

## ITS IMPROVES TRANSITWAY SAFETY

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### **EXECUTIVE SUMMARY**

The University of Minnesota constructed a Transitway in 1992 to take its' primary inter-campus connector routes off of city streets. The accident rates during the first few three years were too high causing the University to contract with Short, Elliot, and Hendrickson, Inc. to conduct an investigation. A few recommended sight line and static sign changes along the Transitway didn't change the accident rates. As a second initiative, the University formed a PARTNERSHIP with the Minnesota Department of Transportation, the City of Minneapolis, and Image Sensing Systems, Inc. to effect a safety improvement program. The Center for Transportation Studies at the University joined the partnership to lead a before and after evaluation. In addition to this academic/public/private sector partnership, other ITS aspects of the program are a test bed for Transitway warning devices, detection of bicycles to activate warning devices, machine vision detection of buses and bicycles, and detection of bus speed to select the duration of warning device illumination. The observed driver behavior before warning device activation was that only 43% of 'crossing' drivers made full stops at the seven test bed stop signs whereas 48% made full stops after installation of the warning devices. Furthermore, the test bed area has had one intersection accident in two years since device installation compared to a rate of four per year during the six years before the installation.

### **INTRODUCTION**

This paper presents the program background, the program phase descriptions, conclusions, and credits to the Human Factor's Research Laboratory researchers that did the driver/vehicle behavior studies.

### **BACKGROUND**

In 1992 the University of Minnesota constructed an exclusive Transitway for buses, connecting the Minneapolis and St. Paul campuses along an abandoned railroad right-of-way (Figure 1). The Transitway length is

3.5 miles from the Huron Blvd Parking Complex through light industrial areas to Commonwealth Avenue on the State Fair grounds. On the West end, the Transitway has seven intersections from the parking complex to the Highway 280 underpass. Transitway vehicles have the right-of-way at each of these, with the crossing street traffic controlled by stop signs. On the St. Paul end, the Transitway intersects two public streets controlled by traffic signals.

