and on sight distances at the intersections. From some of this data and the accident history at each intersection we calculated accident frequencies based on the number of cars crossing each intersection per year, then related some of our findings to both accident frequency and the immediate causes of reported accidents.

An analysis of the data suggested that the following were potentially contributory to intersection accidents:

- Two percent of the drivers run the stop signs and about 50% of the drivers use a rolling rather than a full stop.
- About 20% of drivers do not look both ways before crossing the Transitway.
- Winter weather brings slippery roads and reduced visibility conditions.
- The timing for bus actuated traffic lights may not be optimal.
- Only five of the 32 sight distances met minimum guidelines.

Our broad conclusion was that combinations of the above factors could well contribute to the accidents occurring at the Transitway intersections. Specific recommendations were made for addressing each of the above factors.

Introduction

In the year before Transitway operation began, the buses transferring students between the Minneapolis and St. Paul campuses operated on city streets. There was one minor accident in that last year. In the nearly four years of Transitway operation there has been nearly one accident for each two months of operation. It is important to identify the reason or reasons for this apparent change in accident rate. Until we understand why Transitway accidents occur, it will be difficult to implement cost effective solutions for reducing the number of accidents.

Human Factors Project Objective

The objective of this project is to collect and analyze data related to human factors aspects of Transitway safety. This information can be used to identify aspects of the Transitway which contribute to accidents at Transitway intersections. Knowing the source of safety problems may help to suggest solutions. Once potential solutions have been implemented, we will again evaluate Transitway safety to measure the effectiveness of the solutions. This latter evaluation constitutes Phase 2 while this report deals only with Phase 1.

Potential Accident Causes

Several potential causes for Transitway accidents, either singly or in combination, seem possible:

- *There is no real increase over the pre-Transitway accident rate. Our observations on relative accident frequency are the result of sampling error and chance fluctuations.*

We cannot think of a valid way to make statistical comparisons between the pre- and post-Transitway accidents. Clearly, city streets and the Transitway differ in ways which suggest that direct statistical comparisons based solely on number of accidents would have no meaning. The amount of traffic interacting with the buses is much greater on city streets than on the transitway and this cannot be used to explain the difference in numbers of accidents. The best we can do in trying to decide whether there has been a real increase in accidents, is to make the common sense observation that the Transitway, which was meant to reduce accidents, has instead resulted in a six-fold increase in accidents. While we may not be able to demonstrate statistical significance, we can state our surprise and seek for the reasons which may account for this unexpected and unwanted outcome.

- *Bus drivers are careless or deliberately engage in risk taking driving behavior.*

We included this potential reason for the increase in accidents based on the following observations.

On May 5, 1995 the authors of this report took a round trip Transitway ride starting at the Huron Boulevard Parking Lot. We boarded at about 11:20 am. We left the bus at the main bus stop on Bufford St. near the St. Paul Campus Student Center.

Improper Parking

Just east of the bus stop shelter, on the sidewalk at curbside on the north side of Bufford, is a fire hydrant. Opposite the fire hydrant a station wagon was parked with the driver behind the wheel. An incoming bus going west on Bufford parked closely alongside the station wagon with the bus's front door just in front of the station wagon's front bumper and the bus's rear door just behind the station wagon's rear bumper. The first passenger pushed the front bus door open to leave the bus. At this instant the station wagon accelerated just missing the disembarking passenger. This was very close (less than one second) to being a fatal accident.

Left Turn at Intersection

We continued to wait for our bus back to Huron Boulevard. A bus departed and we heard a loud horn blowing continuously. It was the bus going south on Bufford and approaching the T-intersection with Cleveland. The light was red as the bus approached. However, the bus driver initiated and completed the left turn onto Cleveland. This was not even close to a yellow light dilemma. The bus was going slowly and the driver had plenty of time to stop for the red traffic signal. Fortunately, both north- and south-bound traffic on Cleveland Avenue stopped to let the bus driver make the left turn on their green light. This was not a close-call.

An additional observation is that if northbound traffic on Cleveland stops close to the Bufford intersection, it seems very difficult for the bus driver to make the left turn onto Cleveland without hitting the encroaching car. Space for making the turn is limited.

- *Bus drivers have become relaxed and overly confident due to the apparent protection afforded by the right-of-way for Transitway buses.*

This possible, but incorrect contributory explanation, was explored by collecting data as described in the Methods Section of this report.

- *Drivers of vehicles crossing the Transitway are scofflaws and this driving behavior at the Transitway intersections may sometimes result in accidents.*

The results from collecting data on this issue are described in the Results Section.

- *Poor geometry at the Transitway intersections contributes to accidents.*

The intersections on the Transitway are nearly orthogonal and level. However, short sight distances, as described below, could be contributory.

- *The traffic control signs and signals for the intersecting streets are in some way inadequate.*

We cannot directly provide data bearing on this issue. However, based on other comparisons we can draw tentative conclusions on the effectiveness of the signs and signals.

- *Unauthorized vehicles on the Transitway (including bicycles) are a cause of accidents.*

We have some data on this issue but found that it could only be a weak contributor, if it contributes at all, to Transitway accidents.

- *Other subtle, less identifiable factors are causing the accidents.*

The only way to be sure that the above statement is not true, is to be able to account for all or almost all of the observed accidents by other means than those just listed.

Report Organization

In this introductory section there is no review of the relevant literature since this was covered in the report for Task 2, Literature Review and Analysis. In this review we noted that there was no literature on roadways analogous to the University of Minnesota's Transitway. The literature that was reviewed was related to railroad-highway grade crossings since this is, to an extent, analogous to the Transitway intersecting avenues situation.

We collected independent sets of observations which related to one or more of the potential accident causes listed above. For each of these sets we present a description of the method used. Once all the methods have been discussed, the results are shown. In the Discussion and Conclusion And Recommendations sections all results are discussed together rather than independent discussion for each set of observations. Supporting data are in the two appendices.

Methods

We collected observational data relating to Transitway bus drivers as well as data relating to motorists' behavior at the eight avenues intersecting the Transitway. These avenues are: 23rd Ave., 25th Ave., 29th Ave., 30th Ave., Malcolm Ave., Westgate, Energy Park Drive and Como Ave. Energy Park and Como Avenues were controlled by traffic signals while the other avenues have stop signs. We also made measurements and calculations to determine site distances at those intersections where short sight distances might contribute to the problem.

Bus Drivers

The method for collecting data on Transitway bus drivers was straightforward. Students equipped with data sheets rode the buses and filled in the data sheet at the completion of the trip. The students were instructed to sit near the front of the bus with a view of the driver. They were also told to neither question the driver nor to demonstrate that they were recording data relevant to bus driving. Students boarded the buses at either the Student Center on the St. Paul Campus or the Transitway Parking Lot on the Minneapolis Campus. The students would disembark after one leg of the trip was complete and then board a different bus for the ride back to the origin. Data was taken on over 50 bus rides. A copy of a data sheet can be found in Appendix A, Data Sheets.

Intersection Observations

Students equipped with clipboards and data sheets were stationed at an assigned Transitway intersection. Students were told not to be conspicuous. Some of the students sat in a cars parked near the intersection.

The types of data were: direction of travel, type of vehicle, type of stop, whether the driver looked both ways, number of buses in view, incidents, the presence of cyclists, pedestrians, inline skaters, police or other. The categories of data of each type are shown on the data sheet in Appendix A. Data was taken on over 2,400 vehicles crossing the Transitway.

Sight Distances

If all drivers crossing the Transitway always stopped at the stop signs and red traffic signals, we would not need to consider sight distance. Unfortunately for safety, this is not the case. Since some of the Transitway intersections seemed to have short sight distances we made measurements and calculations to aid in interpreting the safety impact of these sight distances. The calculations

are based on the paper by Easa (1)which was in turn based on Federal Highway Administration and American Association of State Highway And Transportation Officials guidelines. Figure 1 depicts the conventional sight line triangle.

