FINAL REPORT

January 12, 1998

MOTION IMAGING RECORDING SYSTEM (MIRS)

Prepared for:
MIRS Committee Members

Minnesota Department of Transportation
Mn. Department of Public Safety
Canadian Pacific Railway
Metro Transit
City of Bloomington
Cityof Minneapolis
City of St. Paul

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TABLE OF CONTENTS

PART I. INTRODUCTION

This report documents the study and testing of a technology designed to detect and record violations of certain traffic control devices in Minnesota. The system utilizes one of several detection methods to determine the occurrence of a specific vehicle violation, and then activates a camera to photograph the vehicle. The usual nomenclature for this type of technology is photo radar or photo enforcement. However, as this study did not contain any aspect of active enforcement, a less threatening appellation was adopted. The system was called the Motion Imaging Recording System (MIRS).

This type of technology is used in over 30 other countries. It was first used in the United States for enforcement purposes in 1987, in the city of Paradise Valley, Arizona. Since then its usage has been rapidly expanding to other U.S. cities including, but not limited to, New York City, New York; Los Angeles, Sacramento, Pasadena, and San Francisco, California; Jackson, Michigan; Portland and Beaverton, Oregon; Fort Collins and Commerce City, Colorado; Fairfax City, Virginia; and Fort Meade, Florida.

This report was adopted by the MIRS Steering Committee on January 12, 1998.

PART II. BACKGROUND

The impetus for testing MIRS technology in Minnesota began in late 1994 when the Department of Public Safety (DPS) arranged for a demonstration of photo radar equipment. Representatives from the Minnesota Department of Transportation (Mn/DOT) and Metro Transit (MT) also attended the demonstration. The consensus of those attending was that it might be beneficial to consider this type of technology more thoroughly. Thus was born what eventually evolved into the MIRS Steering Committee (hereafter known as the Committee). The membership of the Committee expanded to include representatives of Mn/DOT, DPS, MT, Canadian Pacific Railway (CP), and the cities of Bloomington, Minneapolis, and St. Paul.

The purpose of the Committee was to determine if further study of the technology was warranted, and if it was, what should be tested, and how should the testing be conducted. The Committee quickly determined that further consideration and testing of this technology would be advantageous. It was decided that research should be conducted on this topic to find out what is occurring in other U.S. Cities. Almost all of the information available on this technology is from cities that use it for enforcement purposes. Although this is not specifically the purpose for its testing in this state, the Committee concluded it would be useful to review as much of the available literature as possible. What was found was that the positive attributes of the technology greatly outweigh the negatives. The following are some of the reasons cited in favor of the technology-

* Violations and accidents are reduced.
* Law enforcement officers are freed to enforce more serious crimes.
* All violators are ticketed (motorists now are aware that with so many violations occurring that their chances of being caught are minimal).
* The system operates all the time (not just when law enforcement officers are present).
* It enhances the safety of law enforcement officers (they do not have to approach motorists who have just violated a law).
* The system is “colorblind” (no possibility of racial bias).
* Law enforcement officers cannot be accused of favoritism in the issuance of tickets.
* All types of vehicles are treated the same (law enforcement officers cannot be accused of focusing on motorcycles, sports cars, etc.)

Several negative attributes were also mentioned in the literature. The following are some of the reasons cited in opposition of the technology-

* It is an invasion of privacy to take a picture of a driver and/or vehicle (“big brotherism”).
* Accused violators should have the right to face their accuser immediately after the violation.
* The owner of a vehicle should not be responsible for a violation that another driver received while using the owners vehicle.

* The technology does not allow for discretionary decisions on the part of a law enforcement officer (Ex. The driver ran a red light because he was rushing a child to the hospital).

After considering numerous possible outcomes the Committee decided it would like to have conclusive documentation to answer three questions-

* How extensive are certain violations?
* Is the technology sophisticated enough to detect and record violations?
* Is the equipment durable, dependable, and accurate when used in Minnesota's variable climatic conditions?

Everyone assumes that traffic control devices are being violated, but what is not known is how frequently and flagrantly. A system that could document the responses to these questions would be extremely valuable for safety enhancement efforts. Of course, if the technology is not capable of both detecting and recording violations it would have very limited applications. As to the equipment's capability of operating in adverse weather conditions, it should be noted that none of the other states that have tested it have as varied a climate as Minnesota.

Numerous proposals were presented to the Committee regarding which specific violations to study. The technology is quite flexible and lends itself to many different applications. The Committee felt it was imperative to test the technology in areas where the violations are perceived by the motoring public to be particularly hazardous. If the general public does not support the technology, the question as to its performance is irrelevant. The Committee decided on four violations that would be tested-

* red light running
* work zone speeding
* railroad crossing gate violations
* bus only shoulder lane misuse

The testing of excessive speeding other then in work zones was eliminated from consideration. The general consensus of the Committee was that the motoring public does not perceive speeding as a preeminent danger to their lives, and thus would not be as interested in its enforcement. The marketing research survey, which was conducted before the increase in speed limits, verified this assumption (see PART III., Figure 2b).

A question was raised about what to do with violators if the technology is able to detect and record them. Every course of action was suggested from sending the owners of the vehicles a letter informing them that their vehicles were recorded violating traffic control devices to doing nothing with the information. The Attorney General's Office suggested the latter action might be more prudent. The reasoning being that the Committee is only testing the technology, and furthermore, it has no enforcement authority. The Committee agreed with this suggestion and no action was taken with any recorded violations.

In many, but not all, of the cities where this technology is used the photographs are taken of the front of the vehicle. This procedure not only provides a photo of the front license plate, but also of the driver. The Committee decided that for the MIRS project, photos would only be taken of the rear of the vehicle. This decision was made because we were only testing the technology to determine if a violation could be recorded. This determination could be made by photographing the rear license plate without intruding on the privacy of the driver. Therefore, only photos showing the rear license plates of violating vehicles were taken.

The Committee thought it was important that an extensive public information campaign be conducted before and during the testing. This campaign would explain the technology, why and how it was being tested, the results of the testing as they became available, and most importantly, that no action would be taken against recorded violators. A press release was issued when the first red light equipment was installed in the fall of 1996. This lead to articles in both the major Twin Cities newspapers and coverage on many television and radio stations. In the ensuing year numerous additional stories appeared in newspapers and on television and radio stations throughout the state. In addition, exhibits were displayed at transportation related conferences and at the Minnesota State Fair. Generally, the reporting by the media was very supportive of the MIRS project.

PART III. MARKET RESEARCH SURVEY

One of the questions the Committee had from the beginning was how receptive the public would be to this type of technology, either for data collection, enforcement purposes, or both. Results of surveys taken in other states indicated that this type of technology had majority approval, but what would the level of acceptance be in Minnesota?

In the summer of 1996 Minnesota Guidestar agreed to fund a market research survey covering numerous aspects of this type of technology. The Metro Market Research Division of Mn/DOT was requested to oversee the project. After much discussion with representatives from the Committee to determine what information was needed, the research people developed a Request for Proposal (RFP). This RFP was submitted to four companies and four replies were received. The company chosen was Cook Research and Consulting, Inc., Minneapolis.

Cook Research began the project by conducting two focus groups to determine how thoroughly the general public comprehends this technology. The information that was ascertained from these groups was used to formulate the questions that would be asked in the actual interviews.

It was decided that the phone interviews would be divided into two parts. Half of the interviews would be conducted with residents of the eight county Twin Cities metro area (Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott, and Washington) and half with residents outside this area. Age and gender quotas for each area's sample were met for 1996 population projections based on the 1990 census. The target population was anyone sixteen years of age or older, and as accurately as possible the representation of non-drivers was included. Additional demographic information about the respondents included the length of time they had lived in Minnesota, the level of schooling that had been completed, and total household income before taxes. Respondents were telephoned via a random digit dialing (RDD) procedure, a sampling method that generates random combinations of telephone numbers. RDD enables interviewers to reach households that aren't in telephone directories. Participants were interviewed by professional researchers who followed the ten minute questionnaire reading each question verbatim. There were 804 interviews conducted, 402 in the metro area and 402 outstate. For the sub-samples of the metro and outstate areas there is a 95 percent confidence that error due to sampling is no

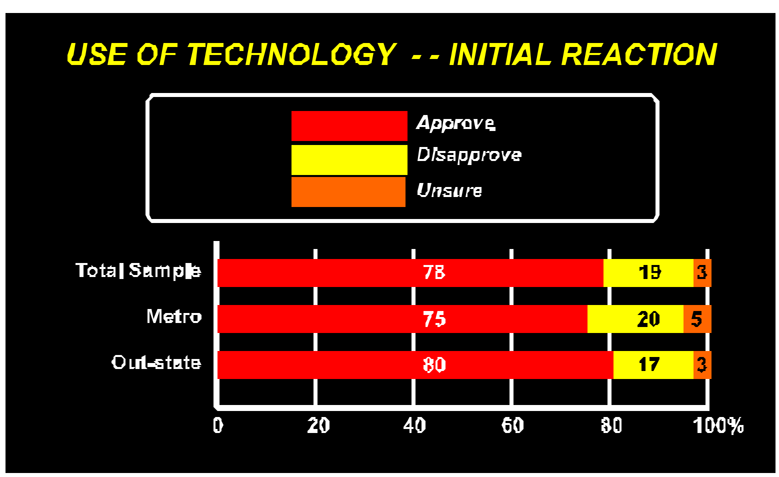


Figure 1

greater than 5.6 percentage points. For the total sample there is a 95 percent confidence that error due to sampling is no greater than 4.0 percentage points. The survey was conducted from March 12 through April 4, 1997.

The first question asked in the survey, other than background information, dealt with the respondents' initial response to the technology (see figure 1). After being read a brief description of the MIRS technology respondents were asked if they approved or disapproved of this type of technology being used to identify vehicles that have ignored traffic control devices. Overwhelmingly, by almost a 4 to 1 margin, respondents approved of this technology. The approval percentage was 75% in the metro area and 80% out-state. This level of approval is significant because it clearly indicates that Minnesotans are not intrinsically opposed to this type of technology.

Next, respondents were asked to assume that the MIRS equipment works accurately, and that testing conclusively proves that certain traffic laws are frequently being violated. They were then asked what the consequence should be for the owner of a vehicle that has been photographed violating specific traffic laws. The possible consequences were a ticket, a non-moving violation (such as a parking ticket), or just a warning.

Out-state respondents were questioned on four different illegal driving behaviors. The four violations were driving through red lights at intersections, speeding in construction zones, driving around down railroad gates, and exceeding the speed limit anywhere.