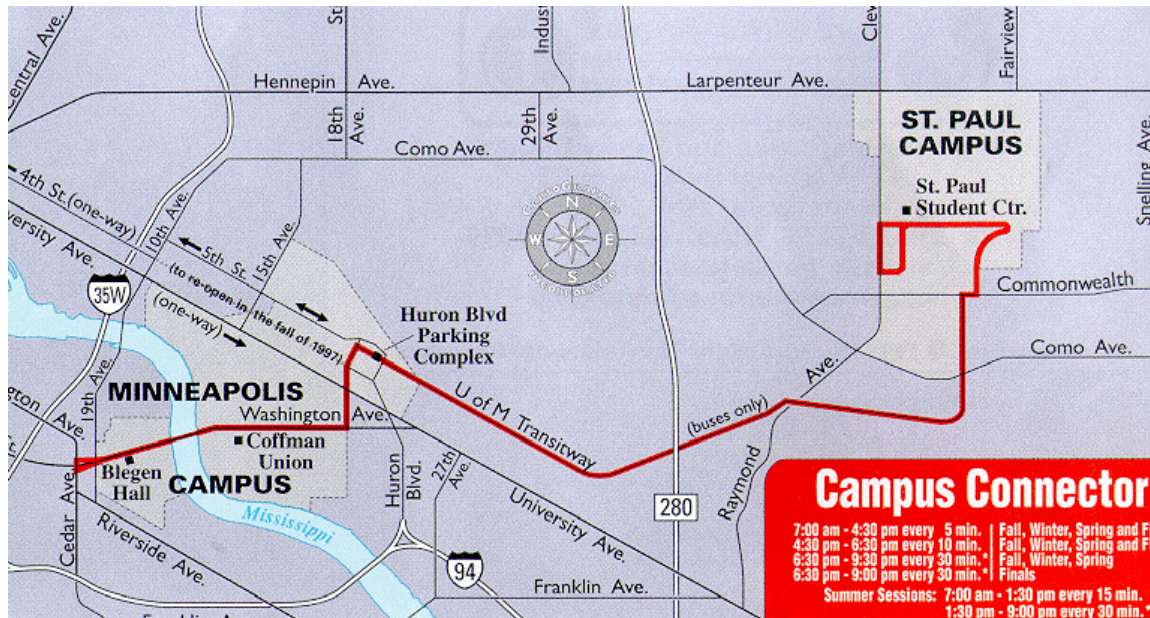


Figure 1. Campus Connector Service Route; 7 AM to 9 PM weekdays

Within the first three years of Transitway operation, the University was experiencing two problems on the western half. There were many accidents and non-bus traffic was using the Transitway. A review found that the Transitway intersection accident rate was ~30 times greater than the state average accident rate for two stop sign intersections. The traffic volume on the cross streets is generally higher than the bus volume on the Transitway; buses both directions on weekdays every 5 minutes from 7 to 4:30 plus every 30 minutes until 9 PM. These 356 daily buses serving sixteen stops carried 2,495,732 passengers during the University 1998-99 fiscal year. Most of the cross street traffic is repeat traffic, crossing the Transitway to access an isolated industrial area north of the Transitway. The highest traffic volume of 900 vehicles per day (VPD) exists on both Westgate Drive and Malcolm Avenue. This is four times higher than the ~400 VPD on the Transitway. This traffic volume differential, the relatively low traffic volumes,

and the desire and need to maintain right-of-way on the Transitway, combine to create a high accident rate for the Transitway. Figure 2 shows the intersection accident counts from March '92 to December '99.