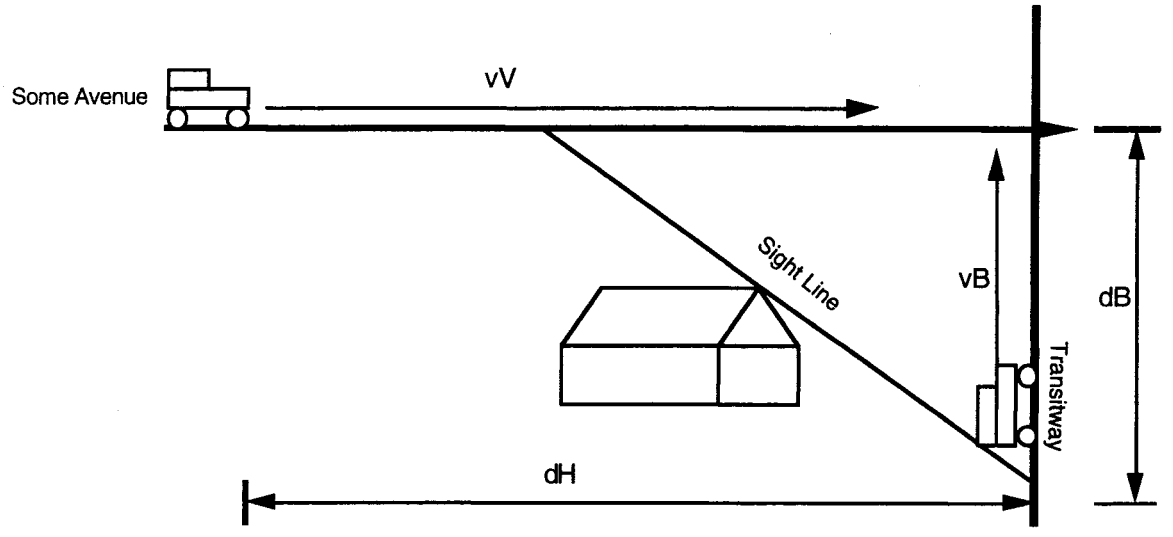

Figure 1 Sight line triangle.

To address the sight distance (feet) leg along the avenue we used Equation 1.

$$Dh = 1.47\ Vv\ t + (Vv/30\ f) + D + De \qquad [1]$$

To address the sight distance leg along the Transitway we used Equation 2.

$$Db = Vv[1.47Vv\ t + (Vv/30f) + 2D + L + W] \qquad [2]$$ where

Dh = sight distance along the avenue
Db = sight distance along the Transitway
Vv = velocity of the approaching vehicle (in mph)
Vb = velocity of the Transitway bus
f = coefficient of friction (f= 0.429 - (0.0023 Vv)
D = distance from the stop line to the near edge of the bus (10 ft)
De = distance from the driver to the front of the vehicle (8 ft)
L = length of vehicle 20 feet, W = width of Transitway lanes (40 feet)

In the Results Section actual, measured sight distances were compared with the required sight distances calculated from Equations 1 and 2. There are three cases of potential interest: 1) The case in which a car is stopped at the crossing and we wish to know the distance down the Transitway required to detect an oncoming bus; 2) The case in which a vehicle is approaching the Transitway and the driver fully intends to stop or nearly stop; and 3) The case in which a driver

either deliberately or inattentively will run the stop sign or red traffic signal. The first two cases are not of interest here, since it is unlikely that accidents will be caused when drivers observe the signs and signals controlling Transitway crossing. For the third case, however, when cars run the stop sign or red traffic light, drivers need to see down the transitway in both directions to avoid hitting a bus.

We have adopted a convention for labeling directions. In what follows, the Transitway runs east and west and the crossing avenues north and south.

Results

Bus Drivers

Based largely on the anecdotal account of bus drivers' behaviors described previously, we elected to formally observe a sample of bus drivers' behavior. These observations were acquired by the method described above and they are documented in Appendix B, Bus Driver Observations.

Based on our observations we can state that it is unlikely that the behavior of the bus drivers contributes in any direct way to Transitway accidents. This is not to say that there is no need for minor improvements, but it is now clear that the potential problems predictable from the initial anecdotal observations presented above, were not at all borne out following analysis of our sample of 60 observations.

Summary of Bus Driver Behavior

The observational data for bus driver behavior was collected in February, 1996. The population of bus drivers consisted of both males and females. Their ages were estimated and ranged from the late 20's to early 70's. Brief physical descriptions were also recorded. The date and time were noted along with the bus number and route number. The direction of travel was recorded. The task for the experimenters was to observe any unusual driving behavior by the bus drivers, also noting appropriate behavior or good, courteous driving skills. Approximately sixty rides were recorded between 8:45 am and 7:55 pm with the majority of observations between 9:00 am and 4:30 pm.

Intersection Observations

Observations of motorist behavior were taken at eight avenues intersecting the Transitway. Data was collected with respect to direction of travel (north or south), type of vehicle (car, light truck, commercial truck and semi-truck), type of stop when approaching an intersection (complete, rolling or yield, and no stop), whether the motorist looked both ways at the intersection (yes, no, and could not see), and the number of buses on the Transitway when motorists were present (zero, one, and more than one). The data in Tables 1-8 was presented as absolute values with fraction of total in parentheses.

For all intersections there were some common findings. The traffic was approximately evenly divided between north-bound and south-bound. There was a mixture of vehicle types with cars predominating and semi-trucks with the smallest number. The number of motorists coming to a

complete stop was approximately the same as the number using a rolling or yielding stop but there were always some drivers who ran the stop signs. The majority of drivers looked both ways before crossing the Transitway. Approximately three-fourths of the time buses were not in view when the motorist crossed the Transitway. Rarely there was more than bus in view at a time.

The data is presented by intersection beginning at 23rd Avenue S.E. and proceeding east toward the St. Paul campus.

Table 1 presents data on motorist behavior at 23rd Ave. S.E. There were 210 observations. Fifty percent of the motorists completely stopped at the intersection while 49% rolled through it and nearly 1.5% ran it.

Table 1 Motorists' Behavior on 23rd Ave SE

Observation:	210			
Direction:	N	95 (.45)		
	S	115 (.55)		
			Commercial	
Type of Vehicle:	Car	Lt. Truck	Truck	Semi-Truck
Total	145 (.69)	41 (.20)	23 (.11)	1 (.00)
N	67 (.69)	19 (.20)	11 (.11)	0 (.00)
S	78 (.69)	22 (.19)	12 (.11)	1 (.01)
Type of Stop:	Complete	Rolling	Ran It	
Total	105 (.50)	102 (.49)	3 (.01)	
N	42 (.42)	56 (.57)	1 (.01)	
S	63 (.57)	46 (.41)	2 (.02)	
Look Both Ways:	Yes	No	Did Not See	
Total	180 (.86)	23 (.11)	7 (.03)	
N	80 (.84)	8 (.08)	7 (.07)	
S	100 (.87)	15 (.13)	0 (.00)	
No. of Buses:	Zero	One	More than One	
Total	170 (.81)	32 (.16)	8 (.03)	
N	74 (.78)	18 (.19)	3 (.03)	
S	96 (.83)	14 (.12)	5 (.04)	

Note: Data is presented as: Actual data followed by fraction of total.

Table 2 shows the behavior of motorists at 25th Ave. SE. There were 563 total observations. Forty-eight percent completely stopped while 50% rolled through and 2% ran the stop sign.

Table 2 Motorists' Behavior on 25th Ave SE

Observation:		563			
Direction:	N	278 (.49)			
	S	285 (.51)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	265 (.47)	200 (.36)	69 (.12)	29 (.05)
	N	124 (.44)	106 (.38)	40 (.14)	10 (.04)
	S	141 (.50)	94 (.33)	29 (.10)	19 (.07)
Type of Stop:		Complete	Rolling	Ran It	
	Total	273 (.48)	280 (.50)	10 (.02)	
	N	149 (.50)	133 (.48)	4 (.01)	
	S	133 (.47)	147 (.52)	6 (.02)	
Look Both Ways:		Yes	No	Did Not See	
	Total	500 (.89)	18 (.03)	45 (.08)	
	N	257 (.96)	7 (.03)	5 (.02)	
	S	243 (.83)	11 (.04)	40 (.14)	
No. of Buses:		Zero	One	More than One	
	Total	486 (.86)	62 (.12)	14 (.02)	
	N	242 (.88)	26 (.09)	8 (.03)	
	S	244 (.85)	37 (.13)	6 (.02)	

Note: Data is presented as: Actual data (fraction of total)

Table 3 displays motorists' behavior at 29th Ave SE. There were 205 observations at this cross street. Sixty percent completely stopped at the intersection while 37% rolled through it and 3% ran it.

Table 3 Motorists' Behavior on 29th Ave SE

Observation:		205			
Direction:	N	104 (.51)			
	S	101 (.49)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	81 (.39)	59 (.29)	40 (.20)	25 (.12)
	N	37 (.36)	30 (.29)	26 (.25)	10 (.10)
	S	44 (.43)	29 (.28)	14 (.14)	15 (.15)
Type of Stop:		Complete	Rolling	Ran It	
	Total	124 (.60)	75 (.37)	6 (.03)	
	N	72 (.66)	32 (.29)	5 (.05)	
	S	52 (.54)	43 (.45)	1 (.01)	
Look Both Ways:		Yes	No	Did Not See	
	Total	189 (.92)	8 (.03)	8 (.04)	
	N	93 (.89)	5 (.05)	6 (.06)	
	S	96 (.95)	3 (.03)	2 (.02)	
No. of Buses:		Zero	One	More than One	
	Total	178 (.87)	26 (.12)	1 (.00)	
	N	96 (.92)	7 (.07)	1 (.01)	
	S	82 (.81)	19 (.19)	0 (.00)	

Note: Data is presented as: Actual data (fraction of total)

Table 4 is behavior of motorists at 30th Ave SE. There were 391 observations at this intersection. Fifty-five percent completely stopped, 42% yielded, with 3% driving through without slowing.

