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KENTUCKY TRANSPORTATION CENTER

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EVALUATION OF AUTO INCIDENT RECORDING SYSTEM (AIRS)

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EVALUATION OF AUTO INCIDENT RECORDING SYSTEM (AIRS)

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in cooperation with

Kentucky Transportation Cabinet
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16. Abstract

The Auto Incident Recording System (AIRS) is a sound-actuated video recording system. It automatically records potential incidents when activated by sound (horns, clashing metal, squealing tires, etc.). The purpose is to detect patterns of crashes at intersections for use in implementing relevant improvements. Videos of incidents and near-incidents were obtained after AIRS was placed in service at an intersection in Louisville, Kentucky on July 22, 2001. Crash reports were obtained from January 1998 through September, 2004 to; a) compare to the available data from AIRS videos, and b) compare the crashes before and after various improvements were made. A traffic conflict study was made at the intersection and the the traffic conflictdata was compared to results obtained from AIRS and to the crash summary.

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EXECUTIVE SUMMARY

The Auto Incident Recording System (AIRS) is a sound-actuated video recording system used to analyze the reasons for traffic crashes at intersections. It automatically records potential incidents when sound is recorded (horns, clashing metal, squealing tires, etc.). The purpose is to detect patterns of crashes at intersections in order to implement relevant improvements. The system consists of two video cameras located on two corners of the intersection to obtain a view of incidents and near-incidents from different perspectives, two directional microphones that listen for sounds that could be related to a traffic crash, digital signal processors and recording media, and a video cassette recorder.

Videos of incidents and near-incidents were obtained after AIRS was placed in service on July 22, 2001 at an intersection in Louisville, Kentucky. Crash reports were obtained from January 1998 through September, 2004 to compare to the available data from AIRS videos and to compare the crashes before and after various improvements were made. The videos and police reports were reviewed and were categorized by type. A traffic conflict study was made at the intersection and the traffic conflict data was compared to results obtained from AIRS and to the crash summary.

It was found that AIRS is capable of documenting crashes at an intersection. AIRS data can be used as a reliable surrogate for crash data. The near-incidents identified by AIRS were very similar to the incidents recorded by AIRS and the crash report data. An excessive number of false incidents were recorded. A large number of crashes (47) occurred that were not recorded by AIRS with no explanation found to explain the failure for approximately one third of those crashes. The AIRS data were a more reliable surrogate of crash data than the conflict data. AIRS provides a time efficient method of analyzing intersection collisions compared to a conflict analysis or a continuous videotaping. However, the efficiency is limited somewhat by the large number of false incidents found by AIRS. A method to minimize these false incidents should be developed. The improvements made as a result of the AIRS data resulted in a reduction in crashes at the study intersection. The crash savings in one year would pay for the cost of the AIRS installations. This shows that AIRS had a high benefit-cost ratio. Given the costs and limitations of both AIRS and conflict studies, an alternative which should be considered is the completion of an intersection safety audit.

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1.0 INTRODUCTION

1.1 Background

More than 2.8 million intersection-related crashes occur in the United States every year. This represents more than 44 percent of all reported crashes on public roads. Data in Kentucky have shown that about 35 percent of all traffic crashes in Kentucky occur at intersections (1). The Kentucky Transportation Cabinet's strategic plan has a goal to reduce the number of intersection-related collisions by 10 percent by the year 2007. The Auto Incident Recording System (AIRS) has been implemented in an effort to aid this undertaking. This video recording system automatically records potential incidents when activated by sound (horns, clashing metal, squealing tires, etc.) that can be used as a method of detecting patterns of crashes so relevant improvements could be implemented.

This system was installed at the intersection of Brook Street and Jefferson Street in Louisville, Kentucky (Figure 1). Several potential conflicts in turning movements exist at this intersection since an exit ramp from Interstate 65 (I 65) is also at the intersection (Figure 2). The system has been in place since July 22, 2001. The installation cost was about $58,000. Installation was a cooperative effort between the Kentucky Transportation Cabinet and the City of Louisville. The system has been operated and maintained by Traffic Response and Incident Management Assisting the River Cities (TRIMARC).

1.2 Research Study Objectives

The primary objective of this study was to evaluate the effectiveness of AIRS as a data collection and analysis tool, including an assessment of the costs and benefits of the system. A secondary objective was to develop recommendations concerning whether additional systems are warranted and a plan for deployment.