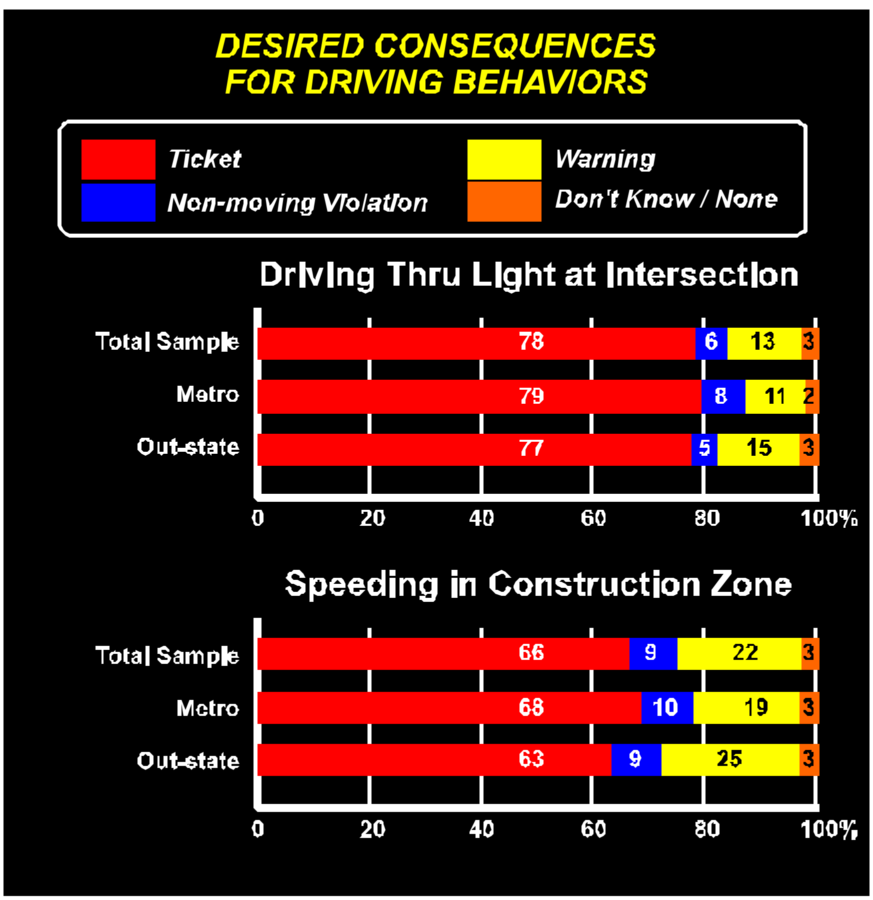


Figure 2a

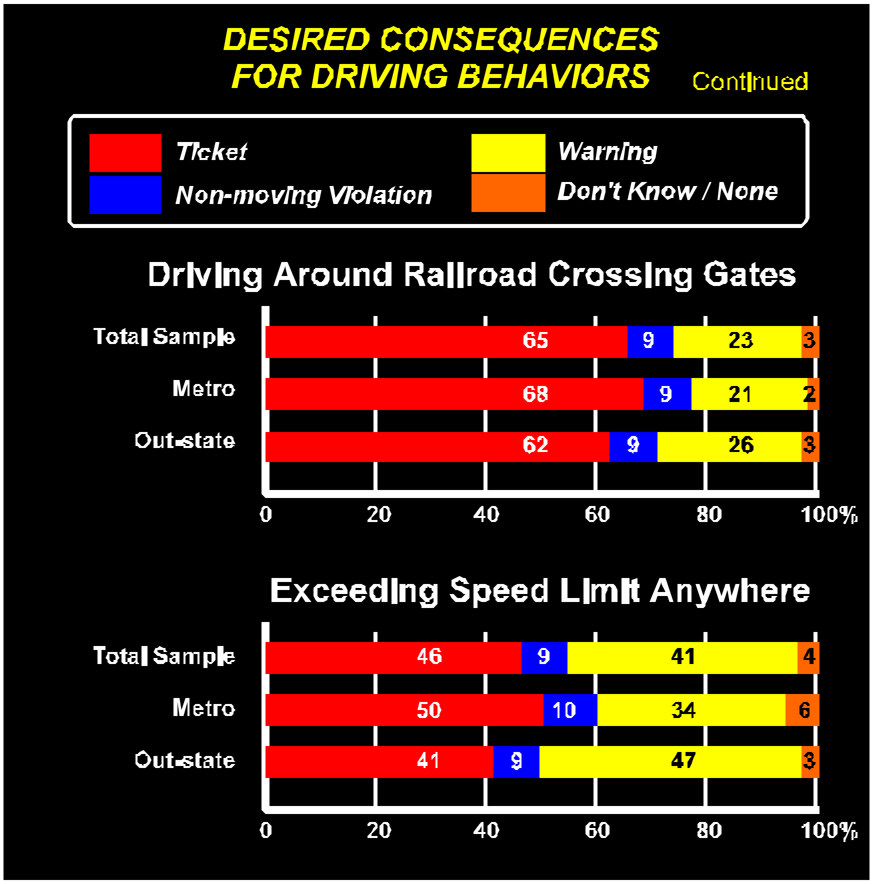


Figure 2b

Metro respondents were questioned on eight different illegal driving behaviors. The eight violations were driving through red lights at intersections, speeding in construction zones, driving around down railroad gates, exceeding the speed limit anywhere, a single driver using HOV lanes, a single driver using ramp bypasses, driving through the red light at ramp meters, and unauthorized vehicles using bus only shoulder lanes. Obviously, the last four behaviors would only apply to the metro area.

Figures 2a and 2b depict the results of the survey of the four driving behaviors that were evaluated by all respondents. Each specific behavior was separated into the responses from out-state, metro, and total of the two. The results clearly show that a large majority of the respondents felt that some type of ticket should be issued to violators that run red lights, speed in construction zones and drive around down railroad crossings gates. A smaller majority felt that tickets should be issued for exceeding the speed limit anywhere. Respondents wanted more serious consequences (tickets) for driving behaviors that appear, at least to them, to have greater risk of loss of life associated with them. Speeding did not seem to be included in this category. In general, the responses for both out-state and metro are very similar. The one exception is that metro residents are more apt to want to issue some type of ticket for exceeding the speed limit anywhere than are out-state residents (60% vs. 50%, respectively).

Another group of questions dealt with attitudes regarding privacy. One of these questions was of particular significance. The respondents were asked to reply to the following statement, "If I am violating a traffic law, then law enforcement personnel should be allowed to photograph my license plates." Over 80% of the respondents for both the out-state and metro areas either strongly agreed or somewhat agreed with this statement (see figure 3).

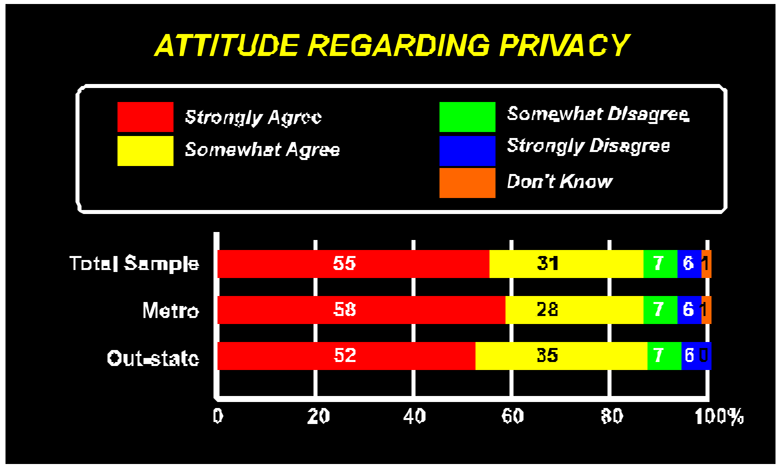


Figure 3

At the end of the interview, before the questions on demographics, respondents were again asked if they approved or disapproved of the technology being used to identify vehicles that have ignored traffic control devices. This question was asked a second time to give respondents the opportunity to change their original response after having had more time to contemplate the technology. Figure 4 depicts the results of this question. There is only a minimal change from the respondents' first response to their second response. As with their first reaction, the approval of the technology is almost 4 to 1 in favor. Also, as in their first reaction, out-state residents are more likely to approve of the MIRS technology than are residents of the metro area (80% to 74%).

There are differences in various demographic subgroups regarding the approval of MIRS technology. However, the support is strongly in favor of the concept, regardless of which subgroup one is in. For instance, in the second response women favored the technology more than men (84% to 70%), non-peak freeway drivers favored the technology over peak freeway drivers (78% to 71%), non-single occupancy vehicle drivers favored the technology over single occupancy drivers (84% to 74%), and respondents without driver's licenses favored the technology over licensed drivers (89% to 76%).

In summary, there appears to be broad support for the MIRS technology as a tool for identifying traffic law violators. This support occurs in both out-state and metro areas. A copy of the survey containing all the questions and responses is available on request.

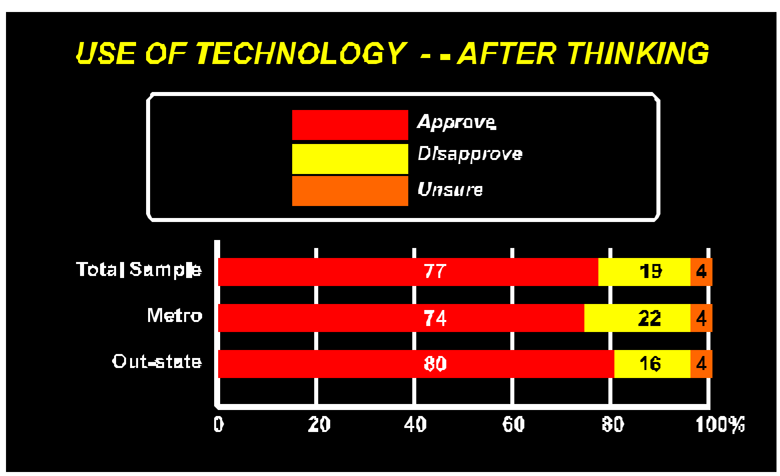


Figure 4

PART IV. TEST PROJECTS

A. RED LIGHT RUNNING

The study of this type of violation was selected because of the number of perceived violations, inherent danger, enforcement problems and generally sympathetic public (84% of the respondents in the market survey approved of the issuance of some type of ticket for red light running).

Other states have experienced an epidemic of red light running. States on both coasts have been especially hard hit with this type of violation, but it appears that it is becoming a major problem throughout the country. Numerous states allow cities to issue tickets to the owners of vehicles that run red lights. Perhaps the biggest program is in New York City, New York. In 1994 the city implemented its system with fifteen cameras rotated between numerous installations. Over 400,000 tickets were issued in the first two years. According to, "The Urban Transportation Monitor", January 31, 1997, ". . . New Yorkers have altered their driving habits significantly, realizing such infringements are now strictly enforced in the courtroom, as evidenced by an 89% conviction rate. Indeed, the city has experienced a 62% decrease in the average number of events per location since the programs inception." Similar results have been realized in other cities.

The installation for a red light camera at a signalized intersection consists of a pole and camera housing located about 75 feet from the intersection, inductance loops imbedded in the roadway after the stop bar and wiring interconnecting the camera pole, loops and signal cabinet (see figure 5). Any vehicle that passes over the inductance loops after the signal turns red triggers the camera to take two pictures of the rear license plate of the vehicle; one as the vehicle enters the intersection and a second approximately one second later.

The maintenance of the equipment and the changing of the film was done on an availability basis, as no one person was assigned to this project full time. When the film was removed from the camera it had to be taken to a specific developer because of the length of the film. It could be picked up several days later.

The Committee decided that two camera housing units would be installed in each of the partnership cities of Bloomington, Minneapolis, and St. Paul. Cameras would then be rotated between the installations. The cities were asked to choose their own sites based on right angle collisions and other considerations.

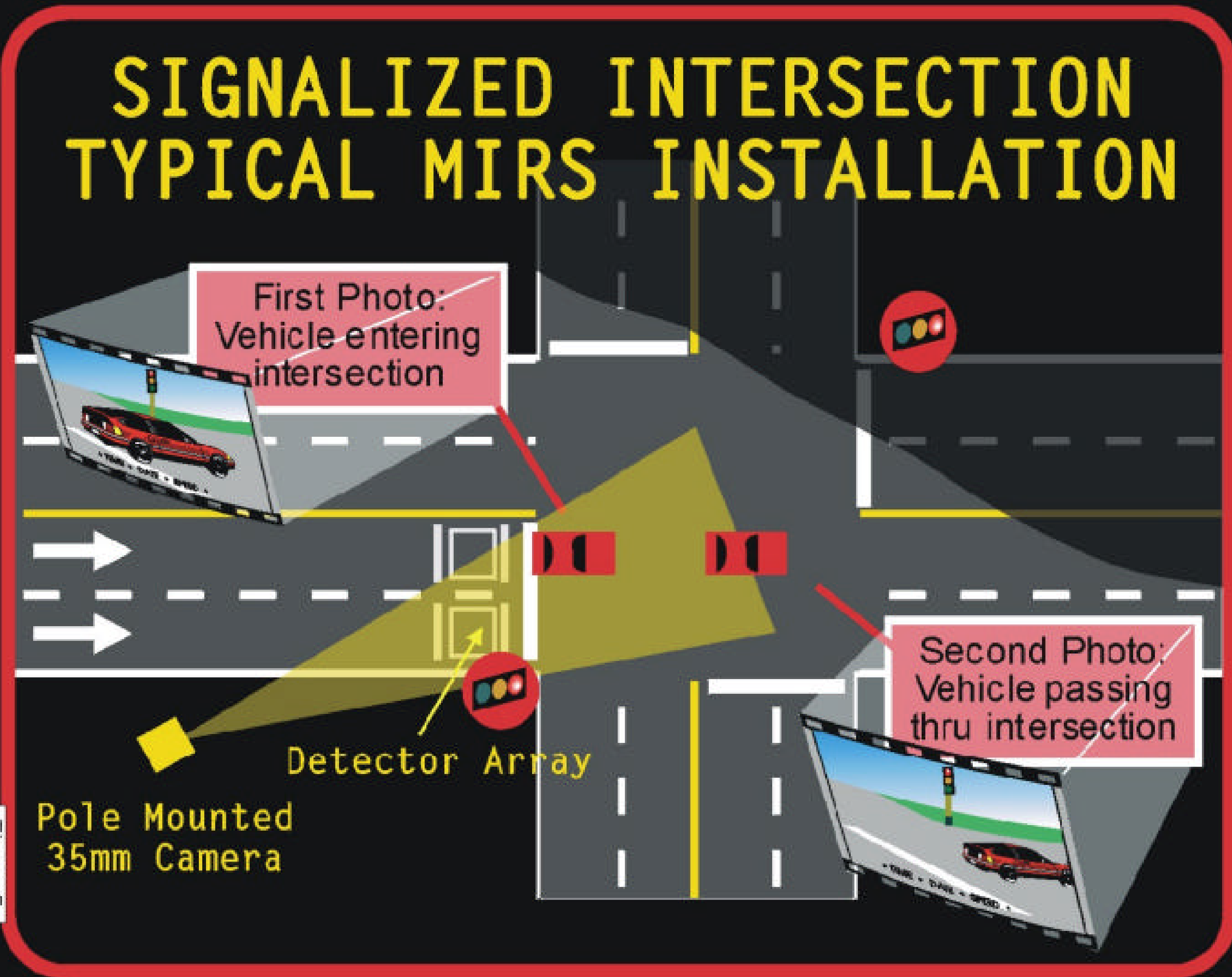

SIGNALIZED INTERSECTION
TYPICAL MIRS INSTALLATION
First Photo:
Vehicle entering
intersection
Second Photo:
Vehicle passing
thru intersection
Detector Array
Pole Mounted
35mm Camera

Figure 5

St. Paul

It was decided that the first installation would be located at the intersection of Snelling Ave. and St. Anthony Ave. in St. Paul, monitoring violations on southbound Snelling Ave.(see appendix A). This site is very ambitious in that there are four lanes of southbound traffic as well as a protected right turn lane. St Anthony Ave. is the north frontage road above I-94 and is a one way street, westbound. Concordia Ave. is the south frontage road above the interstate and is a one way street eastbound. This intersection is a major entrance point to the interstate and accomodates over 17,000 southbound vehicles each day.