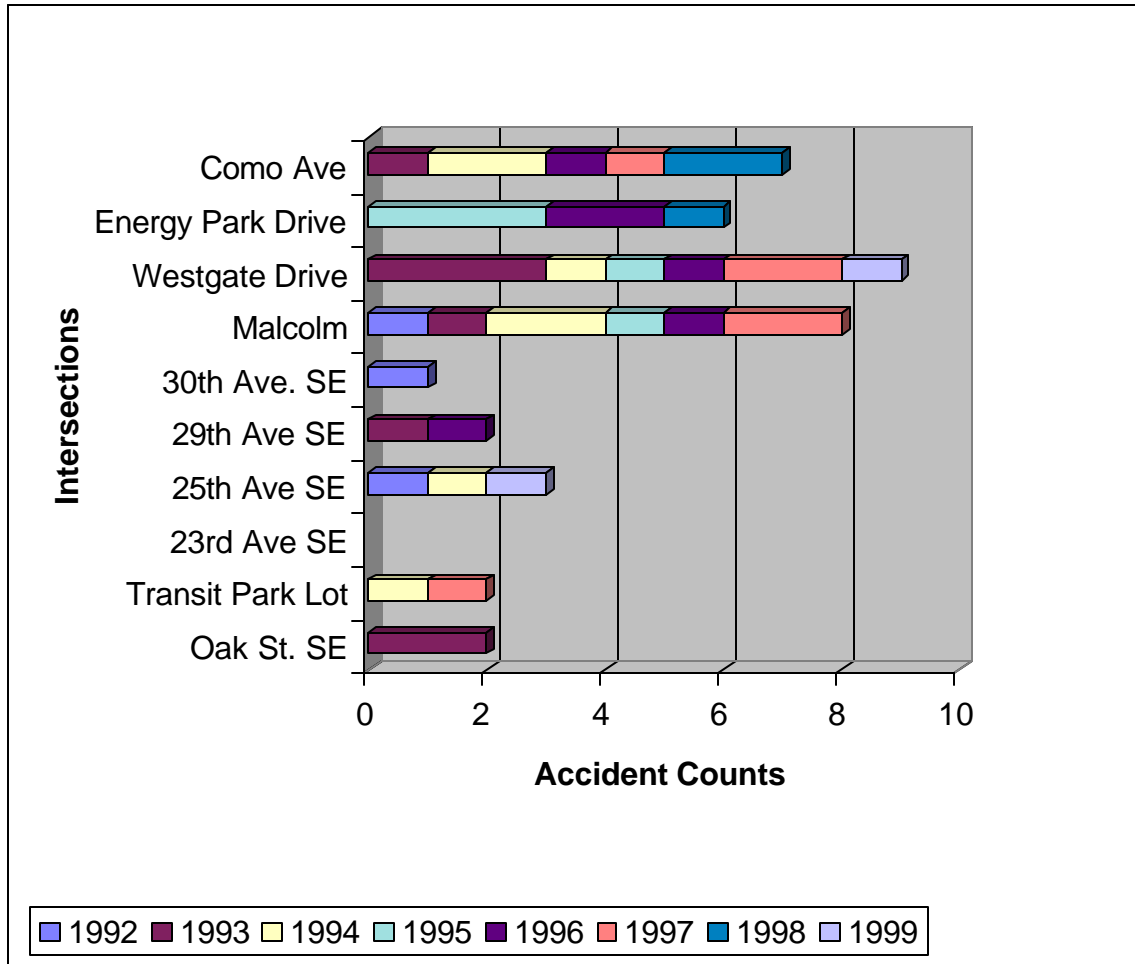


Figure 2. Transitway intersections East to West

In late 1994 the University's Parking and Transportation Services (PTS) Department formed a team to address the safety problems. The team included the City of Minneapolis, the University's Center for Transportation Studies (CTS) and the engineering consulting firm of Short Elliott Hendrickson, Inc. (SEH). As this team began work and developed ideas, Minnesota Guidestar became involved as an Intelligent Transportation Systems funding source, then Image Sensing Systems, Inc. (ISS) became involved as video detection experts.

## **Safety Program Phases**

The team developed a multi-phase project:

1. Quickly fix a couple of apparent causes.
2. Evaluate accident causes by observing driver actions (before data).
3. Design multiple technology accident mitigation systems.
4. Implement the mitigation system designs and put them into operation.
5. Evaluate the effect of the mitigation systems (after data).
6. Operate the system and the site for up to five years.

### **Phase I, Signing Changes**

During the summer of 1995, signing was changed at the intersections to eliminate non-bus traffic and vegetation was trimmed to improve sight lines. Some of the signing changes included adding far left STOP and NO TURNS signs, adding far right NO TURNS signs, replacing "Diamond Lane" signs with DO NOT ENTER signs, and replacing CROSS TRAFFIC DOES NOT STOP with BUSES DO NOT STOP and ONLY with a straight ahead arrow. Also part of Phase 1 was the planning and establishing Phases 2→6.

### **Phase 2, Driver Evaluations**

During the spring of 1996, Dr. Stirling Stackhouse and research assistant Donna Tranchida from the University's Human Factor's Research Laboratory (HFRL) conducted an evaluation trying to determine the causes for the high accident rate. The results of this evaluation were documented in a report "Human Factors for Transitway Safety Improvement", July 17, 1996 available from CTS. The HFRL researchers collected three sets of data for analyses;

- 1) Observations of bus driver actions during 50+ trips along the Transitway,
- 2) Measurements of approach sight distances at eight of the Transitway intersections, and
- 3) Observations of over 2400 vehicles and drivers crossing the Transitway [200+ at each intersection.]

Their measurements and observations before electronics show:

- 1) Bus drivers on the Transitway obey the speed limit and follow departmental guidelines.

- 2) Only five of the 32 triangular sight distances met minimum guidelines based on Federal Highway Administration and American Association of State Highway and Transportation Officials guidelines. {Note that a previous engineering study showed that stop line sight distances meet standards.}
- 3) Two percent of the 'crossing' 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.