1.3 Description of AIRS

The Auto Incident Recording System was developed in Japan by the Mitsubishi Electric Company, and the Louisville installation is the first in the United States. It is a sound-actuated video recording system used to analyze and evaluate the occurrence of traffic crashes at intersections. The system consists of two video cameras, with each one located on opposite corners of the intersection to obtain a view of incidents and near-incidents from different perspectives, two directional microphones that detect sounds that could be related to a traffic crash, digital signal processors and recording media, and a video cassette recorder.

Video and sounds are recorded continuously on an eight-second digital memory loop. When the system detects an event that could be a collision, another four seconds of video are captured. This results in 4 seconds before the event and 4 seconds after the event. An eight-second loop is transmitted to the video recorder (from both cameras). This consists of four seconds before and after the event that activated the system. The signal phase is then encoded onto the recorded video. The system then returns to recording eight-second loops until another incident occurs. The cameras are shown in Figure 3.

Figure 1. View of the intersection of Brook Street and Jefferson Street

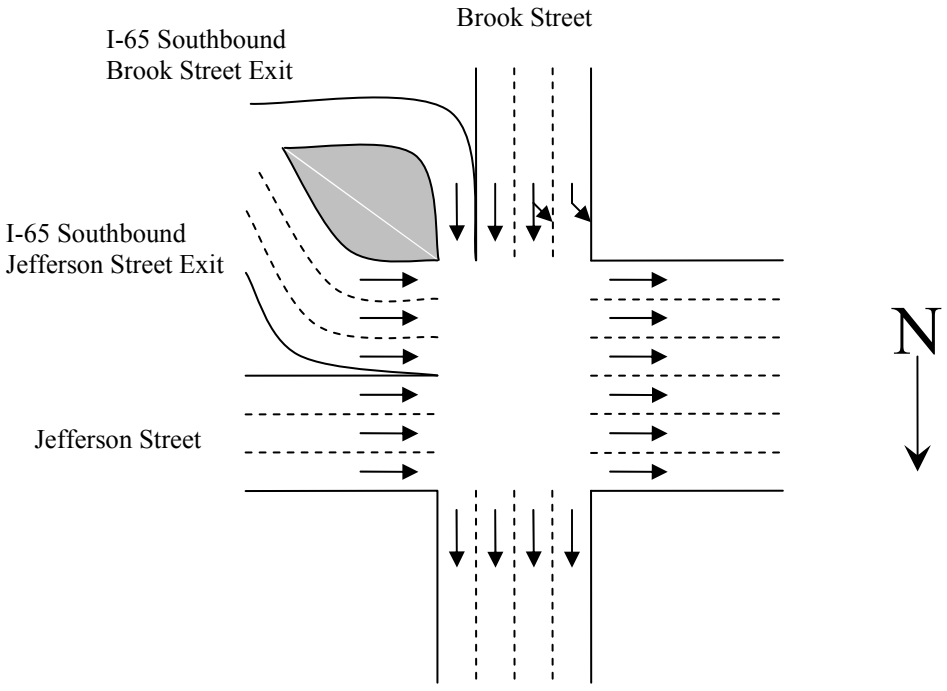

Figure 2. Intersection lane assignment

Figure 3. AIRS cameras

2.0 PROCEDURE

2.1 Literature Review

A limited amount of literature was located that addressed the subject of automatic recording systems to detect traffic crashes. The first reports were in 1996 (2, 3). One of these studies evaluated a recording system called "Traffic Accident Auto Memory System (TAAMS)" that recorded the scene before and after a traffic crash in real time (2). The system was installed at six intersections in Japan with or without signal control. Five cases including crashes and conflict cases were demonstrated as a study of decision strategy on driver behavior at the unsignalized intersection. The TAAMS data were used to develop suggestions to avoid future crashes.

The purpose of the other 1996 paper was to assess the usefulness of an automatic recording system "Traffic Accident Auto-Memory System (TAAMS)" to record the scene before and after a traffic crash (3). The system was installed at two unsignalized intersections in Tokyo in 1994. Crashes and near misses were recorded. The data revealed three misjudgment groups for drivers. Photographs of the crashes were available to locate drivers for interviews.