As southbound traffic on Snelling Ave. passes over I-94, lane 4 (closest to the center median) is a left turn only onto Concordia Ave., lane 3 is a shared left turn or thru lane, lane 2 is a thru lane and lane 1 is a thru lane which merges with lane 2 south of Concordia Ave. A large percentage of the southbound traffic turns left and enters I-94.

The installation on Snelling Ave. was operational for parts of five months, from late November 1996 through the end of April 1997. No testing was conducted from December 3, 1996 through February 6, 1997 due to the malfunctioning of the equipment (see Part V, Efficiency of Equipment).

Over the five months of operation, there were twenty-four deployments (separate operations of the camera with new film) that ran from a single day duration to five days duration. An attempt was made to spread the testing out over different parts of the month and most importantly over different days of the week, to have a more concise record of when violations were occurring. A breakdown of the deployments by day are as follows-

Monday	11
Tuesday	8
Wednesday	6
Thursday	7
Friday	5
Saturday	6
Sunday	7

During the period the camera was operational at least some testing was conducted on 24 days that fell between the first and the fifteenth of the month, and 26 days that fell between the sixteenth and the end of the month.

The camera ran for 712 hours and 52 minutes and detected 5,378 violations. This is approximately 180 per day, or about 7.5 per hour. Figure 6 is a bar graph which shows the number of violations for each hour of the day. The greatest number of violations occurred between 2:00 - 3:00 PM. This is surprising because it is after the lunch hour rush and before the afternoon rush hour. Speculation has been made that because the testing period was during the school year, perhaps this is the time that nearby high schools were letting out for the day. Another speculation was that it might be sales and delivery people running late and realizing that they have “X’” number of stops yet to make before they can go home.

The next highest hours for number of violations occurred during the morning, afternoon, and lunch rush hours. Just as surprising as the peak hours for violations were the hours of least violations, these hours occurred during the middle of the night. Conventional wisdom predicts that the early hours of the morning would produce the most violations, but that is clearly not the case.

Figure 7 shows the times in half-second intervals that violators entered the intersection after the light had turned red. The following is a recap of some of the more significant statistics-

*** 2,758, or 51%, entered after 1.0 seconds**
*** 1,342, or 25%, entered after 1.5 seconds**
*** 639, or 12%, entered after 2.0 seconds**
*** 66 entered after 20 seconds**

Driving at the posted speed limit, the 1,342 that entered after the 1.5 seconds on the red phase would have been at least sixty six feet from the intersection when the light turned red.

It would appear that red light running is an equal opportunity offense. Just about every type of vehicle was photographed running the red light including school buses, Metropolitan Transit buses, police cars and emergency vehicles without flashing lights, taxi cabs, motorcycles, and even bicycles.

The second location chosen by the City of St. Paul was on southbound Arcade St. at Minnehaha Ave. A camera was to be installed here in the summer of 1997, but because of a myriad of problems too numerous to enumerate, this site was never installed.

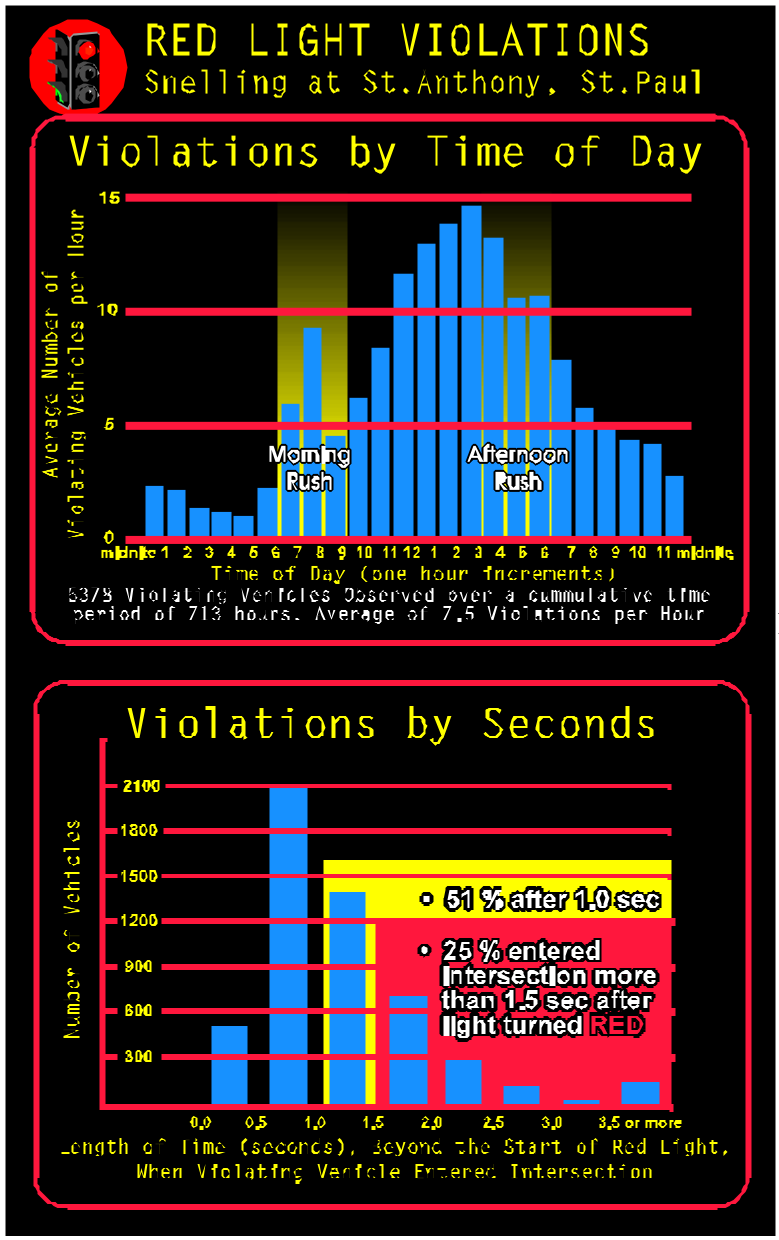


Figure 6

Minneapolis

The two sites that the City of Minneapolis selected for camera locations were 5th Ave. S. at 9th St. S., and 36 St. E. at 1st. Ave. S. One camera was alternated between the two installations.

5th Ave. S. at 9th. St. S.

The camera housing was positioned to detect violators northbound on 5th Ave. S. (see appendix B). 5th Ave. S. is a one way street with five lanes. The lane furthest to the west is a left turn only lane, the next lane is a left turn or thru lane, the next two lanes are thru only, and the final lane is also a thru lane, but is used for parking except between 7:00-9:00 AM. The cross street, 9th St. S., is also a one way street (westbound). It has three thru lanes in the middle, and parking lanes along each curb.

The installation was operational from May 2 through July 29, 1997. There were twelve separate deployments that ran from a one day duration to ten days duration. An attempt was made to spread the testing out over different parts of the month and over different days of the week. A breakdown of the deployments by day are as follows-

Monday	7
Tuesday	7
Wednesday	6
Thursday	6
Friday	7
Saturday	7
Sunday	6

During the period the camera was operational at least some testing was conducted on 25 days that fell between the first and the fifteenth of the month, and 21 days that fell between the sixteenth and the end of the month.

The camera ran for 956 hours and 7 minutes and detected 1,796 violations. This is approximately 45 per day, or 1.88 per hour. Figure 8 is a bar graph which shows the number of violations for each hour of the day. Without question, the greatest number of violations occurred between 8:00 and 9:00 AM, with an average of 6.43 per hour. The second and third highest totals were between 9:00 and 10:00 AM with 4.4 per hour, and between 4:00 and 5:00 PM with 4.03 per hour. These results are not surprising in that they are either during or near the rush hours.

Figure 9 shows the times in half-second intervals that violators entered the intersection after the light had turned red. The following is a recap of some of the more significant statistics-

*** 997, or 56%, entered after 1.0 seconds**
*** 607, or 34%, entered after 1.5 seconds**
*** 331, or 18%, entered after 3.5 seconds**

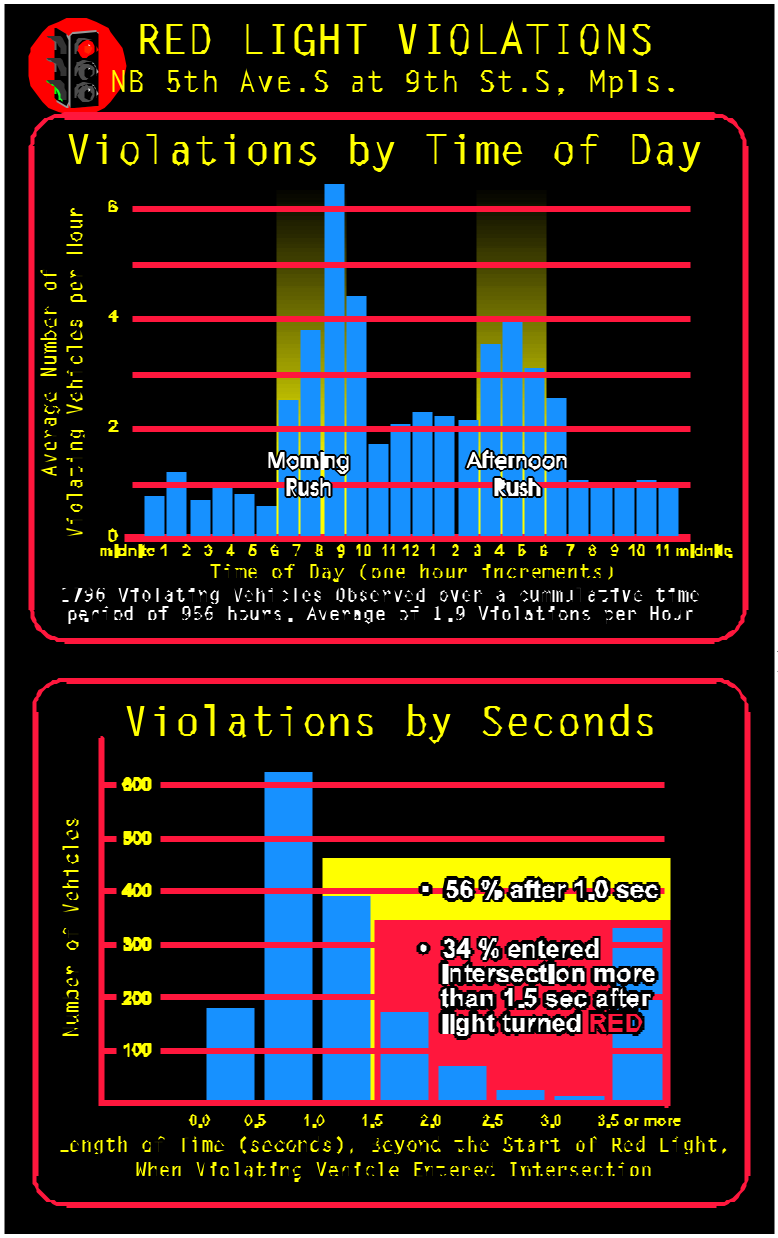


Figure 8

36th St. E. at 1st Ave. S.

The camera housing was positioned to detect violators eastbound on 36th St. E. (see appendix C). 36th St. E. is a one way street eastbound. There are four lanes, but the two curb lanes allow parking twenty-four hours a day, although very few vehicles take advantage of this. The cross street, 1st. Ave.S., is also a one way street northbound. This street has three thru lanes and one parking lane. However, the lane to the east side does allow parking on Saturday and Sunday.

The installation was operational from May 23 through September 21, 1997. There were sixteen separate deployments that ran either three days duration or four days duration. An attempt was made to spread the testing out over different parts of the month and over different days of the week. A breakdown of the deployments by day are as follows-

Monday	5
Tuesday	6
Wednesday	9
Thursday	7
Friday	8
Saturday	8
Sunday	6

During the period the camera was operational at least some testing was conducted on 26 days that fell between the first and the fifteenth of the month, and 23 days that fell between the sixteenth and the end of the month. The camera ran 905 hours and 18 minutes and detected 3,723 violations. This is approximately 98.7 per day, or about 4.1 per hour. Figure 10 is a bar graph which shows the number of violations for each hour of the day. The three one hour time periods with the greatest number of violations were 6:00-7:00 PM with an average of 5.39 per hour, 8:00-9:00 PM with 5.24 per hour, and 7:00-8:00 PM with 5.25 per hour. Of the five camera locations, this was the only one which had a moderate number of violations in the middle of the night.