Table 4 Motorists' Behavior on 30th Ave SE

Observation:		391			
Direction:	N	204 (.52)			
	S	187 (.48)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	178 (.46)	161 (.41)	39 (.10)	13 (.03)
	N	93 (.46)	84 (.41)	18 (.09)	8 (.04)
	S	85 (.45)	77 (.41)	21 (.11)	5 (.03)
Type of Stop:		Complete	Rolling	Ran It	
	Total	214 (.55)	166 (.42)	11 (.03)	
	N	114 (.56)	83 (.41)	6 (.03)	
	S	100 (.53)	83 (.44)	5 (.03)	
Look Both Ways:		Yes	No	Did Not See	
	Total	358 (.92)	11 (.03)	22 (.06)	
	N	179 (.87)	7 (.03)	20 (.10)	
	S	179 (.97)	4 (.02)	2 (.01)	
No. of Buses:		Zero	One	More than One	
	Total	333 (.85)	49 (.12)	9 (.03)	
	N	167 (.83)	31 (.15)	3 (.01)	
	S	166 (.87)	18 (.09)	6 (.03)	

Note: Data is presented as: Actual data (fraction of total)

Table 5 shows motorist's behavior at Malcolm SE. There were 240 total observations. Forty-seven percent of vehicles came to a complete stop, 51%, rolled through and 2% ran it.

Table 5 Motorist's Behavior on Malcolm SE

Observation:		240			
Direction:	N	116 (.48)			
	S	124 (.52)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	99 (.41)	54 (.23)	22 (.09)	65 (.27)
	N	58 (.48)	23 (.19)	10 (.08)	30 (.25)
	S	41 (.34)	31 (.26)	12 (.10)	35 (.29)
Type of Stop:		Complete	Rolling	Ran It	
	Total	114 (.48)	121 (.50)	6 (.03)	
	N	62 (.53)	52 (.44)	3 (.03)	
	S	51 (.41)	69 (.56)	3 (.02)	
Look Both Ways:		Yes	No	Did Not See	
	Total	211 (.88)	12 (.05)	17 (.07)	
	N	102 (.85)	5 (.04)	13 (.11)	
	S	109 (.91)	7 (.06)	4 (.03)	
No. of Buses:		Zero	One	More than One	
		217 (.91)	20 (.08)	3 (.01)	
	N	102 (.89)	12 (.11)	0 (.00)	
	S	115 (.91)	8 (.06)	3 (.02)	

Note: Data is presented as: Actual data (percentage)

Table 6 presents motorists' behavior at Westgate SE. There were 281 observations at this intersection. Forty-one percent of the drivers completely stopped at the intersection, 55% yielded and 4% ran the stop sign.

Table 6 Motorists' Behavior on Westgate SE

Observation:		281			
Direction:	N	119 (.42)			
	S	162 (.58)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	140 (.50)	76 (.27)	25 (.09)	40 (.14)
	N	61 (.52)	28 (.24)	10 (.08)	19 (.12)
	S	79 (.48)	48 (.29)	15 (.09)	21 (.13)
Type of Stop:		Complete	Rolling	Ran It	
	Total	116 (.41)	155 (.55)	10 (.04)	
	N	53 (.45)	62 (.53)	3 (.03)	
	S	63 (.39)	93 (.57)	7 (.04)	
Look Both Ways:		Yes	No	Did Not See	
	Total	251 (.89)	8 (.02)	22 (.08)	
	N	113 (.95)	4 (.03)	2 (.02)	
	S	138 (.85)	4 (.02)	20 (.12)	
No. of Buses:		Zero	One	More than One	
		242 (.86)	31 (.11)	8 (.02)	
	N	106 (.91)	9 (.08)	2 (.02)	
	S	136 (.83)	22 (.13)	6 (.04)	

Note: Data is presented as: Actual data (percentage)

Table 7 shows the behavior of motorists at Energy Park Drive. There were 265 total observations. Most of the motorists (84%) drove through the intersection at a green light, 14 % stopped at a red light, and 2 % drove through the traffic light (authors are uncertain if the light was yellow or red).

Table 7 Motorists' Behavior on Energy Park Drive

Observation:		265			
Direction:	N	117 (.44)			
	S	148 (.56)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	180 (.68)	55 (.21)	22 (.08)	8 (.03)
	N	87 (.74)	24 (.20)	5 (.04)	2 (.02)
	S	93 (.63)	31 (.21)	17 (.12)	6 (.04)
Type of Stop:		Complete	Rolling	Ran It	Green Light
	Total	36 (.14)	5 (.02)	1 (.01)	223 (.84)
	N	19 (.16)	1 (.01)	1 (.01)	98 (.82)
	S	17 (.12)	4 (.03)	0 (.00)	125 (.86)
Look Both Ways:		Yes	No	Did Not See	
	Total	41 (.15)	221 (.83)	3 (.01)	
	N	16 (.14)	101 (.86)	1 (.01)	
	S	25 (.17)	120 (.82)	2 (.01)	
No. of Buses:		Zero	One	More than One	
	Total	228 (.86)	36 (.13)	1 (.00)	
	N	100 (.85)	17 (.14)	1 (.01)	
	S	128 (.87)	19 (.13)	0 (.00)	

Note: Data is presented as: Actual data (percentage)

Table 8 presents motorists' behavior at Como Ave. There were 265 observations taken at this intersection. Motorists traveling through a green light were 81% of the total and motorists completely stopping were 18%.

Table 8 Motorists' Behavior on Como Ave

Observation:		265			
Direction:	N	127 (.48)			
	S	138 (.52)			
Type of Vehicle:		Car	Lt. Truck	Commercial Truck	Semi-Truck
	Total	147 (.55)	77 (.29)	34 (.13)	7 (.03)
	N	78 (.62)	29 (.23)	16 (.13)	3 (.02)
	S	69 (.50)	48 (.35)	18 (.13)	4 (.03)
Type of Stop:		Complete	Rolling	Ran It	Green Light
	Total	48 (.18)	0 (.00)	1 (.00)	216 (.81)
	N	25 (.20)	0 (.00)	0 (.00)	101 (.80)
	S	23 (.17)	0 (.00)	1 (01)	115 (.83)
Look Both Ways:		Yes	No	Did Not See	
	Total	57 (.22)	199 (.75)	9 (.03)	
	N	29 (.22)	100 (.78)	0 (.00)	
	S	28 (.21)	99 (.73)	9 (.07)	
No. of Buses:		Zero	One	More than One	
		204 (.77)	49 (.18)	12 (.05)	
	N	101 (.74)	28 (.20)	8 (.06)	
	S	103 (.80)	21 (.16)	4 (.03)	

Note: Data is presented as: Actual data (percentage)

Table 9 is a summary of the total observations on motorists' behavior. There were 2420 observations collected and 48% of the motorist were traveling north while 52% were traveling south. The distributions of vehicles that crossed the Transitway were 51% cars, 30% light trucks, 11% commercial trucks, and 8% were semi-trucks. Drivers that completely stopped were 43% of the total, those who rolled through were 37%, and 2% ran the stop sign. Those driving through a red or yellow light were about 1% of the total. Seventy-four percent of the motorists looked both ways before crossing the intersection, 21% did not look both ways, and for 5% the observer was not certain. There were no buses present on the Transitway 85% of the time. There was one bus present 13% of the time and one or more buses were present 3% of the time. There were no incidents during this data collection period. Others present on the Transitway while motorists were crossing the intersections were bicyclists (11%) and pedestrians (6%).

Table 9 Total Observations of Motorist Behavior

Observation:	2420			
Direction:	N	1160 (.48)		
	S	1260 (.52)		
Type of Vehicle:	Car	Lt. Truck	Co. Truck	Semi-Truck
	1235 (.51)	723 (.30)	274 (.11)	188 (.08)
Type of Stop:	Complete	Rolling	Ran It	Green Light
	1029 (.43)	904 (.37)	48 (.02)	439 (.18)
Look both ways:	Yes	No	Did Not See	
	1787 (.74)	500 (.21)	133 (.05)	
No. of Buses:	Zero	One	More than One	
	2058 (.85)	306 (.13)	56 (.03)	
Incident:	Yes	No		
	0 (.00)	2420 (1.00)		
Others:	Bicyclist	Pedestrians	Police	Other
	265 (.11)	134 (.06)	11 (.00)	16 (.01)

Note: Data is presented as: Actual data (percentage)

Sight Distances

As discussed in the Methods Section we were interested in the interaction of sight distances with drivers' behavior with respect to stop signs and traffic signals. The required sight distances for buses approaching the intersection at different velocities and for cars approaching the intersections at various velocities are shown in Table 10. The values in Table 10 were calculated using Equations 1 and 2. Actual sight distances were measured for the intersections where sight distance could be a problem and these values are shown in Table 11.