Another study described in a 2002 report considered the development of a system for automatically detecting and reporting traffic crashes at intersections (4). The proposed system would determine crashes directly from the acoustic signal of the crash. An acoustic database of normal traffic sounds, construction sounds, and crash sounds was developed using sounds of

crash tests, routine traffic sounds at intersections, and construction sounds from construction sites. Tests showed the false alarm rate (false positive) was one percent. A conclusion was that the system needed to be further evaluated in situations with routine traffic flow and accident occurrences.

Positive results from an evaluation of the Automated Incident Recording System (AIRS), commonly referred to as "Crashcam" was described in a 2003 report (5). Crashcam was proposed as a supplement to traditional types of analysis. Issues related to location were provision of electricity, mounting of the cameras, lighting, sources of external high volume noise, number of cameras, necessary viewing area of intersection, and vandalism potential. It was noted that at least three months of operation was necessary to capture an adequate sample. The average cost to mobilize a site was $20,000 where there is readily accessible power.

A description of the use of AIRS at the Louisville intersection evaluated in this report was documented in a 2004 report (6). The type of system was described. Preliminary effects of improvements made as a result of data from AIRS on crashes were noted. Reductions in types of crashes addressed by the improvements were given. It was noted that an ongoing evaluation was being conducted.

2.2 Data Collection

AIRS was placed in service at the Brook Street/Jefferson Street intersection on July 22, 2001. Videos of incidents and near-incidents from AIRS were obtained on VHS tape and converted to MPEG files and stored on CDROM for analysis. The date and time of each video were recorded and stored in a database. Each video was reviewed and categorized as a near-incident or incident. Videos involving miscellaneous sounds that triggered the system by mistake were excluded from the analysis.

Crash reports were obtained from the CRASH database from July 22, 2001 through September 18, 2004 to compare to the available data from AIRS videos. Police reports were also obtained from January 1998 until the installment of AIRS in an effort to evaluate the traffic crash patterns before the system was in place and compare the crashes before and after the various improvements were made.

The videos and police reports were reviewed and categorized by type. The type categories used the direction of travel of the vehicles and their movements to describe the incident (crash) or near-incident. Following is a list of the various categories used. The categories use the direction of travel and/or type of collision.

Crash Code	Type of Crash
1	Brook NB & Jefferson WB
2	Exit I-65 Jefferson WB & exit I-65 Brook NB
3	Exit I-65 Jefferson WB & Brook NB
4	Exit I-65 Jefferson WB (improper right turn) & Jefferson WB
5	Exit I-65 Brook NB (improper left turn) & Brook NB
6	Exit I-65 Brook NB & Jefferson WB
7	Exit I-65 Jeff WB & Jeff WB not @ intersection
8	Rear-end crash Brook NB
9	Jefferson EB (wrong way) & Brook NB
10	Rear-end @ exit I-65 Brook
11	Brook NB & Brook NB
12	Brook NB (straight in left turn only lane) & Brook NB turning
13	Jefferson WB & Jefferson WB
14	Exit I-65 Jeff & exit I-65 Jeff (sideswipe or rear-end)
15	Rear-end Jefferson WB
16	Single Vehicle
17	Pedestrian

Reference can be made to the intersection diagram shown in Figure 2 to understand these categories. Additional data were obtained from the police reports indicating the estimated speeds and level of damage to each vehicle.

2.3 Data Analysis

The data from the police reports were used to match each crash report to an AIRS video. Information such as the description of the crash, colors of the vehicles involved and type of crash were used. In some cases, a police report was found with no corresponding AIRS video. These cases were examined in detail to determine why the system did not record the incident. In other cases, no crash report could be found to match an incident recorded by AIRS.

Data from AIRS were used as a basis of making several minor safety improvements at the intersection. The dates of each improvement were obtained along with the specific improvement. Crash data before and after the various improvements were compared.

2.4 Traffic Conflict Data and Analysis

An attempt was made to determine if AIRS data could be used as an alternative to a traffic conflict analysis. A traffic conflict study was made at the intersection with the data compared to the results obtained from AIRS and the crash summary. The conflict study was conducted by Hamilton Associates of Vancouver, British Columbia on Wednesday, November 10 and Thursday, November 11, 2004.