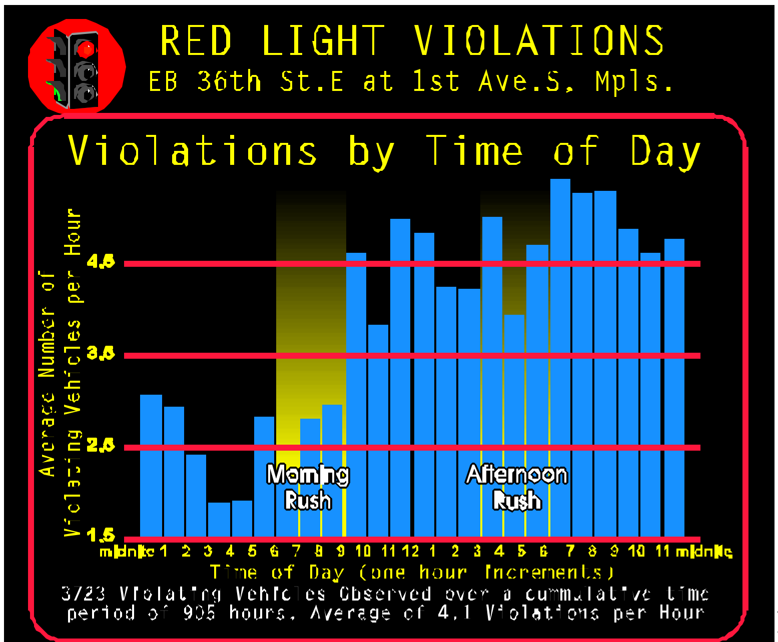
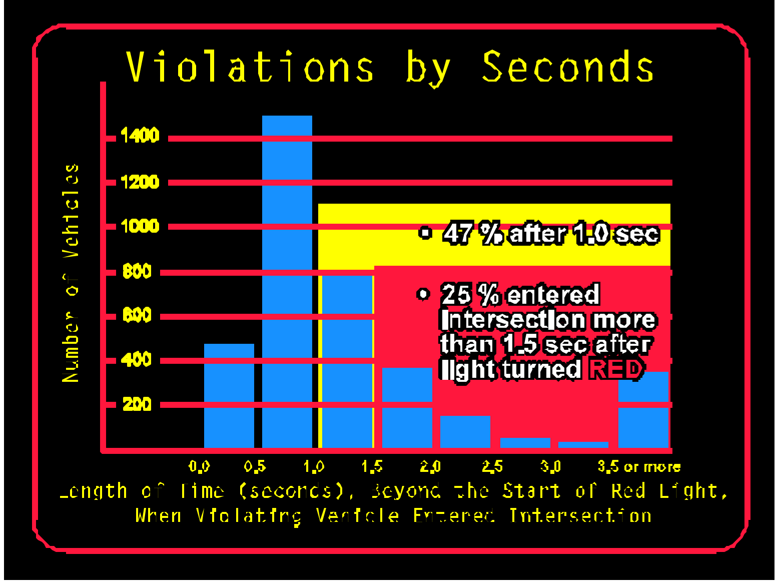


Figure 10

Figure 11 shows the times in half-second intervals that violators entered the intersection after the light had turned red. The following are some of the more significant statistics-



*** 1,745, or 47%, entered after 1.0 seconds**

*** 948, or 25%, entered after 1.5 seconds**

*** 352, or 9.5%, entered after 3.5 seconds**

Bloomington

The two sites chosen in Bloomington were 90th St. at Nicollet Ave. and 80th St. at Penn Ave. The sites were selected by the city. As mentioned earlier, one camera was rotated between the two sites.

90th St. at Nicollet Ave.

The camera housing was positioned to detect violators westbound on 90th St .(see appendix D). 90th St. has two lanes westbound and two lanes eastbound. No parking is allowed in either direction. The cross street, Nicollet Ave., also has four lanes, two southbound and two northbound.

The installation was operational from May 2 through August 26, 1997. There were eighteen separate deployments that ran just two days each. An attempt was made to spread the testing out over different parts of the month and over different days of the week. A breakdown of the deployments by day are as follows-

Monday	4
Tuesday	5
Wednesday	5
Thursday	5
Friday	9
Saturday	8
Sunday	0

Obviously, the distribution of the deployments by day did not end up spread out evenly over the week. The reason for this was because the camera kept running out of film every two days. This was due to the large volume of vehicles turning right onto Nicollet after legally stopping for the red. In order to try to get some information on the number of violations on Sundays, film was frequently replaced on Fridays, but it always ran out before Sunday. During the period the camera was operational at least some testing was conducted on 16 days that fell between the first and the fifteenth of the month, and 20 days that fell between the sixteenth and the end of the month.

The camera ran for 461 hours and detected 636 violations, which is approximately 33 per day. Figure 12 is a bar graph which shows the number of violations for each hour of the day. The greatest number of violations per hour occurred between 5:00 and 6:00 PM, with an average of 2.8 per hour. The second and third highest totals were between 7:00 and 8:00 AM with 2.53 per hour and between 4:00 and 5:00 PM with 2.52 per hour.

Figure 13 shows the times in half-second intervals that violators entered the intersection after the light had turned red. The following is a recap of some of the more significant statistics-

*** 217, or 34%, entered after 1.0 seconds**
*** 102, or 16%, entered after 1.5 seconds**
*** 18 entered after 3.5 seconds**

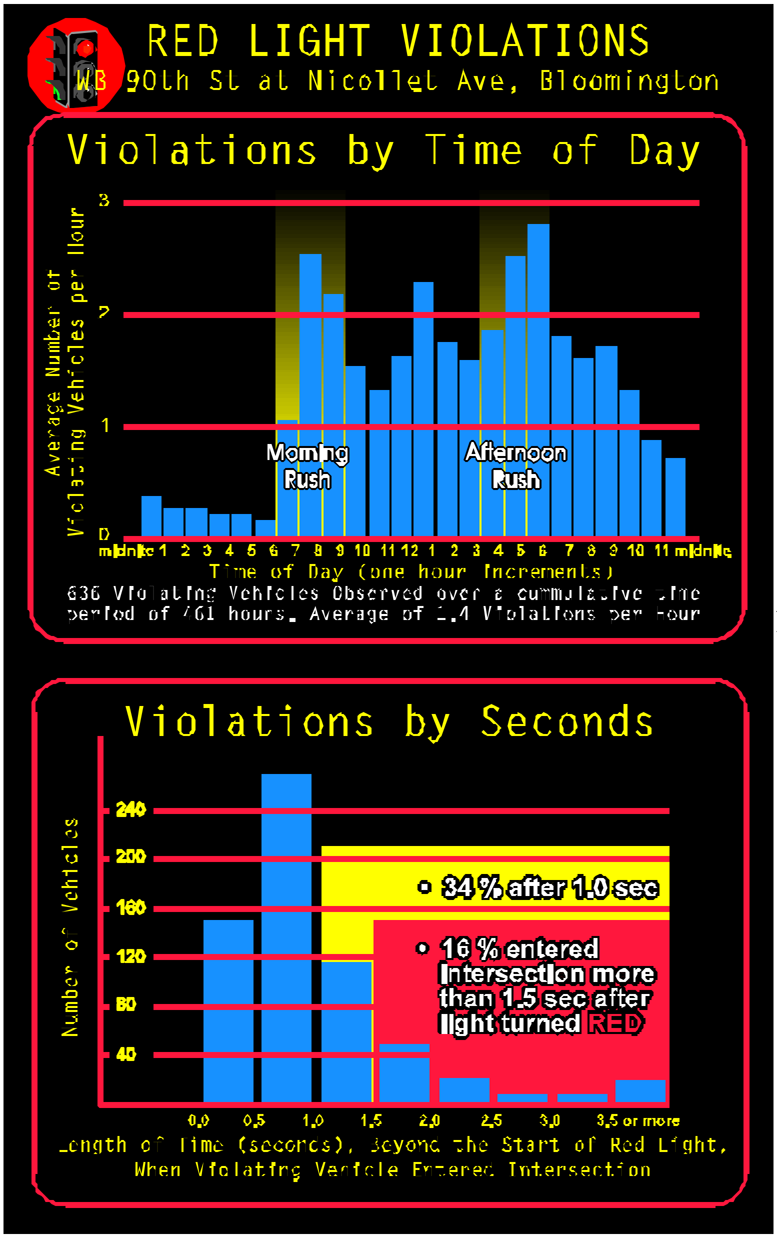


Figure 12

80th St. at Penn Ave.

The camera housing was positioned to detect violators eastbound on 80th St. (see appendix E). The street has four lanes eastbound and two lanes westbound, with a concrete median in between. The two eastbound lanes closest to the median are left turn only lanes, and the two other lanes are thru lanes. A right turn onto Penn Ave. after a legal stop is allowed. Penn Ave. has three lanes in each direction divided by a median.

The installation was operational from June 3 through September 1, 1997. There were six separate deployments that ran from two days duration to six days duration. An attempt was made to spread the testing out over different parts of the month and over different days of the week. A breakdown of the deployments by day are as follows:

Monday	2
Tuesday	3
Wednesday	4
Thursday	4
Friday	3
Saturday	3
Sunday	3

During the period the camera was operational at least some testing was conducted on 12 days that fell between the first and the fifteenth of the month, and 10 days that fell between the sixteenth and the end of the month.

The camera ran for 434 hours and 39 minutes and detected 130 violations. This is approximately 7.2 a day. Although the number of violations per hour was not very large for any given time, the highest figure, that of 1.1 per hour, was between 5:00 and 6:00 PM. The really significant statistic from this location was that 48 vehicles, or 37% of the total violators, entered the intersection after the light had been red 3.6 seconds or longer.

This location, by a wide margin, had the fewest violations. It is impossible to determine why without further investigation, but a good guess would be the configuration of the intersection. A red light runner would have to cross multiple lanes of traffic that run both directions. Also, this intersection has a high volume of traffic which would inhibit red light running.

B. WORK ZONE SPEEDING

The study of this type of violation was selected because of the life threatening conditions, enforcement problems, sympathetic public (75% of the respondents in the market survey approved of the issuance of some type of ticket for work zone speeding), and probable support of workers unions due to their concern for their members safety.

The inherent danger of speeding in work zones is clearly demonstrated by summarizing incident statistics compiled by Mn/DOT from accidents that have occurred in Minnesota work zones in which speeding was the primary or secondary contributing factor. These statistics are from data collected from January 1, 1992 through October 12, 1997.

* **920 crashes resulting in injuries**
* **1,461 injuries**
* **1,414 cases of property damage**
* **18 fatalities**

The equipment used for monitoring a work zone is very portable and can be set up in about 15 minutes (see Figure 14). It consists of a 35mm camera and radar unit on a tripod, a marine battery for power, and a cable connecting the camera and radar unit to a computer and monitor. The unit counts and records the speed of all vehicles that pass by, but only takes a picture of the rear license plate of a vehicle when a pre-determined speed is reached. The radar that is used is a Ka band that has a beam width of 5 degrees, versus conventional radar with a beam width of 10 degrees. The Ka band results in a more precise focus to eliminate stray readings, and more accurate speed measurements. In some states where this technology is used for enforcement the equipment is installed in vans for immediate deployment and for use in adverse weather conditions.

The Committee decided that testing in work zones would only be conducted when three specific conditions existed-

* Traffic lanes would be merged, preferably into a single lane
* A reduced work zone speed limit would be extensively signed (for this report test results were included only when the speed limit had been reduced to 40 miles per hour so that all data was comparable)
* Workers were engaged in activity close to the cameras location

Testing was conducted in both the metropolitan and out-state areas. It was more difficult to find work sites in the metropolitan area that met the required conditions then it was out-state. However, ample testing was conducted in both areas. For statistical purposes the data was evaluated for each area separately, then combined together.