Table 10 Calculated Sight Distances

Vb	Avg Vv	t	f*30	D	L	W	De	Dh	Db
30	5	2.5	12.5	10.0	25.0	40	8	37	623
30	10	2.5	12.2	10.0	25.0	40	8	56	368
30	15	2.5	11.8	10.0	25.0	40	8	74	283
30	20	2.5	11.5	10.0	25.0	40	8	93	240
30	25	2.5	11.1	10.0	25.0	40	8	112	215
30	30	2.5	10.8	10.0	25.0	40	8	131	198
35	5	2.5	12.5	10.0	25.0	40	8	37	726
35	10	2.5	12.2	10.0	25.0	40	8	56	429
35	15	2.5	11.8	10.0	25.0	40	8	74	330
35	20	2.5	11.5	10.0	25.0	40	8	93	280
35	25	2.5	11.1	10.0	25.0	40	8	112	251
40	5	2.5	12.5	10.0	25.0	40	8	37	830
40	10	2.5	12.2	10.0	25.0	40	8	56	490
40	15	2.5	11.8	10.0	25.0	40	8	74	377
40	20	2.5	11.5	10.0	25.0	40	8	93	320
40	25	2.5	11.1	10.0	25.0	40	8	112	287

Table 11 Measured Sight distances at Transitway Intersections

INTERSECTION	LOOKING NORTH			LOOKING SOUTH		
	x (ft)	y (ft)	Meets Rqmt*	x (ft)	y (ft)	Meets Rqmt*
23rd Ave SE						
East bound	80	392	yes	80	129	no
West bound	80	> 500**	yes	80	69	no
25th Ave SE						
East bound	80	29	no	80	90	no
West bound	80	130	no	80	26	no
29th Ave SE						
East bound	80	103	no	80	119	no
West bound	80	94	no	80	26	no
30th Ave SE						
East bound	80	97	no	80	141	no
West bound	80	36	no	80	36	no
Malcolm St.						
East bound	80	10	no	80	106	no
West bound	80	78	no	80	206	no
Westgate						
East bound	80	106	no	80	> 500**	yes
West bound	80	310	yes	80	> 500**	yes
Energy Park Dr.						
East bound	80	116	no	80	> 500	yes
West bound	80	180	no	80	< 50	no
Como Ave						
East bound	80	< 25	no	80	< 60	no
West bound	80	< 50	no	80	< 25	no

* Meets requirement when a vehicle is traveling 10 mph and 80 feet from the intersection with the Transitway. ** Sight line not continuous.

Using the definitions seen in Figure 2 we can show whether a line of sight is obstructed at combinations of average vehicle speeds and Transitway bus speeds. These values are shown in Table 12. Figure 2 shows that an obstruction can reduce sight lines so that the required sight line cannot be achieved; that is, Dh is greater than D'h or Db is greater than D'b. Reducing vehicle speed decreases Dh but increases Db.

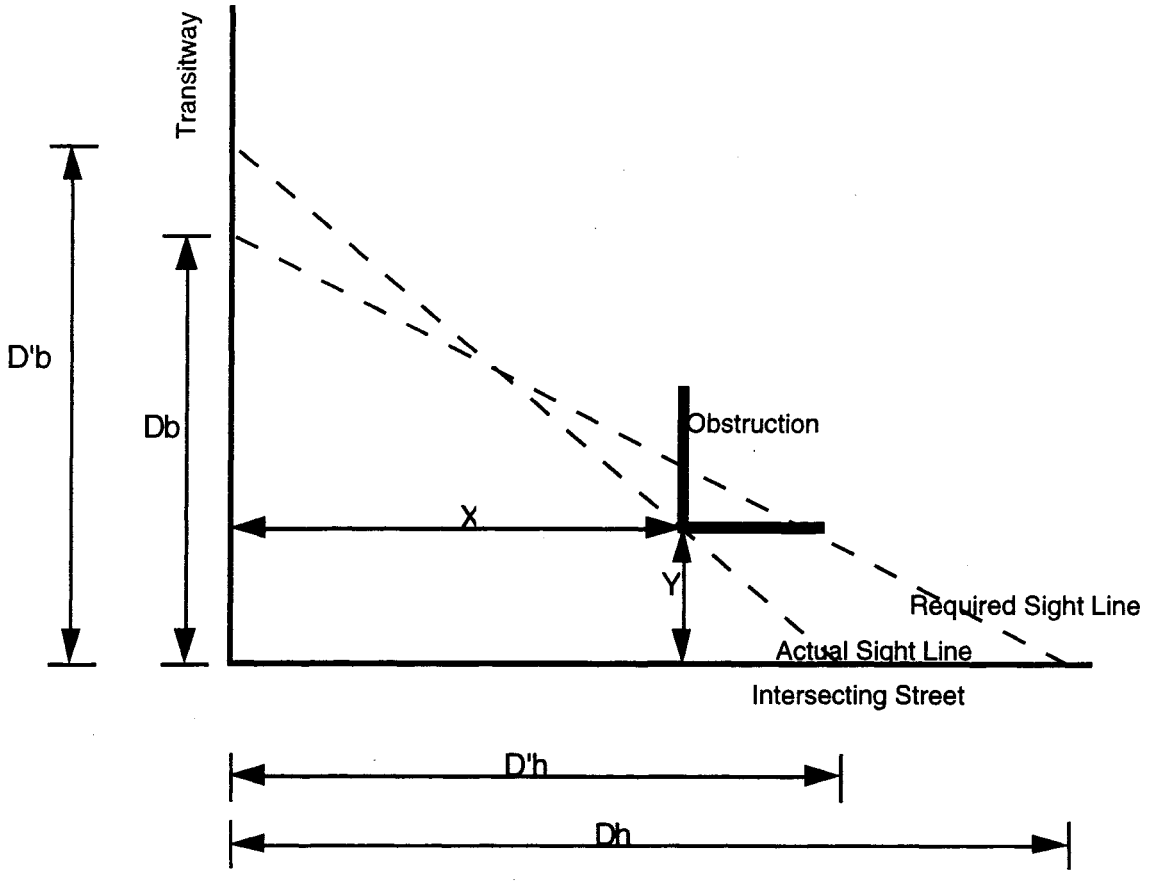

Figure 2. Definitions for showing sight line distances.

The values of X and Y in Figure 2 are the distances of the obstruction from the Transitway and the intersecting street respectively. The last column in Table 12, required average vehicle velocity, is the speed required to satisfy the sight distance requirement imposed by the bus speed and the distance of the obstruction from the Transitway and the intersecting avenue.

Table 12 Sight Line Examples (Using Figure 2 definitions)

x(ft)	y(ft)	Required Vb (mph)	Vv (mph)
80	340	20	10
160	220	20	20
280	200	20	30
80	680	40	10
160	450	40	20
280	400	40	30

Notice in Table 12 that when the obstruction is placed near the Transitway (x is small, less than 40 feet and y is large) Vv must be considerably decreased. Note too that with a typical bus speed of 40 mph and with the obstruction located 680 feet from the street, the vehicle's average speed cannot exceed 10 mph if an adequate sight distance is to be maintained.

Table 13 represents the accident frequencies on the Transitway's intersecting avenues. The frequency figures were calculated from the number of vehicles which we observed for each Transitway intersection and the time periods over which these vehicles were observed. We expressed the number of vehicles which crossed the Transitway during a "bus year"; that is, 246 days. This number was divided by the number of recorded accidents yielding the frequency of accidents per bus year and then multiplied by one million to avoid large negative exponents.

Table 13 Accident Frequency

	Accidents/yr	Frequency *
23rd Ave SE	0.00	0.00
25th Ave SE	0.50	1.78
29th Ave SE	0.50	1.37
30th Ave SE	0.25	4.33
Malcolm St	1.25	1.46
Westgate	1.00	1.29
Energy Park Dr	0.75	6.01
Como Ave	1.00	3.83

* Frequency values were multiplied by one million.

Discussion

Bus Driver Observations

The majority of bus drivers arrived promptly and drove the buses cautiously. For instance, looking in the rear view mirrors, being observant at intersections and approaching intersections slowly, looking both ways. Most drivers stayed within the posted speed limit ranges of 35 to 45 mph. Some drivers were pleasant with passengers and courteous upon arrival and departure. Some bus drivers appeared to be notably cautious in their driving behavior, viewing their jobs as important. They seemed to take pride in their work.

However, a few drivers were less concerned with their driving behavior. Some were less likely to look in rear view mirrors regardless of other traffic. At the intersections, some drivers didn't hesitate, not even slowing regardless of the presence of other vehicles. Several of the bus drivers tended to speed at some time during the trip. Excess speed was usually around 5 mph, however, a few drove about 10 mph above the limit. Very few of the drivers seemed to slow for the speed bumps. Some drivers talked on the CB radio to the dispatcher or other bus drivers. Most drivers would call in for a time check or rerouting instructions, but it was apparent that others would continue the conversation, which might have distracted them from their driving. Some drivers excessively accelerated or decelerated at bus stops and intersections causing the passengers to hold the seat back or adjacent poles for balance.