3.0 RESULTS

3.1 Comparison of AIRS and Crash Data

All videos obtained from AIRS were reviewed to eliminate any video that was not related to a traffic incident or near-incident. It was estimated that 99 percent of the videos were removed from the analysis since they were not related. This estimate was calculated from a review of the tapes and a comparison of the total number of triggers with the number of incidents and near-incidents. In most cases a trigger results in two recordings; one from each camera. The number of triggers was approximated by dividing the total number of recordings on the tapes by two. Typical causes of unrelated triggers were sound from the following: ambulance runs due to the location of the intersection near several hospitals; nearby construction; the noise from large vehicles traveling over a manhole cover in the intersection; and background noise from sources such as birds.

The date and time of all AIRS videos were placed in a database. This included both incidents and near-incidents. All police reports occurring at the intersection within the analysis period were also obtained. Attempts were made to match police report data with the video where an incident occurred. In a very few number of cases the police report date or time was recorded incorrectly. These dates were modified when an undisputable match was found. When a match from AIRS was not found for a police report, the police report data were added to the database. This resulted in a database that included each of the following three types of events:

- AIRS video with a matched police report,
- AIRS video where a corresponding police report could not be located, and
- Police report where a corresponding AIRS video could not be located.

Information pertaining to vehicle speed and damage was added to the database when a police report was available. This included the estimated speeds for up to three units involved and the description of damage for up to three units as given on the police collision report.

During the approximate 38-month study period, a total of 92 incidents and 201 near-incidents were recorded by AIRS. During this same time period, 107 crash reports were identified as occurring at the intersection. The comparisons of incidents and crashes resulted in the following summaries:

- a match of an AIRS video and a crash report – 60
- an AIRS video with no corresponding police report – 32
- a police report with no corresponding AIRS video – 47

Police Reports with No AIRS Videos

There were 47 records in the database that had a police report but no matching AIRS video. The reasons for the failure of AIRS to record these incidents were investigated. Following is a

summary of the reasons found.

Reason	Number of Occurrences	Percentage
Not recorded	16	34.0
Recorded over	6	12.8
Tape not available (removed by police)	5	10.6
System down for maintenance	2	4.3
Unknown (however, aftermath of crash was recorded)	6	12.8
Unknown	12	25.5

AIRS Videos with No Police Reports

There were 32 AIRS videos where no police report could be located. The reasons to explain these findings were investigated. One possible reason is that the impact was minor such that no police report was filed. Following is a subjective summary of the impact severity of the crashes as observed on the video.

Severity of Impact	Number Of Occurrences	Percentage
Major	4	12.5
Moderate	3	9.4
Minor	15	46.9
Very minor	10	31.2

Most of the crashes were minor or very minor which could explain why no police report was filed. One video recorded a crash that was beyond the intersection of Brook and Jefferson Streets, which could explain why a police report was not found.

3.2 Analysis of Types of Crashes

A total of 139 crashes were documented either by a crash report, AIRS video, or both. Each crash was placed into a category based on the direction of travel of the vehicles and their intended movement through the intersection. The categories listed in section 2.2 describe each category and the corresponding number code that will be referenced throughout the remainder of the report.

Following is a summary of the number of crashes in each category. When both an AIRS video and a crash report were located, the AIRS video was used to determine the proper code since the video provided a better description than the police report.

	Number				
Crash Code	AIRS only	Police Report only	Both	Total	Percent
1	1	7	6	14	10.1
2	1	1	3	5	3.6
3	3	4	4	11	7.9
4	9	4	22	35	25.2
5	13	9	17	39	28.1
6	0	0	2	2	1.4
7	2	1	1	4	2.9
8	0	1	1	2	1.4
11	0	5	0	5	3.6
12	2	6	2	10	7.2
13	0	8	0	8	5.8
14	1	0	0	1	0.7
15	0	0	1	1	0.7
17	0	1	1	2	1.4

The analysis showed that the most common crash involved a driver exiting I-65 making an improper turn. This involved either turning right from the Jefferson Street exit onto Brook Street or turning left from the Brook Street exit onto Jefferson Street. Both of these turns are prohibited. There were also several crashes involving a driver in the left turn only lane on Brook Street attempting to travel straight through the intersection.