Out-State Data

Testing was conducted at 25 sites throughout the state including locations near the cities of St. Cloud, Detroit Lakes, Duluth, St.Charles, and Cambridge. Testing was conducted for a total of 25.45 hours. Figure 15 is a bar graph that depicts the data collected from all out-state test sites. The following are some of the more relevant statistics from the graph-

* **13,667 vehicles counted**
* **5,181, or 38 % of all the vehicles were exceeding the posted 40 MPH reduced speed limit**
* **654, or 5% of all the vehicles were going at least 10 MPH over the posted reduced speed limit**
* **73 MPH was the fastest speed recorded**

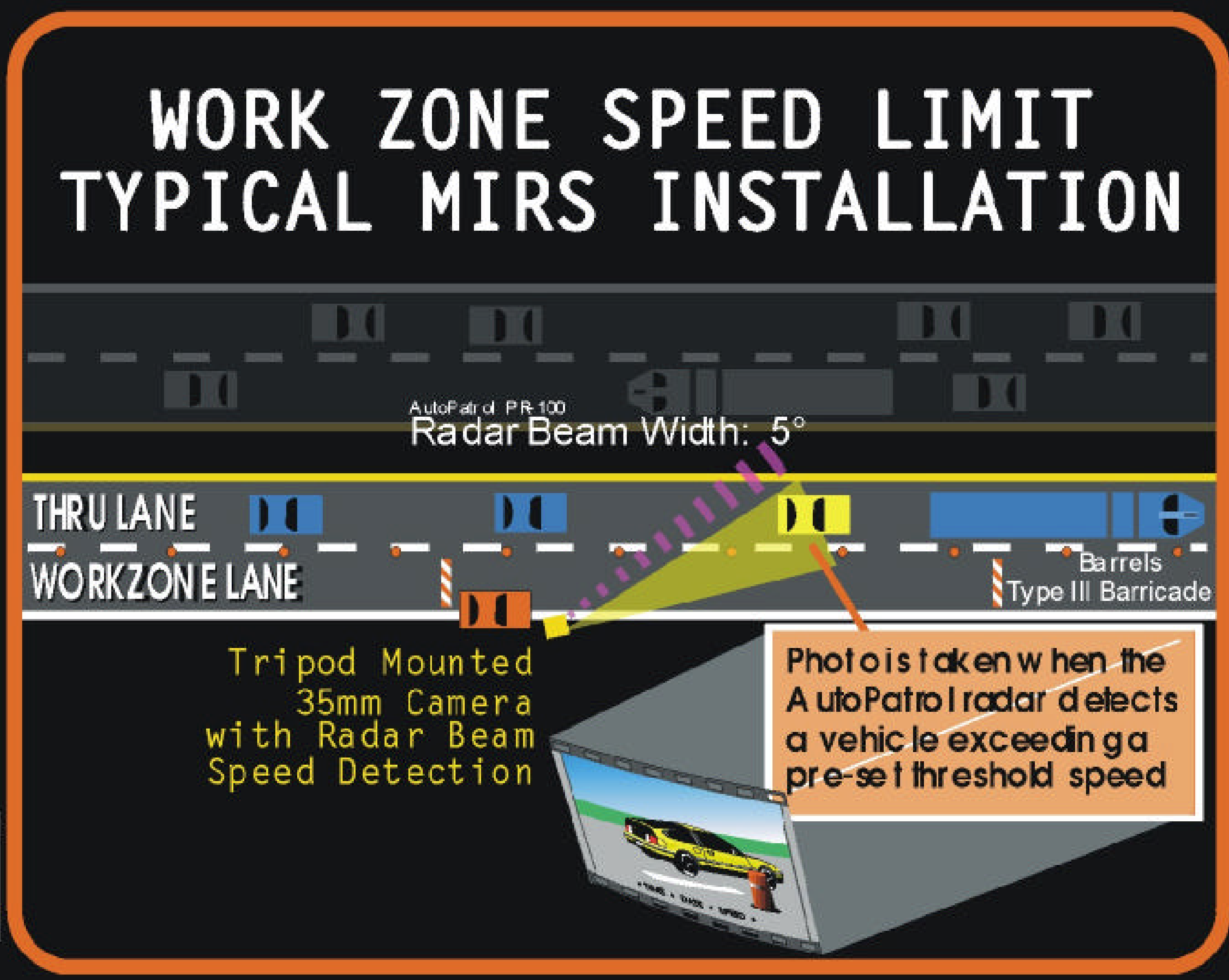

WORK ZONE SPEED LIMIT
TYPICAL MIRS INSTALLATION
AutoPatrol PR-100
Radar Beam Width: 5°
THRU LANE
WORKZONE LANE
Barrels
Type III Barricade
Tripod Mounted
35mm Camera
with Radar Beam
Speed Detection
Photo is taken when the
AutoPatrol radar detects
a vehicle exceeding a
pre-set threshold speed

Figure 14

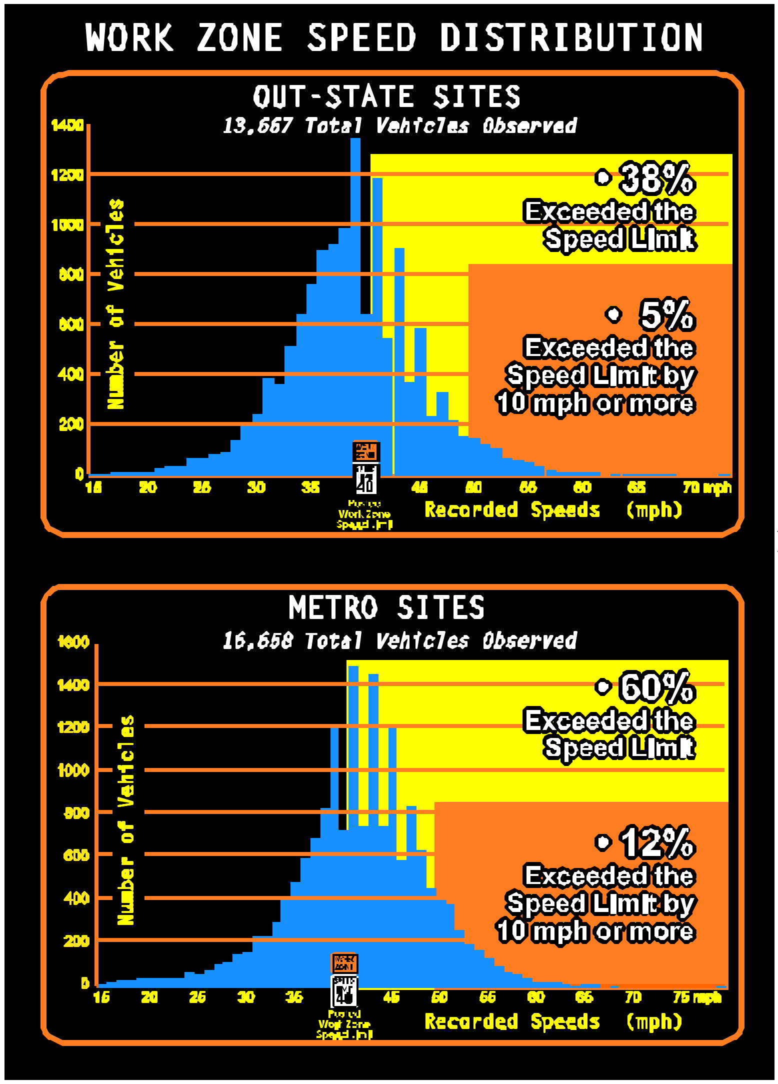


Figure 15

Metropolitan Data

Testing was conducted at 20 sites in the metro area including I-494 between TH 61 and I-94, I-35W between TH 36 and I- 694, I-35W north of TH 118, and TH 169 south of I-694. The total time of testing was 14.88 hours. Figure 16 is a bar graph that depicts the data collected from all metro test sites. The following are some of the more relevant statistics from the graph-

- **16,658 vehicles counted**
- **9,999, or 60% of all the vehicles were exceeding the posted 40 MPH reduced speed limit**
- **1,908, or 12% of all the vehicles were going at least 10 MPH over the posted reduced speed limit**
- **79 MPH was the fastest speed recorded**

Combined Out-State and Metro Data

The total time for both areas of testing was 40.33 hours. Figure 17 is a bar graph that depicts the data collected from all test sites. The following are some of the more relevant statistics from the graph-

- **30,325 vehicles counted**
- **15,180, or 50% of all the vehicles were exceeding the posted 40 MPH reduced speed limit**
- **2,562, or 8% of all the vehicles were going at least 10 MPH over the posted reduced speed limit**
- **94 vehicles were going 20 MPH or faster over the posted reduced speed limit.**

Certain tendencies can be educed from the data collected, and from personal observations made at the test sites-

- speeding in work zones is still a very prevalent violation
- excessive speeding in work zones (10 MPH or greater) is a particularly dangerous and serious problem
- speeds of 15 to 20 MPH over the posted reduced speeds are not unusual
- out-state motorists appear to obey the reduced speed limit in work zones more than motorists in the metro area
- cars, trucks, motorcycles, and taxi cabs were all detected speeding
- the presence of a law enforcement vehicle with lights flashing did reduce the number of violations, but definitely did not eliminate them
- the number of speeding vehicles would probably be greater than depicted, except that a lawful driver on a single lane passing through a work zone compels all the following drivers to also obey the law.

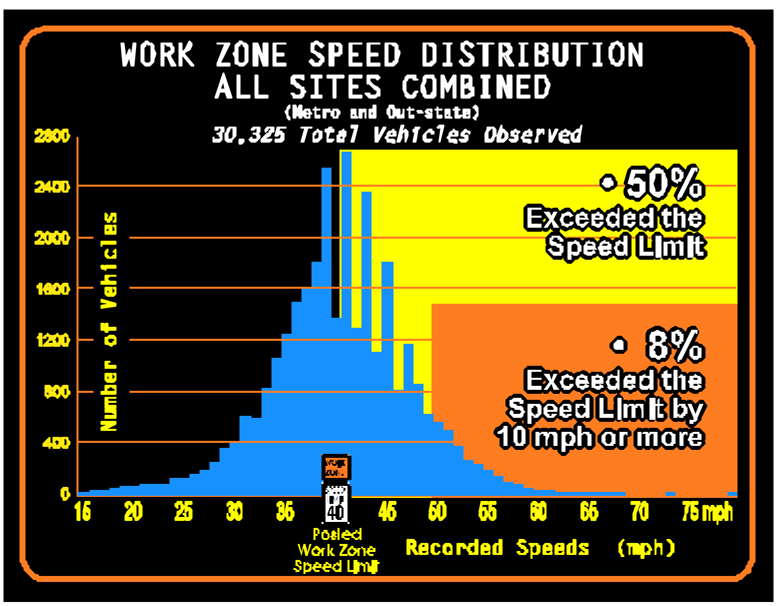


Figure 17

C. DRIVING AROUND DOWN RAILROAD CROSSING GATE ARMS

The study of this type of violation was selected because of the near impossibility of enforcement, generally sympathetic public (74% of the respondents in the market survey approved of some type of ticket for driving around down railroad gates), and because of the catastrophic consequences of vehicle-train collisions.

Figures supplied by the Mn/DOT Office of Freight, Railways, and Waterways clearly illustrate this fact. In the five most recent years in which the figures are complete (1992-1996) there were 656 vehicle-train collisions, of which, 58 collisions resulted in 69 deaths.

The Committee had originally intended to have camera installations in at lease two locations and possibly four. Initial contacts with two railroads were very promising, and several prospective locations were identified. Unfortunately, due to delays encountered with our vendor, it was necessary to limit our testing to just one installation with each of the railroads. Then one of the railroads we had been working with became very uncooperative and we were forced to go with one test site. The location chosen was 12th St. in Newport between TH 61 and 7th Ave. There are three tracks at this location, the Canadian Pacific (CP) switching track to the west, the main line CP track in the middle, and the Burlington Northern Santa Fe main line track on the east. The two main lines are 76 feet apart, while the CP switching track and CP main line are 56 feet apart. Because the CP switching track is not utilized frequently, the only signal device protecting this track from eastbound traffic is flashing red lights. All the other tracks, in both directions, are protected by crossing gates. The decision was made to monitor eastbound traffic crossing the CP main line.

The installation for a railroad crossing camera is similar to that for a red light (see Figure 18). It consists of a pole and camera housing located about 70 feet from the crossing, inductance loops imbedded in the roadway between the gate and the tracks, and wiring interconnecting the camera pole, loops and signal cabinet. Normally the loops would be installed between the end of the lowered gate and the curb side of the oncoming traffic to detect vehicles going around the down gate, but per the request of the CP one loop was also installed right behind the gate to detect vehicles crashing through it. It seems broken gates are not an uncommon problem at rail crossings.

The main purpose of the test was to detect and photograph vehicles driving around or through down gates. A second type of violation, that of ignoring the flashing lights and racing to beat the gate before it was down, was also statistically significant. According to state statute, a vehicle must stop when a visible electric device warns of the approach of a train. For this study we only counted vehicles that drove under the gate when it was at least a third of the way down. Consequently, there was no way the driver could not see the flashing lights and have ample time to stop.