We could find no consistent bus driver behaviors which would unduly contribute to accidents. If bus drivers were to become exceptionally cautious in their driving, for example coming to near stops at each intersection, it is likely that accidents could be reduced. However, it is also likely that the efficiency of the bus service would be curtailed to an unwarranted extent. In the following we suggest that there are more compelling potential causes for Transitway accidents than bus drivers' driving behavior.

Intersection Observations

In this section we discuss findings presented in the previous section. Two of the data categories suggest problems which are serious enough to account potentially for most of the accidents which have occurred at the intersections on the Transitway. These categories are stop sign violations and limited sight distances. The data for the other categories are interesting and

may, in several instances, be contributory to our understanding of the causes of Transitway accidents.

Vehicle Type

The data in Tables 1 through 8 is consistent in showing that there was a mixture of vehicle types passing through the Transitway intersections with cars predominating followed by light trucks, commercial trucks and semi-trucks. Fifteen of the 24 Transitway accidents as of April 29, 1996 involved cars, six light trucks, one commercial truck and one semi-truck. This data suggested that accidents were not primarily confined to one vehicle type but rather accidents were related to frequency of vehicle types which crossed the Transitway. Thus slightly more that 60% of accidents were caused by cars and about 50 % of the vehicles crossing the Transitway were cars. At the other extreme commercial trucks and semi-trucks each accounted for about 4% of the accidents while each class accounted for about 8% of traffic crossing the Transitway.

Signal Light Violations

At Energy Park Drive and Como Avenue where the intersections are controlled by stop lights actuated by the approaching buses, no drivers were definitely identified as violating the red lights. Table 13 showed that Energy Park Drive and Como Avenue had the highest accident frequencies among the Transitway intersections. This observation is discussed below in the context of the contrast between accident frequencies at intersections governed by stop signs and those by signal lights.

Stop Sign Violations

At the intersections with stop signs from one percent to four percent of the motorists ran the stop sign (mean of about two percent) and 37% to 55% (mean of about 46%) of the motorists used a rolling stop. The number of people running the stop signs alone, *two percent of the total*, could be sufficient to account for the Transitway accidents observed.

Those failing to stop, who also failed to look both ways before crossing the Transitway, form another group of risk takers which could easily contribute to accidents. About 14% of the drivers crossing the Transitway were in this category of failed-to-look while executing a rolling stop or running the stop sign.

The number of occasions in which one or more buses were present when a driver approached the intersection was only 16% of the total number of Transitway crossings. If we reason that accidents between vehicles crossing the Transitway and buses cannot occur if a bus is not present at the intersection, then we observe that the accident frequencies shown in Table 13 which are

based on the total number of vehicles crossing the intersections during the time the Transitway buses are running, could also be presented based on the number of times a vehicle and a bus were both present at or near the intersection. That is the frequencies in Table 13 could be multiplied 6.25 (100/16). We could continue this line of reasoning by suggesting that the drivers most likely to cause accidents were those that that failed to come to a complete stop and we could again increase the accident frequency by a factor reflecting drivers that did not stop. This latter reasoning is, however, not based on the logically firm foundation that if and only if a bus is present can there be an accident. Nevertheless common sense suggests that this latter line of reasoning is not completely specious.

Nearly one-half of the drivers failed to stop at the Transitway stop signs. Two percent of the drivers ran the stop signs. The reasons for this behavior are not clear. Given the nature of the businesses on the north side of the Transitway and the fact that the Transitway has been in operation for about four years, it is reasonable to suppose that almost all of the drivers are familiar with the Transitway intersections and that they have crossed the Transitway at a given intersection many times. It is also reasonable to suppose that the drivers of the vehicles crossing the Transitway understand the meaning of a stop sign. The stop signs themselves are completely evident and as noted almost all drivers are familiar with the Transitway and know that it is guarded by stop signs. Apparently, nearly one-half the drivers crossing the Transitway are scofflaws. Of these scofflaws about 14% percent failed to look both ways before running the stop sign or rolling through it. The reasons for scofflaw behavior were not evident from the data. There is nothing in the data to suggest that larger stop signs or stop signs with flashing lights or more warning signs stating that there is a stop sign ahead would have an impact. In fact due to the likely drivers' familiarity with the intersections, it is unlikely that such signing and signaling would have more than a transient impact on the scofflaw behavior.

Energy Park Drive and Como Avenue had the highest accident frequency but a complete lack of drivers definitely known to be running the red light. Reconciling this observation with the apparent scofflaw behavior at the intersections guarded only by stop signs is difficult. We could postulate a sampling accident, however, we made 265 observations at both Como Avenue and Energy Park Drive and this compares favorably with the numbers of observations made at the other intersections guarded by stop signs. We could suggest that there were very intermittent system failures and the light did not turn red for traffic crossing the Transitway when the bus approached. Perhaps the yellow interval was too short and drivers were trapped by the yellow light dilemma. If the system actuating the traffic lights did not allow enough time for cross traffic to clear the intersection before the bus arrived at the intersection, then accidents could result. If this later explanation is combined with the yellow light dilemma then this would be a slightly stronger

possibility as a cause for accidents. The logical difficulty which none of these suggestions convincingly overcomes is that accidents at Como Avenue and Energy Park Drive could not occur unless drivers were running red lights and we saw no instances of drivers running red lights.

The accident reports for Como Avenue and Energy Park Drive suggest various causes for accidents:

- Como Avenue. A car in a light snowfall trying to make a U-Turn on the Transitway struck a bus.
- Como Avenue. A car ran the red light on lightly packed snow and struck a bus.
- Como Avenue. A car slid onto the Transitway on very icy pavement and struck a bus.

  In these cases weather could have been, or for the icy pavement was, a factor.

- Energy Park Drive. The driver of the car did not stop and ran into a bus. She stated she did not remember seeing a red light
- Energy Park Drive. "Bus was stopped, waiting for break in traffic to make left turn onto T-Way when it was hit from behind." (This may not qualify as a Transitway accident.)
- Energy Park Drive. (This report was apparently written by the Transitway bus driver.) "While going north of T-Way I slowed to 20 mph to let light change. When it changed I started to accelerate and looked west then no cars. I looked right and saw a small white car approach. The light had changed so I started to go when I saw that the car was not slowing. I hit the brakes and horn and tried to avoid her door but hit the left front outer panel."

These accident reports suggest additional possible explanations for the accidents occurring at the intersections protected by bus-actuated traffic lights as well as reinforcing some of the above suggestions not based directly on accident reports.

Weather could be a factor in some of the accidents. Sliding through the intersection or attending to driving and not to traffic lights due to reduced visibility was different than the scofflaw behavior observed at the intersections protected by stop signs. The last accident report is interesting in that the bus driver clearly stated that he had to slow to 20 mph to allow the light to change to green for the bus and red for the cross traffic. This reinforces the suggestion made above that system timing might be improved. The bus driver should not be required to reduce speed to accommodate the traffic light's change to green for the bus and then to increase speed to pass through the intersection before the light changed back to red for the bus and green for the

cross traffic. One of the authors of this report commented that she had on several occasions seen this, slow for a green then accelerate to avoid a red, bus driver behavior.

While we have no hard evidence to conclusively show why there were relatively high accident frequencies at Como Avenue and Energy Park Drive, we think that some of the suggestions offered above, operating either alone or in combination, could account for at least some of the accidents.

There is one other factor which, when combined with the observations on scofflaw behavior and the lack of searching for approaching buses, may contribute to the explanation for the observed accident frequencies and that factor is sight distance.

Sight Distances

According to our measurements and calculations based on published guidelines, there are sight distance deficiencies at all of the eight Transitway intersections studied. At each intersection a driver can be proceeding either north or south across the intersection and for either direction of travel the driver can look for approaching eastbound or westbound Transitway buses. This means that we are concerned with four sight distances at each of the intersections. At five of the intersections all four sight distances failed to meet guidelines and at Energy Park Drive three of the four sight distances failed to meet guidelines. For these sight distance calculations we made the conservative assumption that when the approaching vehicle was 80 feet from the Transitway its speed was 10 mph. It is likely that the speed of vehicles preparing to run the stop sign was greater than 10 mph when it was 80 feet from the intersection and it is possible that the speed of vehicles which would subsequently roll through the intersection with out stopping was also greater than 10 mph at 80 feet from the intersection. The clear implication is that under these sight distance conditions with the bus approaching the intersection at 40 mph, drivers could not stop in time to avoid an accident if the bus and vehicles arrival were destined to be coincident in time.

While there is no firm data to support this observation, we note that the intersections with the greatest number of adequate sight distances had the lowest accident frequencies. That is 23rd Avenue and Westgate avenue had two and three adequate sight distances respectively. No intersecting avenues had adequate sight distances in all four directions of view.