There was no single cause identified for most of the accidents either from the accident data or from the observations. Driver inattention or driver risk taking is a reasonable conclusion. We also know that winter weather brings slippery roads and reduced visibility conditions. Figure 3 showing most accidents during five of the six winter months (October through March) supports this conclusion excluding December because of the reduced bus schedules during winter quarter break.

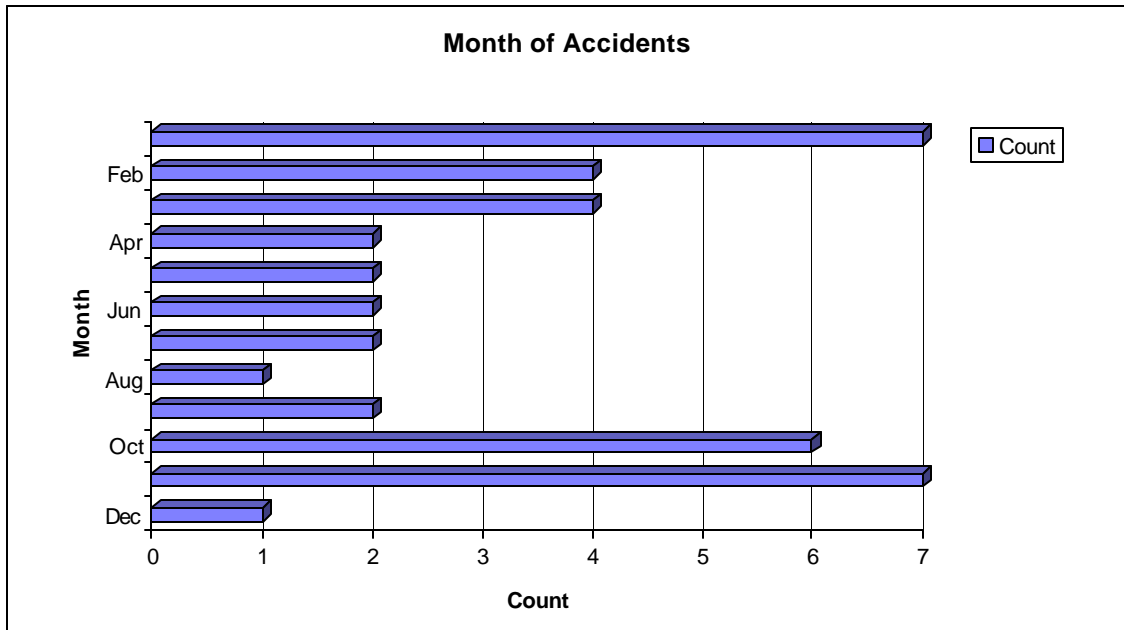


Figure 3. Accident distribution by month

### Phase 3, Intersection Warning Device Designs

In Phase 3, five varied improvements were agreed to and designed for the seven stop sign intersections. The improvements targeted the driver in-attention identified by Phase 2, as well as providing a test bed for warning device methods. All improvements retain the STOP signs

as the primary flow control device while trying to alert drivers approaching the Transitway intersections. This was agreed to by the Minneapolis jurisdictional authority after discussing alternative means of warning and/or establishing right-of-way control. Alternatives considered but not employed included railroad crossing gates and traffic signals. The five improvement types include:

- Red Warning Flashers on at all times and mounted atop the STOP sign posts (intersections in the Huron parking lot, at 23<sup>rd</sup> Avenue, and at Westgate Drive.)
- Red Warning Flashers atop the stop sign activated through detector loops by approaching vehicles on the Transitway and by bicycles on a new bike path (at 25<sup>th</sup> Avenue as shown in Figure 4.)
- Fiber Optic illuminated STOP Sign activated through detector loops (at 29<sup>th</sup> Avenue, also illustrated in figure 4.)
- Blank-out Illuminated Warning Sign activated through Autoscope™ video detection of buses and bicycles (at 30<sup>th</sup> Avenue.)
- Blank-out Fiber Optic Warning Sign activated through Autoscope™ video detection (at Malcolm Avenue.)