The installation was operational from September 4 through November 4, 1997. There were five different deployments (separate operations of the camera with new film)

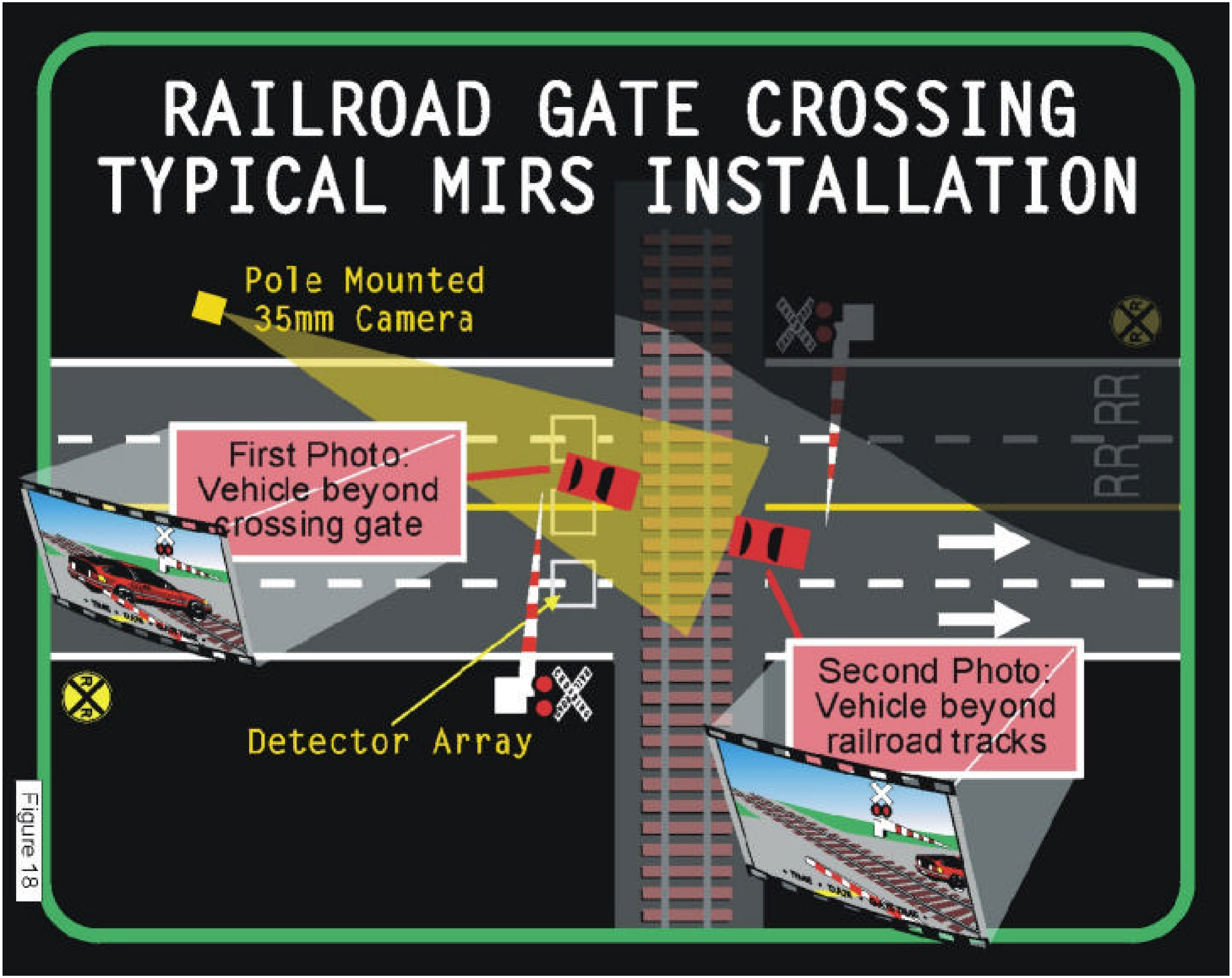

RAILROAD GATE CROSSING
TYPICAL MIRS INSTALLATION
Pole Mounted
35mm Camera
First Photo:
Vehicle beyond
crossing gate
Detector Array
Second Photo:
Vehicle beyond
railroad tracks
RR

Figure 18

that ran from five days duration to seventeen days duration. An attempt was made to spread the testing out over different parts of the month and over different days of the week. A breakdown of the deployments by day are as follows-

Monday	7
Tuesday	7
Wednesday	6
Thursday	7
Friday	8
Saturday	7
Sunday	7

The breakdown by parts of the month was not as successful. During the period the camera was operational at least some testing was conducted on 31 days that fell between the first and the fifteenth of the month, and only 18 days that fell between the sixteenth and the end of the month. This discrepancy was the result of not changing the film on a regular basis.

The camera ran for 1,089 hours and 25 minutes and detected 200 vehicles driving around down gates, which is approximately 4.4 per day. It also detected 81 vehicles going under lowering gates, which is approximately 1.8 per day. However, the daily averages are misleading. This railroad crossing is not a main thoroughfare, so the majority of the people who use it probably either live or work in the near vicinity. This means that most people use the crossing on a regular basis. A surprise result observed at this site was that, with one exception*, the longer the site was operational the lower the number of violations recorded per day. It would appear that even though the people knew they were not getting citations, they did not want their pictures taken when violating the law.

The following chart shows the decreases for both vehicles driving around the gates and vehicles driving under the lowering gates.

Averages per day for each deployment.

Deployment number	Average vehicles Around	Average Vehicles Under
1	7.63	3.95
2	3.59	2.18
3	*5.69	1.69
4	3.09	1.37
5	2.37	.79

Figure 19 is a bar graph which shows the breakdown per hour for the number of violations combining both vehicles driving around gates and under lowering gates. The three one hour time periods with the greatest number of violations were 5:00- 6:00 PM with 41,

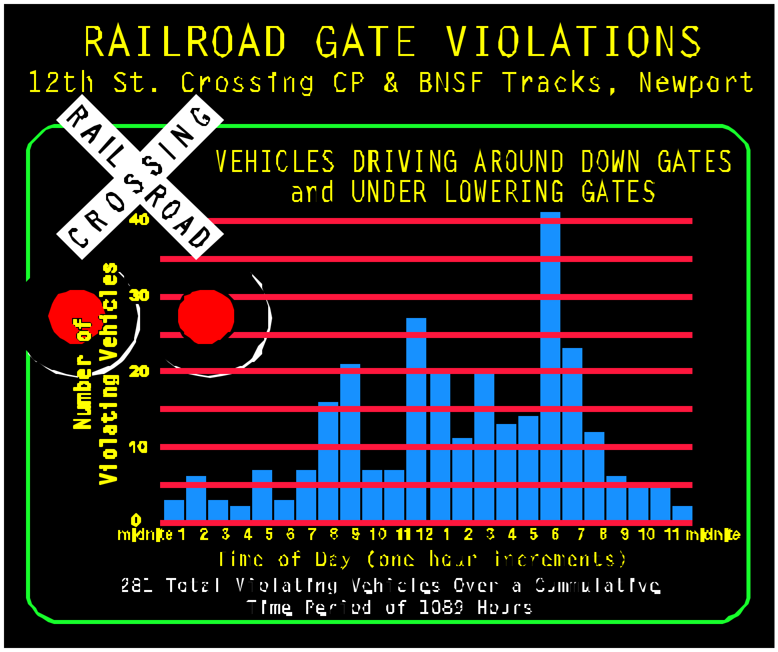


Figure 19

11:00-noon with 27, and 6:00-7:00 PM with 23. These times closely correspond with the noon and evening rush hours. Very few railroad crossing gate violations occurred in the middle of the night.

D. MISUSE OF BUS ONLY SHOULDER LANES

The study of the misuse of bus only shoulder lanes was selected because of the impracticality of enforcing this type of violation, and because no one really knew how extensive the violations were.

Metro Transit had selected the location where they had wanted to do the testing (the eastbound I-94 exit ramp to 4th St. in downtown Minneapolis), and the Mn/DOT Bridge Office had most of the logistics for the installation resolved.

The project was halted when the vendor informed us that the cost for programming would be approximately $18,000. This change had not been mentioned before, and as a matter of fact, when a former vendor employee had been questioned a few months earlier about possible additional programming costs, had said there would be none. Because of the additional cost, and because it was too late in the summer of 1997 to consider other alternatives, the study of misuse of bus only shoulder lanes was canceled.

PART V. EFFICIENCY OF EQUIPMENT

A. PREFACE

The efficiency of the equipment comprised two of the three questions the Committee had determined needed to be answered regarding the technology. Those two questions were whether the technology was sophisticated enough to detect and record violations, and was the equipment durable, dependable, and accurate when used in Minnesota's variable climatic conditions. With minor reservations both questions were answered.

The photographic and computer equipment was supplied by American Traffic Systems. Although the same basic principle was utilized in the design of all the equipment that was used for the different tests, there were sufficient dissimilarities to necessitate a discussion of each type of violation.

B. RED LIGHT AND RAILROAD CROSSING EQUIPMENT

The equipment used for both red light and railroad crossing violation detection is the same. It consists of a metal post (approximately fourteen feet high), a metal camera/computer housing fastened to the pole which slides up and down via a system that resembles a vertical garage door opener, and a camera/computer unit that fits in the housing. The camera is a 35mm that is equipped with either an 80mm or 150mm lens depending on the location. The modified film magazine holds over 100 feet of film. Also attached to the camera is a high speed flash (1/1000th of a second) which is used to illuminate the license plate of the violating vehicle. The computer regulates the entire system and records the violation on a PC memory card.

The peripheral equipment worked very efficiently. The tracks on the poles that raised and lowered the camera housings performed well even in adverse weather conditions. They operated correctly in the rain, snow, heat, and cold (to minus five degrees fahrenheit). The camera housings protected the camera/computer in all conditions. The key systems that controlled the pole tracks and access to the camera housings also worked well. The flash units operated correctly, but two flash units did burn out over the winter, possibly due to the cold. Only one complaint was received concerning the brightness of the flash during the entire testing program.

During the project two cameras were used for red light and rail crossing tests. These cameras were rotated from one installation to another. The first camera installed worked inadequately from the beginning to the end. The camera photographed every violation, but the license plates were barely legible to begin with and deteriorated as the testing progressed. Numerous attempts were made to correct the problem including sending the camera back to the vendor for repair. The vendor made some minor adjustments and returned the camera. It was again installed in the field but there was no improvement in the pictures. The vendor then suggested that we were not properly focusing the lens. Over a period of several weeks different lens settings were made, but again no improvement. We even moved the camera to different locations to see if the distance to the vehicles or differences in lighting would make a difference. But again nothing improved the quality of the photos. The vendor did credit us for many rolls of film due to the poor quality of the photos.

Conversely, the second camera performed very efficiently. The pictures were quite clear and the license plates very legible. Wherever this camera was moved the results remained the same. The camera operated over part of the winter. During one of the times it was running the temperature fell to minus five degrees fahrenheit and the camera/computer still detected and photographed violating vehicles. The only problem detected with operating the unit during the winter was that when it snows the pictures lose most of their clarity. As the flash goes off the light reflects off the snowflakes. This results in dozens of little white spots in the pictures. The harder it snows the more white spots appear. This same phenomenon occurs only minimally when it is raining. Neither camera was affected by the heat during the summer.

As was mentioned earlier, the film magazine can hold over 100 feet of film. This results in approximately 650 photos per roll of film. Two photos are taken of each violating vehicle and several photos are snapped as the unit self tests itself. This means that there is a potential for photographing as many as 300 violators per roll of film (it should be noted that we never achieved this total). Loading and unloading the film is a very easy process. When the film is unloaded it can only be developed at specific developers who can handle film of this length. The developed film is then viewed through a special machine which enlarges the negative and transfers the image to a television. It is this magnification that results in the license plates being legible.

The computer component of both units operated without a breakdown. However, several problems were encountered with the programming. The first installation was inoperable for nine weeks when the program did not function correctly. Also, at various times throughout the project, programming problems were encountered that could only be rectified by contacting the vendor for corrective action. At times the problem could be solved immediately, and at other times it took several weeks.

C. WORK ZONE SPEEDING EQUIPMENT

A work zone speeding installation consists of a camera, an attached Ka band radar unit, the tripod the camera rests on, marine batteries for power, and a computer that remains in the control vehicle.

The principal difference between the equipment used in the detection of work zone speeding violations and the detection used in red light and railroad crossing violations is the portability of the former. Whereas the camera/computer rests in a metal housing at red light and railroad crossing installations, the speed camera rests on a tripod at work zones. This means the unit can be easily moved from one work zone to another, while the red light and railroad crossing equipment is stationary. It takes approximately twenty minutes for one person to assemble or dismantle the installation.

The camera that was used for the work zone speeding tests functioned correctly. The pictures were quite clear and the license plates were very legible. The camera did miss a percentage of trucks with high clearance trailers. This occurred because the camera was set low enough to take pictures of normal sized vehicles.

The radar was very accurate in detecting the speed of passing vehicles. We tested the radar several times by having law enforcement vehicles drive by and comparing their speedometer readings to the readings we had recorded. In all cases the speeds were within one mile per hour or less of each other.

Numerous problems were encountered with the programming. Several times the camera/computer would not detect all passing vehicles. When this occurred the vendor had to be called for instructions on how to rectify the problem. On occasion the computer screen would show random symbols. Again, the vendor had to be contacted to correct the problem. A few times during the summer the computer screen froze up, but the problem was resolved by rebooting the computer.

D. SUMMARY

Overall the efficiency of the equipment was good. With rare exceptions all violations were detected, and two of the three cameras operated efficiently while recording the violations. Unfortunately the one red light camera was defective and that detracted from the otherwise positive rating of the equipment. All of the equipment performed adequately in most climatic conditions. The changes in the temperature did not seem to adversely affect the equipment However, it is not known how well the speed camera would function in the cold because without major road construction there were no work zones in which to test it.