Another factor which contributes to accidents is driver behavior. We have noted the scofflaw behavior with respect to running stop signs. And we have further noted that when this behavior is combined with short sight distances and failure to look both ways for oncoming buses, it is not difficult to envision that this is an very real opportunity for an accident. This risk taking behavior

is of course not confined to Transitway intersections. A few people probably run all stop signs but for any given stop sign the number may not be as high as the two percent observed for the Transitway. In the literature review for this project we looked at risk taking behavior at railroad-highway grade crossings. Even in this well-studied situation the reasons for taking the risks are obscure and to date remedial steps have not met with good success. In the Transitway situation it is difficult to believe that such actions as different signing or better lighting would reduce the risk taking proclivities of the scofflaws. Perhaps a frequent and conspicuous police presence would have an effect.

While we cannot suggest specific actions guaranteed to permanently alter scofflaw driving behavior (short of a continuous police presence), we can suggest specific actions for reducing the effect of other factors which may contribute to Transitway accidents and these suggestions are a part of our recommendations presented in the next section.

Conclusions And Recommendations

We were not able to identify a single cause for the Transitway accidents which have occurred over the last four years. The data has, however, allowed us to suggest that certain factors acting in combination, may have contributed to causing Transitway accidents. These factors are:

- Two percent of the drivers run the stop signs and about one-half the drivers participating in a rolling rather than a full stop.
- About 20% of drivers do not look both ways before crossing the Transitway.
- Winter weather brought slippery roads and reduced visibility conditions.
- The timing for bus actuated traffic lights may not be optimal.
- Only five of the 32 sight distances met minimum guidelines.

The data we have collected is supportive of the idea that each of the above factors may have contributed to Transitway accidents. Interpretation of the data suggests that combinations of these factors are more likely to have contributed to accidents than any factor operating alone. The causes of accidents are complex and combinations of factors causing accidents need not be the same for all accidents.

While we have no suggestions for eliminating the risk-taking behavior of scofflaws, we recommend a more frequent and conspicuous police presence at Transitway Intersections. Other recommendations are:

- Improve lighting at the intersections to improve visibility. We cannot prevent snow or fog but we may be able to reduce their impact on drivers' ability to detect on-coming buses.

- Improve sight distances by eliminating the sight line obstacles whenever this is possible. If it is not possible, then information signs could be used to warn drivers of the short sight distances. One such frequently seen sign is BLIND DRIVEWAY.

- Be especially diligent and thorough about snow and ice removal at the approaches to the Transitway.

- Adjust the timing parameters of the bus actuated system for switching traffic lights to permit buses to drive at a constant speed when approaching and passing through the intersections.

- Consider the effect on accident reduction of reducing bus speed. We have shown the clear relationship between bus speed and sight distance. This could be especially important in the vicinity of intersections where sight distances cannot be improved.

- We recommend considering the development and use of "new wave" messages on signing for the streets intersecting the Transitway. The signing could be done on portable electronic signs. Messages would address the factors cited above as potentially accident causing. The messages would be designed to have high impact for example "NEVER HIT A SCHOOL BUS. THE BUS WILL HIT BACK."

References

1. Easa, S.M. (1993). Should vehicle 15-percentile speed be used in railroad grade crossing design? ITE Journal, August, p 37-46.

2. Lerner, N. (1990). Driver behavior at rail-highway crossings. Prepared by the Comsis Corp. Federal Highway Administration Report No. FHWA-SA-90-008.

Appendix A

Data Sheets

for

Motorists' Behavior at Transitway Intersections

and

Bus Driver Behavior

Data Sheets

BUS DRIVER BEHAVIOR

OBSERVER:_____

DATE: _____ DAY: _____

TIME: _____

VEHICLE# _____ ROUTE# _____

DIRECTION:

TO ST. PAUL_____ FROM ST. PAUL _____

TO MINN _____ FROM MINN _____

OBSERVATIONS:

The Transitway was designed to transport staff and students between the Minneapolis campus and the St. Paul campus in a cost-effective and time efficient manner. These objective have been fulfilled, however, safety has become an issue with regards to the street crossings on the Transitway system. Therefore, our task is to identify bus driver behavior while traveling the Transitway. Open-ended observations will be recorded in the logbook provided. Observations will be made at various times of the day, to and from both campuses. Data recorded should indicate the crossing or intersection of the observation noted. The following are some ideas that you might record in the logbook.

Does the bus drive respect the current traffic laws on and off the Transitway?

When traveling off the T-way, does the driver practice safety and caution, with respect to other motorist?

Is the driver within the speed limit regulations? Note highest speed.

Is the driver respectful of others using the T-way?

Is this bus on schedule or on-time, does the driver compensate for this?

Note any unusual driving behavior.

MOTORIST BEHAVIOR AT INTERSECTIONS:

1. Date:									
2. Time of Day:									
3. Intersection:									
23rd Ave									
25th Ave									
29th Ave									
30th Ave									
Malcolm									
Westgate									
Energy Park Dr									
Como Ave									
4. Direction of Travel:									
North or South									
5. Type of Vehicle:									
Car									
Light Truck									
Commercial Truck									
Semi-Truck									
6. Type of Stop									
Complee									
Yield (rolling)									
Ran It									
Green Light									
7. Did Motorist Look Both Ways?									
Yes									
No									
Unable to See									
8. How Many Buses Were in Sight?									
0, 1, 2, 3									
9. Was There an Incident?									
Yes of No									
10. Were Others Present of the Transitway?									
Bicyclist									
Pedestrians									
Inline Skaters									
Police									
Other									

Appendix B

Bus Driver Behavioral Observations

Bus Driver Observation Data

Bus rides to St. Paul:

Date: 1-29-96
3:40 pm Monday
#422 13W to St. Paul
Notes:
- 5 min. late - Arrival on time
- Driver was observant at all intersections.
- He slowed as approached intersection and looked both ways.
- Speed was in accordance with posted limit.
- He looked in side-view mirror often.
- He acknowledged other bus drivers with a wave.
- Overall good driver.

Date: 1-31-96
4:00 pm Wednesday
#441 13W to St. Paul
Notes:
- Time: 4:02
- The driver looked in side-view mirror while leaving T-way stops.
- Speed was good, within 30-35 mph limit.
- At Energy Park and T-way, he looked both ways and slowed down so light would change.
- At Como Ave. and T-way, the light was green and driver didn't look, but okay.
- At Fairgrounds Parking lots, he yields for a car before making a left onto Buford.
- Overall good riding experience.

Date: 2-12-96
10:40 am Monday
#445 13W to St. Paul (via Energy Park and Raymond)
Notes:
- Male, gray hair, very heavy frame, 40-50 years.
- On time.
- 35 mph in 30 mph zone
- Driver doesn't hesitate or yield at intersections and maybe looks both ways. A semi-truck was half way in the road at cross street and driver drove around truck without slowing down much.
- He announced all stops at St. Paul Campus.
- Makes turns with one hand - should probably use two to maneuver the bus safely.
- Signals at corners only when other cars are present, otherwise doesn't use turn signal.

Date: 2-12-96
11:10 am Monday
#604 13T to St. Paul
Notes:
- Male, gray hair, older, in 70's.
- Traveling 45-52 mph on T-way.
- Capacity of bus was full, with many people standing.
- Driver would approach turns without yielding to other traffic.
- Driver doesn't appear to be as cautious as other bus drivers.

Date: 2-13-96

10:40 am Tuesday
#434 13W to St. Paul
Notes:
- Rick has straight gray hair covering back of neck, also wearing solar shields (See description from 2-12-96, 10:40 am 13W to St. Paul) *Same driver.
- Arrival time: 10:43 am
- Similar driving behavior (See previous entry from 2-12-96)

Date: 2-13-96
11:10 am Tuesday
#604 13W to St. Paul
Notes:
- Older male in 70's (See 2-12-96 entry, 13T, 11:10 am to St. Paul)
- Similar driving habits as other entry.
- Mph 50's

Date: 2-13-96
1:40 pm Tuesday
#419 13W to St. Paul (via Energy Park and Raymond)
Notes:
- Male in his 30's with brown wavy hair and thin build. He wore rose tinted glasses.
- On time.
- He looks in the rearview mirror often.
- He approaches corners (intersections) slowly and cautiously.
- No incidents or unusual driving behavior.
- Unable to monitor mph.
- Overall good driver.

Date: 2-13-96
2:10 pm Tuesday
#443 13T to St. Paul
Notes:
- Male, D.J. Swanny (See entry from 1-31-96, 13W at 4:15 pm to Mpls.)
- Arrival time was 2:15 pm (5 minutes late).
- At Energy Park and T-way, he looked both ways before crossing intercession.
- He approached the curve on the bridge slowly and cautiously.
- At Como and T-way, he looked before crossing.
- He drove more cautiously today.