Figure 4. Loop detector activated warning & stop signs

The Fiber Optic STOP Sign is basically a 36" x 36" (915 mm x 915 mm) STOP sign with the white border and letters outlined with fiber optic lights. This sign is lit when buses approaching the intersection pass over the detector loops in the Transitway from either direction. It is also lit when bicycles go over loop detectors in the bicycle path.

The Blank-out Warning Signs contain the message BUSES/BIKES DO NOT STOP. This message is illuminated when activated by the video detection on the transit way and bicycle path. These signs are 48" x 48" (1220 mm x 1220 mm) as shown in Figure 5.

All warning flashers, signs, and the Fiber Optic STOP Sign are installed on the near right and far left corners of the cross street approaches to the intersection.

The detector loop placement was based on providing 10 seconds of warning for buses approaching at 30 MPH (50 km/h) and bicycles approaching at 15 MPH (15 km/h). This same placement would provide 7 seconds of warning for a bus approaching at 40 MPH (60 km/h) and a bike approaching at 20 MPH (35 km/h). This timing design was also planned for machine vision implementation [Autoscope™] even though bicycle detection is not part of the standard 2004 product. The original design layout had a '170' controller for the warning sign timing control. As a cost avoidance, the management team decided to use direct outputs from the Autoscope™ to turn warning sign light-control-relays on and off.

The sign design incorporated a feature to allow bus drivers to be able to tell if the warning signs are activated. This provided a plexi-glass covered hole in the side of the signs facing the approaching bus driver and at right angles to the crossing drivers.

During this design period, the University's telecommunications department began planning a fiber optic link between campuses along the Transitway right of way. PTS and CTS decided to jointly lay fiber in the same trench to facilitate future sign status monitoring and use of the machine vision site for Transitway detection research. This connection would link the intersection controls to the University's Parking and Transportation Department offices and CTS ITS Laboratory.

#### **PHASE 4, Install the devices along the Transitway – Operate them**

The five different improvements were installed during the fall/winter of 1997. Based on the design, initial timings for display of the loop detector activated warning devices was set at 11 seconds. After

review, observation, and input from bus drivers, transit officials, and University PTS staff, the warning timing was increased to 17 seconds. Operationally, this timing will provide 15 seconds of warning for a bus approaching at 20 MPH (35 km/h) and a bike approaching at 10 MPH (15 km/h) with an additional 2 seconds of lighted time for the bicycle or bus to clear the intersection.

Initially the same 11-second fixed timing was set for the warning devices activated by the Autoscope™. The team requested that Image Sensing Systems, Inc. tailor this Transitway Autoscope™ application to use approaching bus speed detection to determine the duration of the warning device activation. A warning time of 12 seconds is provided for buses approaching at greater than 30 MPH, 14 seconds for 20 to 30 MPH, and 17 seconds for speeds less than 20 MPH. The speed detection was not used for the bicycle approaches (bicycle speed measurement is not a part of the Autoscope™ product.) The warning time for them, as with the loop detectors, was set for 17 seconds. This sign is illustrated in figure 5.

The plexi-glass 'windows' on the side of the signs were originally considered to assist in system maintenance, by confirming that the system is operational. This design didn't work because the internal illumination was insufficient for drivers to observe when driving at or near the Transitway speed limit. A larger light source, similar to confirmation lights for emergency vehicle preemption systems was incorporated in mid-1998, fixing the insufficient illumination problem.