A brief discourse on the relationship and cooperation with the vendor is necessary when considering the efficiency of the equipment. As a preface it should be noted that the vendor we used does not normally lease their equipment for testing purposes, so this was a new experience for them also.

One of the continuing problems we encountered was a failure of communication. Many times our calls went unanswered, or were not answered for several days. This resulted in numerous delays throughout the entire project. When contact was made, however, most problems were resolved in an efficient manner. Another problem that occurred occasionally was delays in the shipment of material. Several times items did not arrive when they were due. This led to necessary inconvenient changes in our scheduling.

The most troubling problem encountered was a change the vendor made in their personnel. The person who had been coordinating our project for them left their service and we were not informed of this for several weeks. Then it took the person replacing them a period of time to become current with the project. All of this resulted in major changes and/or delays in our plans.

PART VI. PROJECT COST

From the very beginning the Committee was concerned about the cost of the project and where the sources for funding would be found. Before any decisions could be finalized as to the number of specific applications of the technology that would be tested and how extensive the testing would be for each application, it was necessary to determine the level of funding that would be available.

Minnesota Guidestar, an Office of Mn/DOT, made a financial commitment to the project. They allocated $100,000 in funding. Then, the Mn/DOT Office of Traffic Engineering, in conjunction with the Federal Highway Administration and Department of Public Safety, made a commitment for $55,000. These funds would come from 402 roadway safety funds.

For their financial contribution, each of the partnership cities of Bloomington, Minneapolis, and St. Paul committed to absorbing the installation expenses. These expenses varied from city to city and from site to site. But the estimated costs ran from a low of $3,500 to a high of $7,500. Included in these figures are the costs for installing the inductance loops, preparing the base for the pole, laying the wiring from the signal box to the camera box, and the hook-up of all the wiring to the camera.

For the railroad crossing site, Mn/DOT installed the inductance loops, prepared the base for the camera pole, and connected all the wiring to the camera. The railroad did the trenching and wiring from the signal box and the inductance loops to the base of the camera box.

At both the red light and railroad crossing sites Mn/DOT delivered the equipment for installation and removed it when the testing was completed.

Once the funding problem was resolved, and the Committee had determined the projects to be tested, the next step was to procure a vendor to supply the equipment. A Request for Proposal (RFP)was developed and published in the June 26, 1996 issue of the State Register. Copies of the RFP were sent to four vendors, and three responses were received. An evaluation subcommittee consisting of five members from the MIRS Committee was chosen to evaluate and rank the three proposals. American Traffic Systems Inc.(ATS) of Scottsdale, Arizona was chosen as the vendor to supply the equipment for testing. A lease agreement was then negotiated between Mn/DOT and ATS which took effect September 30, 1996.

The actual project cost is impossible to calculate because of the in kind services performed. But certain costs, such as for the equipment and associated expenses, can be ascertained.

The total amount paid to ATS was $96,256. This amount included all charges for the equipment, film, and consulting fees. The following is a list of the services supplied and the cost of each item-

Service	**Cost**
RL-200 red light and railroad crossing cameras	$33,905
RL-200 set-up fee	2,000
PR-100 speed camera	25,632
PR-100 set-up fee	6,000
Poles and housings(three additional units)	7,461
Shipping	4,668
Film	4,080
Film viewing equipment	3,100
Travel expenses (ATS)	4,000
Engineering costs	1,107
Blueprints	103
Consulting fees (ATS)	4,200
Total	**$ 96,256**

There were additional expenses incurred and paid for by Mn/DOT exclusive of in kind services. The following is a listing of those expenses-

Service	**Cost**
Photo development and enlarging	$ 5,903
Insurance (equipment and liability)	615
Shipping charges (estimated)	1,000
Conference fees (Est.)	250
Miscellaneous purchases for installations (Est.)	300
Outside copying services (Est.)	500
Total	**$ 8,568**

As was detailed earlier (Part III. Marketing Research Survey) the Committee felt that it would be advantageous to do a public survey to ascertain its opinion on this type of technology. Guidestar agreed to fund this survey. The final cost was $ 33,450.

VII. CONCLUSIONS

Several conclusions can be drawn from the MIRS project. Some of the outcomes were anticipated and others were unexpected. The consideration of these conclusions must be made with the understanding that the testing was not extensive. Although definitive declarations can be made about the locations that were tested, an assumption cannot be made that these same results would be duplicated elsewhere.

One conclusion drawn from the MIRS testing is quite conspicuous; certain traffic control devices are being violated at a higher incidence than anticipated. This is particularly true of red light running and speeding in work zones. The expectation of these types of violations was that they were occurring, but not that they had become a problem of epidemic proportions. The continued disregard of certain violations could lead to a general disregard for all traffic control devices. If law abiding motorists begin to perceive that traffic laws are being ignored without consequences, then they too will begin to ignore those laws.

The MIRS technology proved to be quite effective at detecting violations. This was true even when violations were occurring simultaneously or in rapid succession. Other than having an individual manually recording violations, which is inefficient and cost prohibitive, there is no known system that can duplicate the accuracy of the MIRS technology.

Unfortunately, the actual recording (by camera) of the detected violations did not prove to be consistent. Two of the cameras worked correctly, but the third took pictures that were not legible enough to read the license plates. What is not known is if the defective camera was an exception or if this type of camera is unreliable. The two cameras that did function correctly took very legible photos that clearly showed the numbers and letters on license plates. These photos could be used to determine the owners of the violating vehicles.

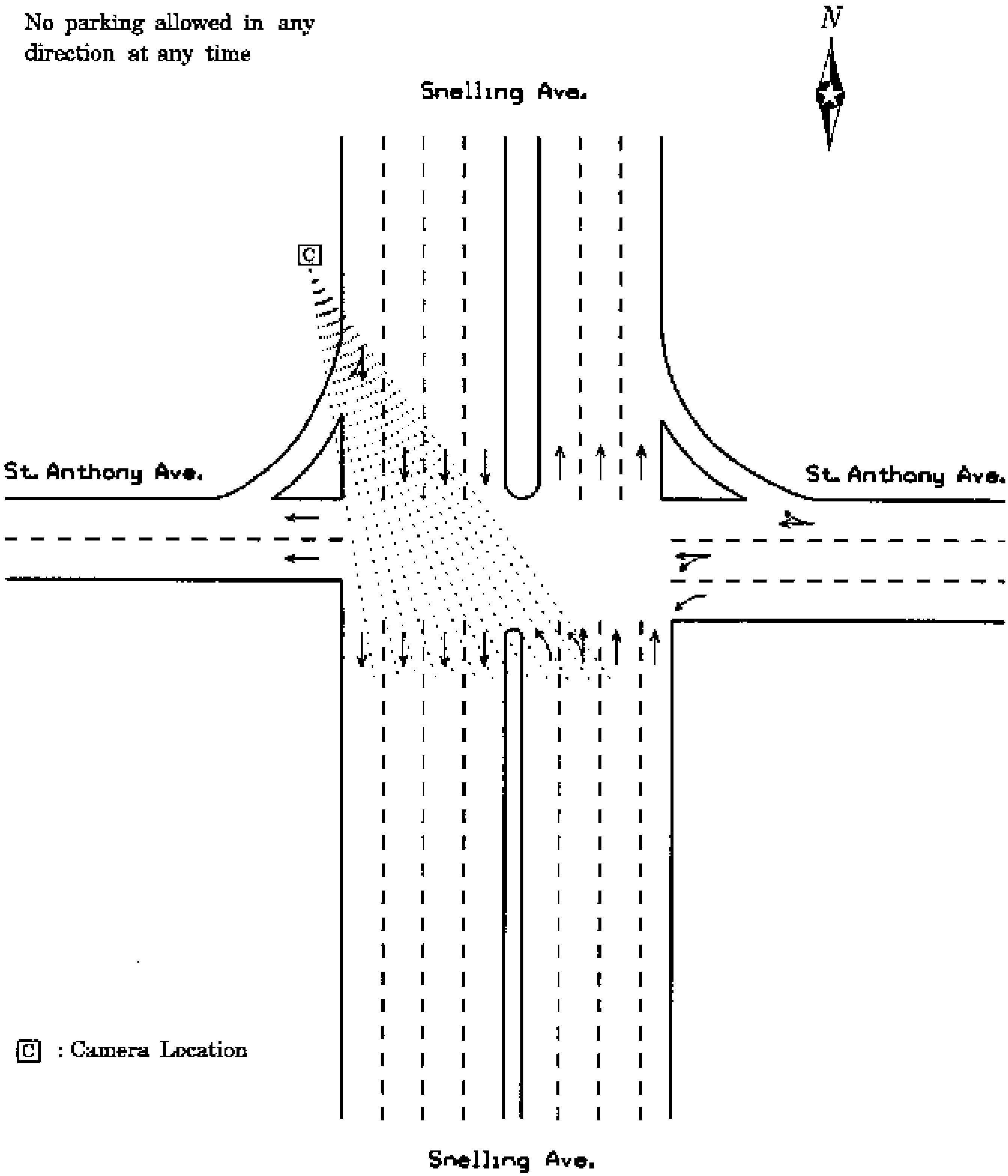
The last conclusion that can be educed from the MIRS testing is that additional testing needs to be conducted. Confirmation must be made of the prevalence of violations to determine if this is a statistical anomaly or a widespread occurrence. Furthermore, additional testing must be conducted on the equipment that actually records the detected violations, as our testing proved inconclusive. There are several manufacturers of this equipment and it would be a disservice to the public to not test the efficiency of diverse equipment before making a determination on this type of technology.

Appendix A

Snelling AVE. and St. Anthony AVE.