Date: 2-19-96
10:05 am Monday
#634 13T to St. Paul
Notes:
- Male, gray hair, 60's years old, medium build
- on time (Arrival 10:07).
- Driver looks in rear-view mirror often.
- Travels within speed limit, 30-35 mph.
- When approaching Energy Park intersection, he slowed down with plenty of time for light to change.
- Driving over T-way (on bridge), traveling at 45 mph. s/b 35 around corner.
- He approached all stops slowly and cautiously.
- Good defensive driver.
- Comfortable ride.

Date: 2-19-96
11:00 am Monday
#441 13W to St. Paul
Notes:
- Female with long blond hair in 20-30's years old. Stocky, overweight build.
- On time.
- She was a good driver, very cautious.
- Unable to record mph - Standing room only.
- Driver was curious with other motorists
- Very cautious at Westgate, Como Ave., and Fairgrounds intersections.
- Very pleasant riding experience.

Date: 2-20-96
12:00 pm Tuesday
#446 13W to St. Paul
Notes:
- Female in 20's with long dirty blond hair, heavy build, wearing Gopher hat. (Also see entry from 2-13-96 13W at 11:35 to Mpls.)
- Arrival time 12:04.
- Driver doesn't look in the mirrors very much or doesn't make an obvious attempt to.
- She approaches intersections at a comfortable speed.
- Also at bus stops, a smooth non-jerky approach.
- Drives within speed limits, although I was unable to monitor actual speed variations.

Date: 2-20-96
12:40 pm Tuesday
#441 13W to St. Paul
Notes:
- Female - same driver as early ride (12:15) (See also entry from 2-19-96 13W at 11:00 am to St. Paul)
- Arrival time 12:46.
- Again, driver is cautious and drives slow, within speed limits (or slower).
- I missed the connecting bus at 12:55, we arrived at 1:00 pm.
- No new observations.

Date: 2-22-96
9:05 am Thursday
#445 13T to St. Paul
Notes:
- Male in 40-50's, very heavy, gray hair covering back of neck, wearing glasses. (Maybe same driver as 2-13-96 13W at 10:40 am to St. Paul, Rick).
- Arrival time 9:07
- Unable to monitor mph's.
- Doesn't really look at cross streets - wasn't obvious.
- Driver yielded for a car on Westgate.
- No incidents to report.
- He maintained speed throughout trip.

Date: 2-22-96
9:35 am Thursday
#439 13T to St. Paul
Notes:
- Male in 40's, big guy, black hair and mustache with gray on sideburns. (Mark Hammer, see entry from 2-12-96 13W at 11:35 am to Mpls.)

- Drives very well, cautious, and considerate.
- Mark has a very good demeanor - greeting passengers on arrival.
- Very comfortable ride.

Bus rides to Minneapolis:

Date: 1-29-96
3:55 pm Monday
#442 13W to Mpls.
Notes:
- Male, 55-65, gray hair, glasses, heavy stature, 'Gene'.
- Bus was on time.
- Speed was good, 5 mph over sometimes.
- Wasn't too observant at intersections - Didn't look both ways.
- At 29th SE - Didn't slow down as truck approached intersection (truck did stop).
*Note - snow/ice packed on roads.
- At SE 30th - Didn't slow down while sand truck didn't stop at crossing and proceeded through intersection. (No incident).
- Also, Gene was talking on CB radio while crossing Como Ave. He didn't slow, but expected traffic light to change and other traffic to stop. (No incident).

Date: 1-31-96
4:15 pm Wednesday'
#443 13W to Mpls.
Notes:
- Male, 30's, dirty blond hair - long, sunglasses, slim, wearing hat with "DJ Swanny" on back side.
- On time.
- While leaving St. Paul Center, at corner (Cleveland), lights were blinking red.
- Driver was following too close to car on Buford Ave. and had to apply brakes to avoid hitting car.
- He looked in rear-view mirror often.
- At Como and T-way - looks both ways
- At Energy Park and T-way - slows down and looks both ways
- Driver was cautious at crossings.

Date: 2-12-96
10:55 am Monday
#442 13W to Mpls.
Notes:
- Tony had mousy greyish hair with a beard. He was overweight and in his 50's.
- Tony was talking on CB while driving, was minimally distracted due to the location of handset receiver. The location of mount is above head on left side.
- He looks in mirrors often.
- Mph was good and within limits.
- No yielding at cross streets on T-way, but there was no need.

Date: 2-12-96
11:35 am Monday
#439 13W to Mpls.
Notes:
- Mark Hammer has black hair and mustache with gray on temples, heavy frame, early 40's.
- radio was on - BOB100 station.
- Called dispatcher for time check.
- Mark was very courteous with passengers, greeting them.

- He looks both ways at intersections, even though the lights were green.
- Mph was within limits.
- Overall good, safe driving behavior.
- Note: Mark called dispatcher about cars that were parked at 30th on T-way. They were blocking a sign and he was concerned with the visibility of those signs and wanted to notify the police to take action.

Date: 2-13-96
10:55 am Tuesday
#426 13W to Mpls.
Notes:
- Tony was 40- years old, mousy brown hair with some gray and a mustache, medium build.
- On time.
- Tony was very cautious at all intersections and yields for cross traffic.
- No incidents to mention.
- Overall good driving behavior.

Date: 2-13-96
11:35 am Tuesday
#446 13W to Mpls.
Notes:
- Female in 20's, long hair - dirty blond, heavy build, Gopher hat.
- On time.
- Radio was playing - KDWB 103.
- Route traveled was Cleveland, Raymond, Energy Park, to T-way.
- Appeared to drive faster around corners and common streets(not including T-way), but unable to record actual speed limit.
- No situations to mention.

Date: 2-13-96
1:55 pm Tuesday
#441 13W to Mpls.
Notes:
- Male, brown hair with beard, heavy build, wearing glasses, in his 40's (refer to entry from 1-31-96 13W at 4:00 pm to St. Paul)
- On time.
- Driver went through yellow light at Cleveland and Buford. He should have waited for a green light rather than speeding up to make the light before it turned red.
- He uses turn signals.
- He approaches some intersections too fast, and must apply the brakes hard. Some passengers (including myself) must hold on or slide of the seat.
- Mph was between 30-40.
- At Energy Park and T-way, the driver didn't slow down or hesitate for the light to change, but maintained speed and drove through. *This concerned me because potential for incident was high with that behavior.

Date: 2-13-96
2:35 pm Tuesday
#443 to Mpls. (via Cleveland/EP)
Notes:
- Male (D.J. Swanny) (See entry from 1-21-96 13W at 4:15 pm to Mpls.)
- Similar driving behavior, but was reading log book while making a turn onto T-way (from EP).
- Mph: 30-35

Date: 2-19-96
10:35 am Monday
#688 13W to Mpls.
Notes:
- Female with long straight black hair, wears glasses, small woman (oriental), 20-30 years old.
- On time.
- She fastened seat belt before leaving St. Paul Center.
- She also had a briefcase on her seat, as a back support.
- She often looked in rearview mirror.
- She was very cautious while turning corners.
- Generally, drives slower and more cautiously than other bus drivers.
- Good comfortable ride.

Date: 2-19-96
11:15 am Monday
#443 13W to Mpls.
Notes:
- Male with brown hair, beard and mustache, butch cut, wore tinted glasses, medium build, late 40's.
- On time.
- Driver was more aggressive than female drivers I rode with earlier, but still no reason for concern.
- He approached the turns faster, but under control and slowed as we approached intersections.
- He did look around a lot, taking eyes off the road, however no incidents to report.

Date: 2-20-96
12:15 pm Tuesday
#441 13W to Mpls.
Notes:
- Female in 30's, long blond hair, stocky frame. (See entry from 2-19-96 13W at 11:00 am to St. Paul)
- On time.
- bus was full - standing room only.
- I sat in the middle on the bus and was unable to observe the driver, however we traveled at a comfortable speed.
- Very smooth approaching and stopping at bus stops.
- No abrupt movements.
- Appeared to be within speed limits.

Date: 2-20-96
1:05 pm Tuesday
#441 13T to Mpls.
Notes:
- Male in late 20's (30's), stocky build, wearing BB-hat and glasses.
- Bus was full.
- Unable to make observations.
- No obvious incidents to report.

Date: 2-22-96
9:20 am Thursday
#442 13T to Mpls.
Notes:
- Male in late 40's, tall and thin, brown hair and beard (with gray), dirty appearance, wearing solar shields and black "Camel" hat.

- On time.
- Driving style was very abrupt, fast starts and stops. This was a very rough ride.
*- The condition of this bus was bad, very noisy, everything rattled, the floor was cracked and would open as we hit a bump.
- When picking up passengers, he approached stop very fast and started leaving (taking off) forcing passengers to find seats quickly and causing some to become very unstable.
- He also approached traffic lights fast.
- Mph was 50+ on T-way bridge.
- Very uncomfortable ride.