Figure 5. Installation at Malcolm/30th - Autoscope™ activated

## Phase 5, Evaluate the device effect on drivers

The Center for Transportation Studies under the leadership of the ITS Laboratory manager, Lowell Benson, was responsible for this evaluation phase. Dr. Stackhouse, who had led the Phase 2 evaluation, left the University however agreed to return as a consultant to provide continuity for the "AFTER ELECTRONICS" evaluation. The HFRL with the cooperation of Dr. Steve Scallen, Acting Director, agreed to coordinate student help for crossing driver observations. The objectives of this phase are:

1. Measure total Effect of alerting devices on behavior of crossing drivers,
2. Determine which device effects crossing driver behavior the most (or least),
3. Determine whether driver behavior changed or stayed the same at 'no change' intersections,
4. Determine the impact of tree/brush cutting on sight lines, and
5. Generate a report of conclusions and present project history and conclusions at conferences.

We decided to not re-observe the bus drivers for two reasons; there were no problems identified in these observations in the 'before' study and funding for this phase was limited.

While re-taking sight line measurements Dr. Stackhouse commented that many sight line improvements have occurred because of landscaping changes, tree removal, and newly marked no-parking spaces in a lot where vehicles previously obscured the view of approaching buses. Specific comparisons are in his final report.

CTS, Dr. Stackhouse, and the HFRL engaged several students to observe crossing driver behavior. For consistency, they used the same data collection forms that were used in 1996 during the 'BEFORE' study. They concluded the study with a draft report in July 1998; a final report on driver behavior was printed by the Center for Transportation Studies, contact [benso046@cts.umn.edu](mailto:benso046@cts.umn.edu) to request a copy.

## Phase 6, Operate the system

The PTS department maintains the electronic warning signs for the Transitway under the guidance of Roger Huss, Assistant Director-Transportation. Mr. Huss is also responsible for the Circulator Routes on both campuses that moved 640,388 passengers last fiscal year as well as coordinating the University system with the Metro Transit routes that transport approximately 7,000 passengers per regular academic year day. Lowell Benson, now ITS Technical Staff at CTS, updates the accident spreadsheet and graphs twice a year. He also represents CTS and the ITS Institute with transit project papers and presentations.

### **Conclusions, a successful safety improvement project**

The good news is that Transitway accidents have been mitigated! This is attributed to a combination of:

- The sight line improvements,
- Warning devices at intersections, and
- Bus-top strobe lights installed in September of 1997.

The last bus => truck accident in the test bed area was in March 1999 when a snowplow and bus sideswiped each other between intersections. The last bus => car accident in the test bed area was May 1999 (figure 6.) when a car ran a stop sign in front of a bus. The most unusual accident (of any type) along the transitway was October 1997 when a pedestrian (on roller blades) clipped a bus near the Oak Street entrance to the Transitway. One accident in two years at the seven-intersection test bed [0.5 per year] is significantly better than the 23 over six years [4 per year] before the devices were activate.

Comparisons between the Phase 1 and Phase 2 report were presented at the August 1998 Institute for Transportation Engineers conference in Toronto, Canada - summarized in the table on the last page of this paper. Although 5% more people obeyed the stop signs with full stops in 1998 versus 1996, the results of individual devices are not conclusive. The on-all-time flasher at Westgate resulted in more full stops, while at 23<sup>rd</sup> there were fewer full stops. The Actuated Warning at 30<sup>th</sup> had more stops while at Malcolm there were fewer. The actuated lighted stop sign at 29<sup>th</sup> appears to be the best device!