Speed 30 MPH

No parking allowed in any direction at any time



C : Camera Location

Appendix B

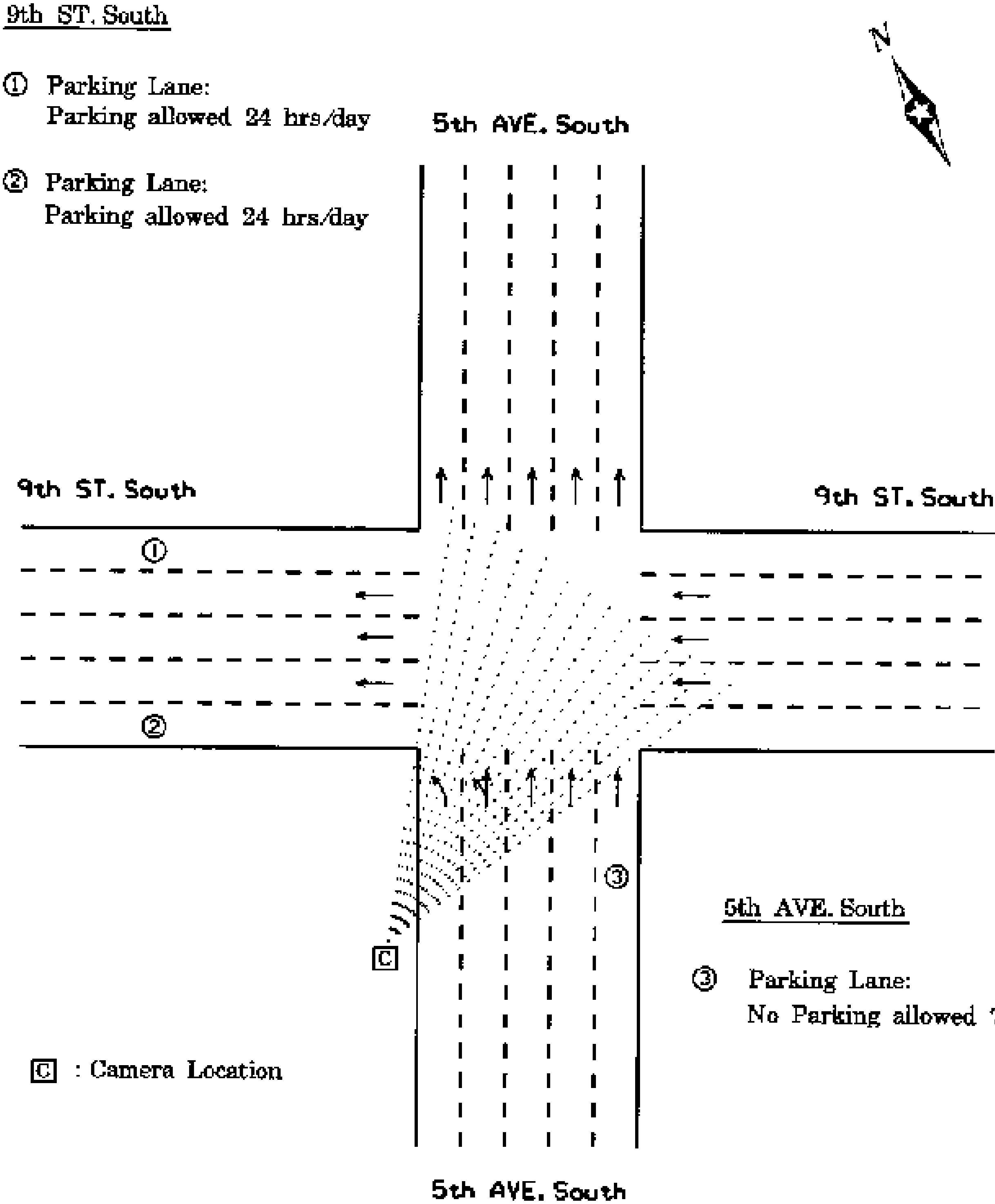
5th AVE. South and 9th ST. South

Speed 30 MPH

9th ST. South

① Parking Lane:
Parking allowed 24 hrs/day

② Parking Lane:
Parking allowed 24 hrs/day



5th AVE. South

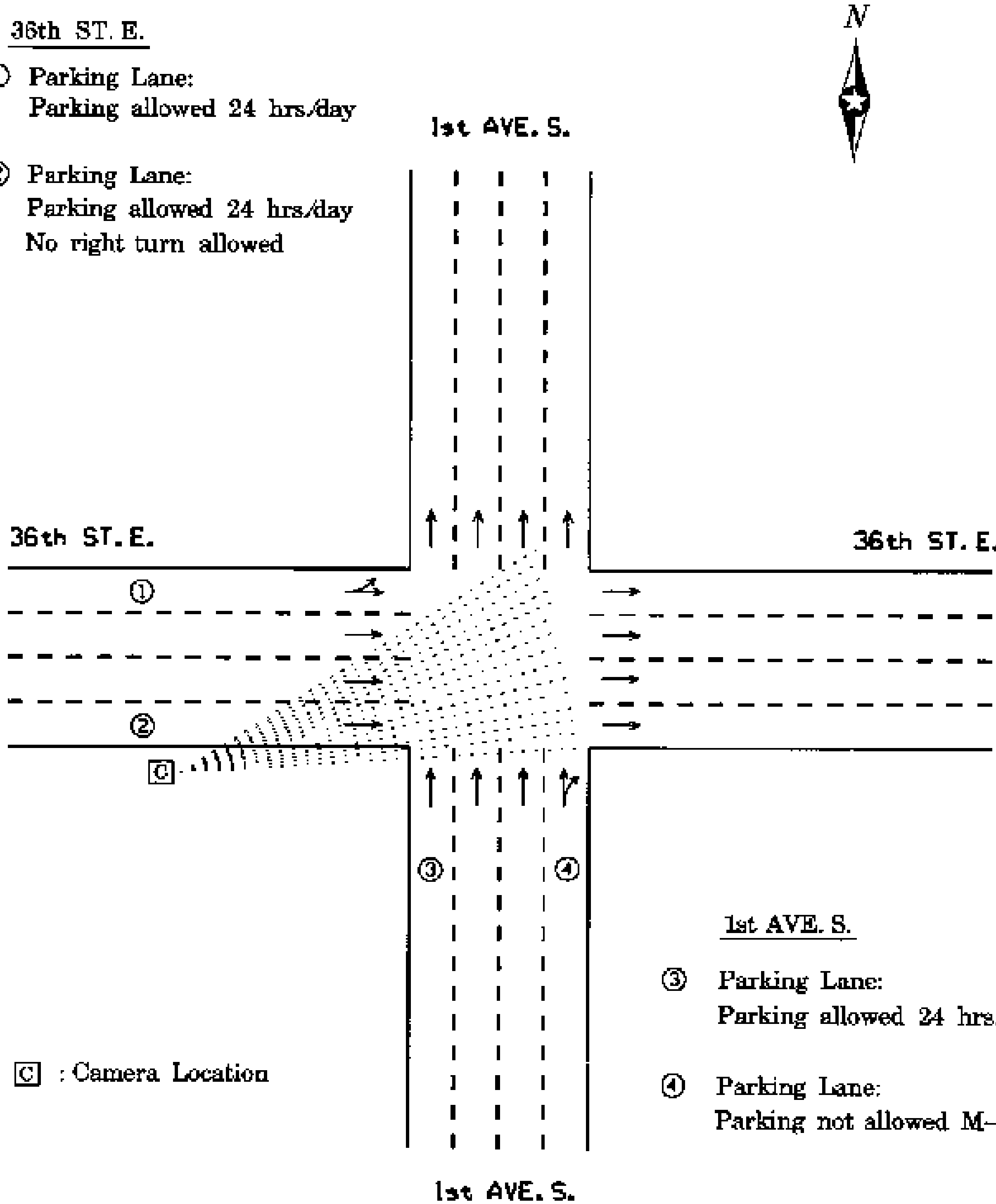
③ Parking Lane:
No Parking allowed 7–9 AM

[C] : Camera Location

Appendix C

36th ST. East and 1st AVE. South

Speed 30 MPH



36th ST. E.

① Parking Lane:
Parking allowed 24 hrs/day

② Parking Lane:
Parking allowed 24 hrs/day
No right turn allowed

1st AVE. S.

③ Parking Lane:
Parking allowed 24 hrs/day

④ Parking Lane:
Parking not allowed M–F

C : Camera Location

Appendix D

90th ST. and Nicollet AVE.

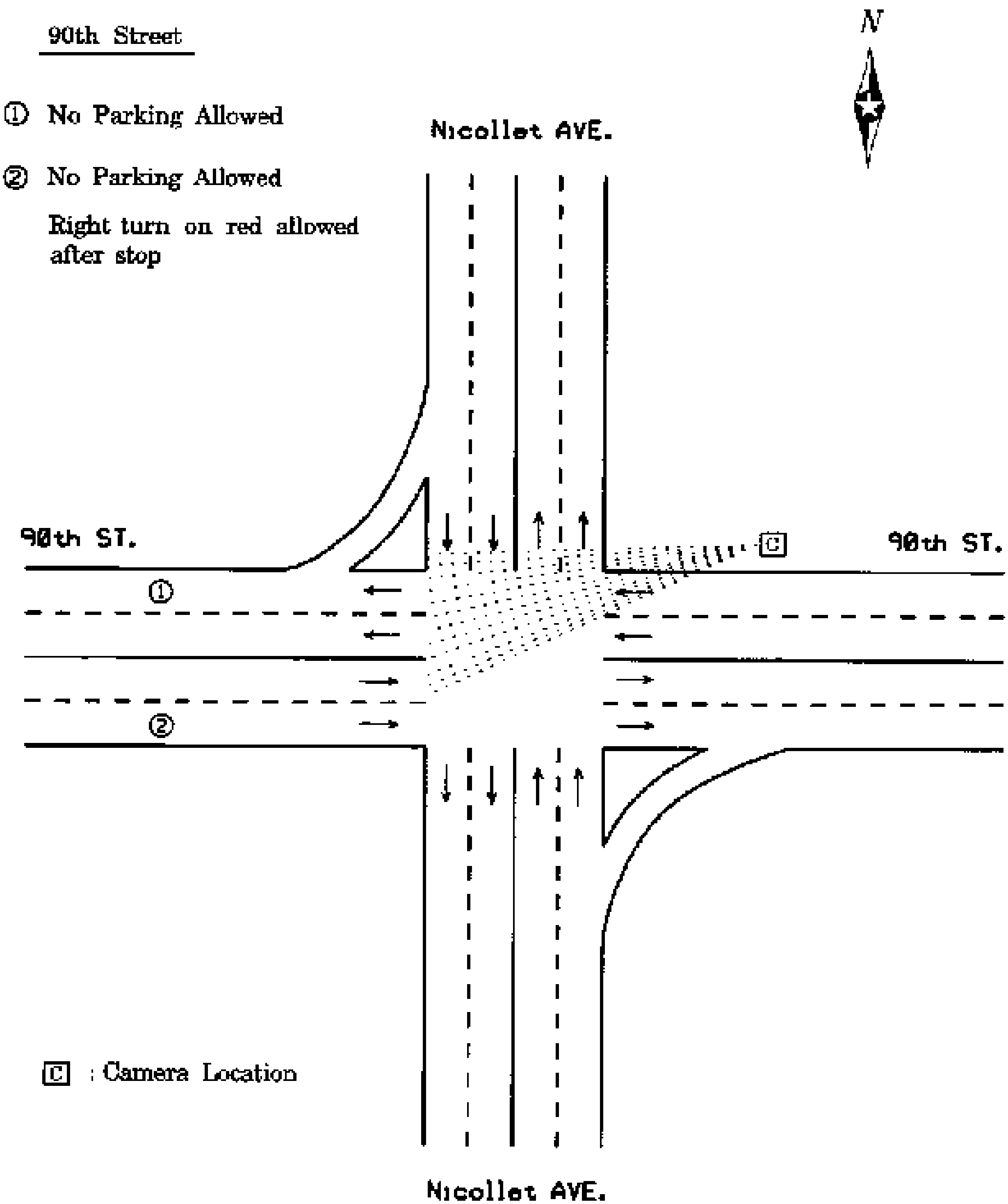
Speed 35 MPH

90th Street

① No Parking Allowed

② No Parking Allowed

Right turn on red allowed after stop



[C] : Camera Location

Appendix E

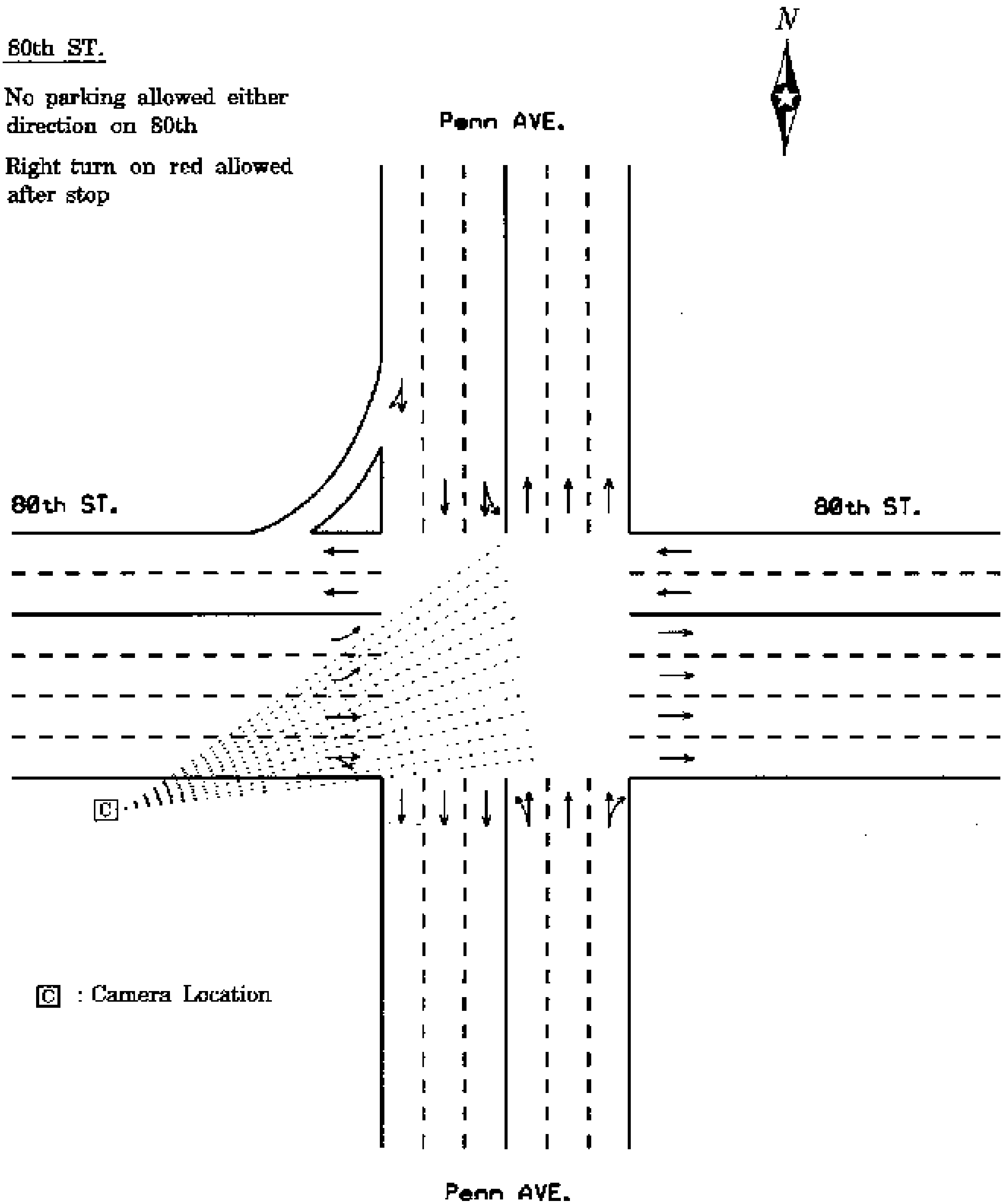
80th ST. and Penn AVE.

Speed 30 MPH

80th ST.

No parking allowed either direction on 80th

Right turn on red allowed after stop



C : Camera Location