Date: 2-22-96
9:50 am Thursday
#446 13T to Mpls.
Notes:
- Female in 20's wearing Gopher hat, long blond hair. (Also see entry from 2-20-96 13W at 12:00 pm to St. Paul)
- Good driver, cautious of cross streets and other motorists.

Buses to St. Paul:
Date: 1-31-96
11:00 am Wednesday
#? 13W to St. Paul
Notes:
- Pulled to left to avoid passing pedestrian too closely on T-way.
- 35 in 30 mph zone.
- On time for Mpls and at St. Paul.
- Overall was a very cautious driver.

Date: 1-31-96
12:05 pm Wednesday
#478 13T to St. Paul
Notes:
- early at 12:01.
- Always drove at the speed limit.
- Seemed to be extra cautious when braking, allowing plenty of room to stop.
- No violations of any traffic rules.

Date: 2-7-96
12:55 pm Wednesday
#442 13W to St. Paul
Notes:
- At Oak and Huron Blvd. he was about 3" from the vehicle in front of him.
- 45 mph in a 40 mph zone.
- Didn't signal left in St. Paul parking lot area.
- Arrived on time in St. Paul.
* Caught 13W at 1:35 from St. Paul but it was via Raymond and Como Avenue.

Date: 2-8-96
3:55 pm Thursday
#441 13W to St. Paul
Notes:
- Was extra cautious not to splash us on.

- Observed speed limits closely.
- Didn't slow down at all for the speed bumps at St. Paul campus.
- Right before Student Center a car was trying to get turned around and was blocking traffic in each direction. Driver practiced no caution. Slowed down at the last minute and then was stopped so close to the car it took him extra time to get out of there.

Date: 2-8-96
5:35 pm Thursday
#442 13W to St. Paul
Notes:
- Turned left onto Oak in front of a car and car had to slow.
- Observed speed limits.
- Seemed to pass bikers a little too closely.
- At first light on T-way to St. Paul, a guy ran the yellow and driver made no attempt to slow.
- Doesn't slow for speed bumps either.
- After dropping someone at the lots didn't observe him checking his mirrors before switching lanes to make a left.
- Arrived on time.

Date: 2-9-96
4:05 pm Friday
#? 13T to St. Paul
Notes:
- Went through yellow at Church Street.
- Turned onto Oak on red, wasn't in the intersection.
- Went between 40-45 the entire length of the T-way.
- Didn't come to a full stop at stop sign just before the Student Center. This was the first time no one got off at the stop and there was no other traffic so it was interesting that he did a rolling stop.

Date: 2-12-96
7:15 am Monday
#442 13W to St. Paul
Notes:
- Traffic rather heavy on Washington and he stops at the last minute.
- 45-48 mph in 35 mph zone.
- This speed is too fast for the sensors because at the first light 2 cars were hitting their brakes hard at the quick change of the light. Of course they may have been speeding too.
- Came to rolling stop at sign right before entering St. Paul campus by lots.

Date: 2-13-96
8:40 am Tuesday
#438 13T to St. Paul
Notes:
- Had to turn onto University on a red because of inconsiderate pedestrians.
- Cautiously slowed for five peds j-walking across University to the Rec. Center.
Maintained 35 and 40 mph limit on the nose. (This seemed to help with the light sensors but it still seems like cross traffic gets a surprise.)
- He actually slowed for the speed bumps at St. Paul Campus. Very nice considering the bus was packed.
- This was a pretty flawless trip.

Date: 2-14-96
1:15 pm Wednesday
#443 13W to St. Paul

Notes:
- Almost hit a guy pulling back into traffic after making drop in front of Moos Tower. Guess he didn't check his mirrors careful enough.
- Exceed speed limit by approximately 5 mph on T-way.
- Came to complete stops at signs.
- Seemed cautious of cross traffic at the intersecting lights.

Date: 2-15-96
6:05 pm Thursday
#634 13T to St. Paul
Notes:
- Turning right onto University he turned in front of some peds but it's almost necessary to get through that intersection.
- Followed speed limits within 2-3 mph.
- Felt he could have gone a little slower around the curved ramp on T-way. Road conditions were good but the curve is pretty tight. I hate sitting on a stranger's lap.
- Noticed he slowed a little after hitting the road sensors to give cross traffic a little time to respond.
- Overall a very good driver.
*Had to catch a 13W via Raymond back, nothing else runs this late.

Date: 2-20-96
9:20 am Tuesday
#634 13T to St. Paul
Notes:
- This guy doesn't know how big his bus is. Each time he's pulled away from the curb after loading people he has entered the second lane of traffic to some extent with the left corner of the bus. At Blegen, a car swerved to avoid him.
- Taking corners with him is a little scary too.
- He follows the traffic laws fine. Driving the bus is his problem.

Date: 2-21-96
10:35 am Wednesday
#415 13W to St. Paul
Notes:
- Drove speed limit, followed all traffic rules.
- Seemed to be watching for cross traffic on T-way.
- Was very courteous to the many bikers.

Date: 2-22-96
3:05 pm Thursday
#634 13T to St. Paul
Notes:
- He cruised down the T-way between 40-45 the whole way.
- Traffic at Energy Park Drive had to stop quick. At that speed he reaches the intersection too quickly.
- Blazed over the speed bumps and I almost fell out of my seat when he turned onto Buford from Randal.
- Did make complete stop at Buford and Gurtner and no one was getting off.

Buses to Minneapolis:
Date: 1-31-96
11:35 am Wednesday
#440 13W to Mpls.
Notes:

- Left and arrived on time.
- Extra wide right on Washington but there was no traffic.
- Made left across bridge on a yellow mostly red (to go to Blegen).
- When turning onto Washington, sitting at red light on Oak, a car came up her right side and turned right as she was moving forward to start her right turn.
- When turning onto Cleveland didn't come to a complete stop at flashing red light.

Date: 2-8-96
5:05 pm Thursday
#433 13T to Mpls.
Notes:
- 30 mph through the inner campus (Limit is 20 mph).
- At 4-way stop, failed to yield right of way to guy on his right.
- Didn't slow for speed bumps.
- At the first light where buses enter the T-way, a Volvo almost ran the red most likely because the sun was in our eyes. By the time the bus driver realized this, we were already in the middle of the intersection. He stopped in the middle which would have done us no good if the Volvo hadn't stopped in time.
- No hostile behavior towards any of the bikers on the T-way.

Date: 2-8-96
6:15 pm Thursday
#? 13W to Mpls.
Notes:
- I got stuck in the middle. Didn't notice anything overtly wrong but I couldn't see much from my position or through the muddy windows.

Date: 2-9-96
5:05 pm Friday
#? 13T to Mpls.
Notes:
- Observed all speed limits.
-Nothing to report except for the ped he cut off turning left onto 15th and when turning onto Washington bridge I thought he should have waited for this car to pass, but he pulled out in front of him so that driver switched lanes (out of preference or necessity, I don't know).

Date: 2-12-96
7:55 am Monday
#451 13W to Mpls.
Notes:
- Left turn leaving campus was difficult because cars going opposite direction didn't stop at the white line.
- Observed speed limits in all areas.
- Lots of bikers. Wasn't overly curious but didn't try to run them over either.
Turning left onto Oak from T-way he sort of pulled in front of an oncoming car. It was a judgment call, but considering his length he probably should have waited.

Date: 2-13-96
9:10 am Tuesday
#419 13T to Mpls.
Notes:
-* Just a note, the whole loop around thing these guys have to make is ridiculous. It is full of tight turns and seems to be asking for trouble.

- Turning right by the expensive parking lot, he didn't come to a complete stop but there were no oncoming cars.
- Could have taken curved bridge on T-way a little slower. Looked like he was going about 40 mph and it's tough to hand on when standing. Otherwise followed speed limit reasonably.

Date: 2-14-96
1:55 pm Wednesday
#451 13W to Mpls.
Notes:
- No notable deviations.
- Bus was pretty empty and traffic seemed light.
- He was just cruising through his route.
- Didn't speed.

Date: 2-20-96
10:10 am Tuesday
#435 13T to Mpls.
Notes:
- Went about 25-30 mph down Bufford and did a rolling stop onto Randall, but there was no traffic.
- Exceeded speed limit on T-way 5-10 mph. 45 in 40 mph zone, and 40 in 30 mph zone.
- A car crossed in front of him at Malcom and he didn't even slow. He wasn't real close but caution would have been nice.

Date: 2-21-96
11:15 am Wednesday
#440 13W to Mpls.
Notes:
- 35 mph in 30 mph zone and about 45 in 40 mph zone.
- Came to rolling stop turning onto Randal.
- Lots of bikers. He wasn't mean, but didn't give them extra room.
- Nothing glaringly wrong.

Date: 2-22-96
3:35 pm Thursday
#? 13W to Mpls.
Notes:
- Overall was a good driver obeying all rules, but turning off T-way onto Oak traffic was heavier because of construction. I think he got a little impatient because a car turned right off 4th and he pulled out anyhow. It was sort of his only chance between lights but it looked like the car had to slow a little.