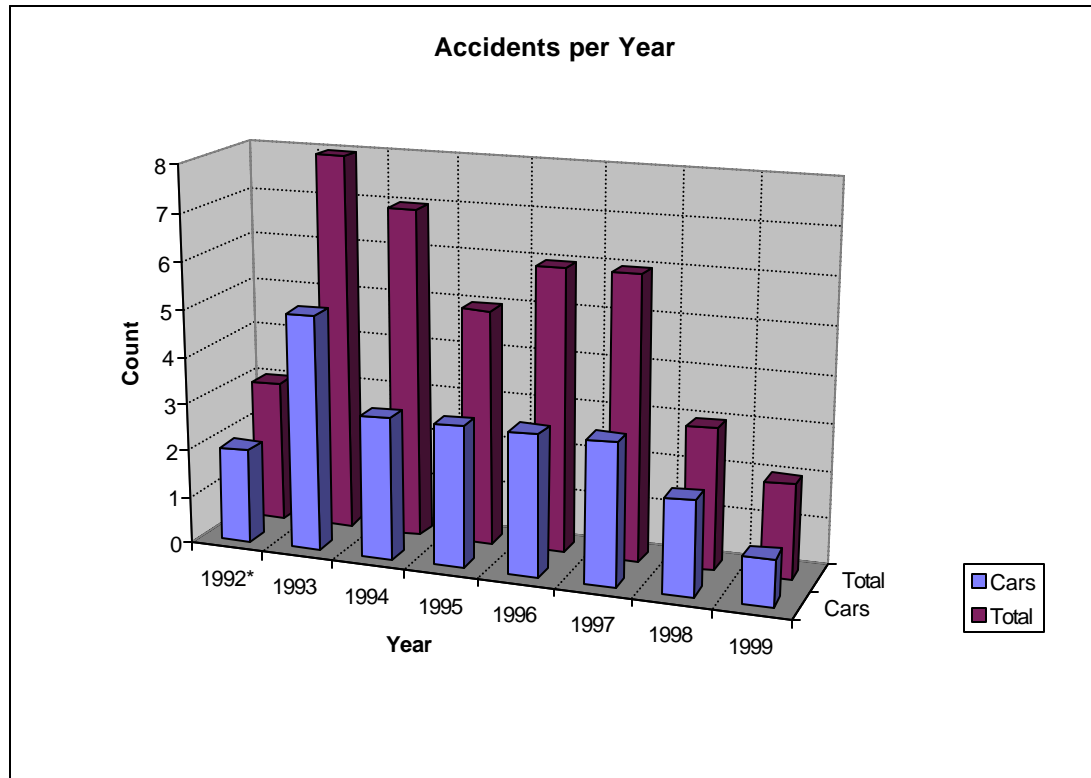


Figure 6. Count as of 12/31/99

### **CREDITS:**

Thanks to Dr. Stirling Stackhouse and Dr. Steve Scallen, their research disciplines and skills produced the before and after driver behavior studies mentioned earlier in this paper.

Thanks to Tom Sohrweide of SEH, Inc. who co-authored the original paper presented at the 1998 ITE Annual conference in Toronto.

Thanks to the Mn/DOT Office of Advanced Transportation Systems for providing some of the funding for project implementation.

Thanks to the Center for Transportation Studies for publication support of this paper and its presentation at the 10<sup>th</sup> ITS America Annual meeting.

<u>Intersection</u>	Accident Counts by Intersection								Observed Driver Behavior**				
	<u>Sign Changes</u>				<u>ITS Treatment</u>				<u>Full Stop Percent</u>		<u>Ran It Percent</u>		
	1992	1993	1994	1995	1996*	1997	1998	1999	<u>on or by stop sign</u>	1996	1998	1996	1998
Transit Park Lot			1				1		Flasher				
23rd Ave SE									Flasher	50	25	1	2
25th Ave SE	1		1					1	Actuated Flasher	48	51	2	2
29th Ave SE		1				1			Actuated Stop Sign	60	78	3	1
30th Ave. SE	1								Actuated Warning	55	75	3	0
Malcolm	1	1	2	1	1	2			Actuated Warning	53	39	3	3
Westgate Drive		3	1	1	1	2		1	Flasher	45	63	4	2
Energy Park Drive				3	2		1		None (Priority signal)			1	6
Como Ave		1	2		1	1	2		None (Priority signal)			0	1
Oak St. SE		2							None				
										43	48	2	2
Accidents/year	3	8	7	5	6	6	3	2					
Cumulative Accidents	11	18	23	29	35	38	40						
*Bike path opened													
**Many Drivers did just a 'rolling stop'													