3.3 Analysis of Near-Incidents

A total of 201 near-incidents were document by AIRS. The type of crash that almost occurred was summarized using the same crash codes. Following is a summary of the types of near-incidents identified by AIRS.

Crash Code	Number	Percent
1	3	1.5
2	18	9.0
3	31	15.4
4	77	38.3
5	61	30.3
6	1	0.5
7	3	1.5
9	1	0.5
10	2	1.0
11	0	0.0
12	2	1.0
14	1	0.5
17	1	0.5

It was noted that the most common near-incident was the same as the most common incident.

3.4 Traffic Conflict Results

Eighty-four conflicts were recorded during the two-day 32 person hour study. This involved 2 people conducting the study 8 hours a day for 2 days. Each conflict was categorized into one of the 17 categories used for the AIRS analysis. The conflict data were then compared to the AIRS and police report data. A severity score was assigned to each traffic conflict by the team of engineers. The score reflects how severe the crash would have been. A higher score indicates a more severe conflict. Conflicts having a severity score of 4 or higher were also compared to the AIRS and police report data. Forty-six of the 84 conflicts had a severity score of 4 or higher.

3.5 Comparison of Crash Types with AIRS Incidents and Near-Incidents and Traffic Conflicts

Following are the percentages, using the categories previously given for each crash code, for the crash reports, AIRS incidents and near-incident, and traffic conflicts were compared.

	Percent				
	AIRS			Traffic Conflict Study*	
Code	Incident	Near-Incident	Crash Report	All	Severe**
1	7.6	1.5	16.8	0.0	0.0
2	4.3	9.0	0.9	1.2	2.1
3	7.6	15.4	8.4	2.4	0.0
4	33.7	38.3	22.4	2.4	2.1
5	32.6	30.3	22.4	4.9	8.5
6	2.2	0.5	0.0	0.0	0.0
7	3.3	1.5	1.9	0.0	0.0
8	1.1	0.0	1.9	12.2	12.8
9	0.0	0.5	0.0	0.0	0.0
10	0.0	1.0	0.0	0.0	0.0
11	0.0	0.0	5.6	8.5	10.6
12	4.3	1.0	7.5	8.5	4.3
13	0.0	0.0	9.3	37.8	38.3
14	1.1	0.5	0.0	7.3	6.4
15	1.1	0.0	0.9	12.2	12.8
17	1.1	0.5	1.9	2.4	2.1

*Traffic conflict data is from 11/10/2004 and 11/11/2004

**A severity score of 4 or higher was assigned to these conflicts

The results show that there was closer agreement between the crash and AIRS data than between conflict and crash data. The most common codes for the AIRS incidents and near-incidents as well as crashes were codes 4 and 5. These codes involved improper right and left turns from the I-65 exit ramps. However, the most common code from the traffic conflict study was code 13 which involved two westbound vehicles on Jefferson Street. Possible explanations for this discrepancy are that conflict data were: not taken during nighttime or weekend hours, taken during a limited timeframe, or not taken during the lowest volume time periods (for example the data found that code 1 crashes and incidents occurred during very low volume conditions).

3.6 Crashes Before and After Improvements

As a result of the information obtained from AIRS, various types of crashes were identified with several improvements made in an attempt to reduce specific crash types. As previously noted, the most common crash types involved a driver on the I-65 exit ramps attempting to make a prohibited right or left turn. This occurred when a driver on the exit ramp to Jefferson Street attempted to turn right onto Brook Street or when a driver on the exit ramp to Brook Street attempted to turn left onto Jefferson Street even though these turns were prohibited.

Following is a list of the dates and types of improvements made.

Date	Improvement
November 2001	Extended island between I-65 exit to Brook Street and near Brook Street lane[1]
	Painted straight arrow for I-65 exit to Brook Street[2]
	Installed sign on pole at I-65 exit to Brook Street indicating straight only[3]
	Multilane assignment sign installed[4] (has since been replaced)
February 2004	Added signal head on I-65 exit ramp to Jefferson Street[5]
July 2004	Installed flexible posts between I-65 Brook Street exit ramp and Brook Street near lane[6]
	Installed overhead lane assignment signs for Brook Street[7]

Following is a diagram showing the existing signage and traffic control at the AIRS intersection. The superscripts on the improvement correspond to the numbers labeled on the diagram.

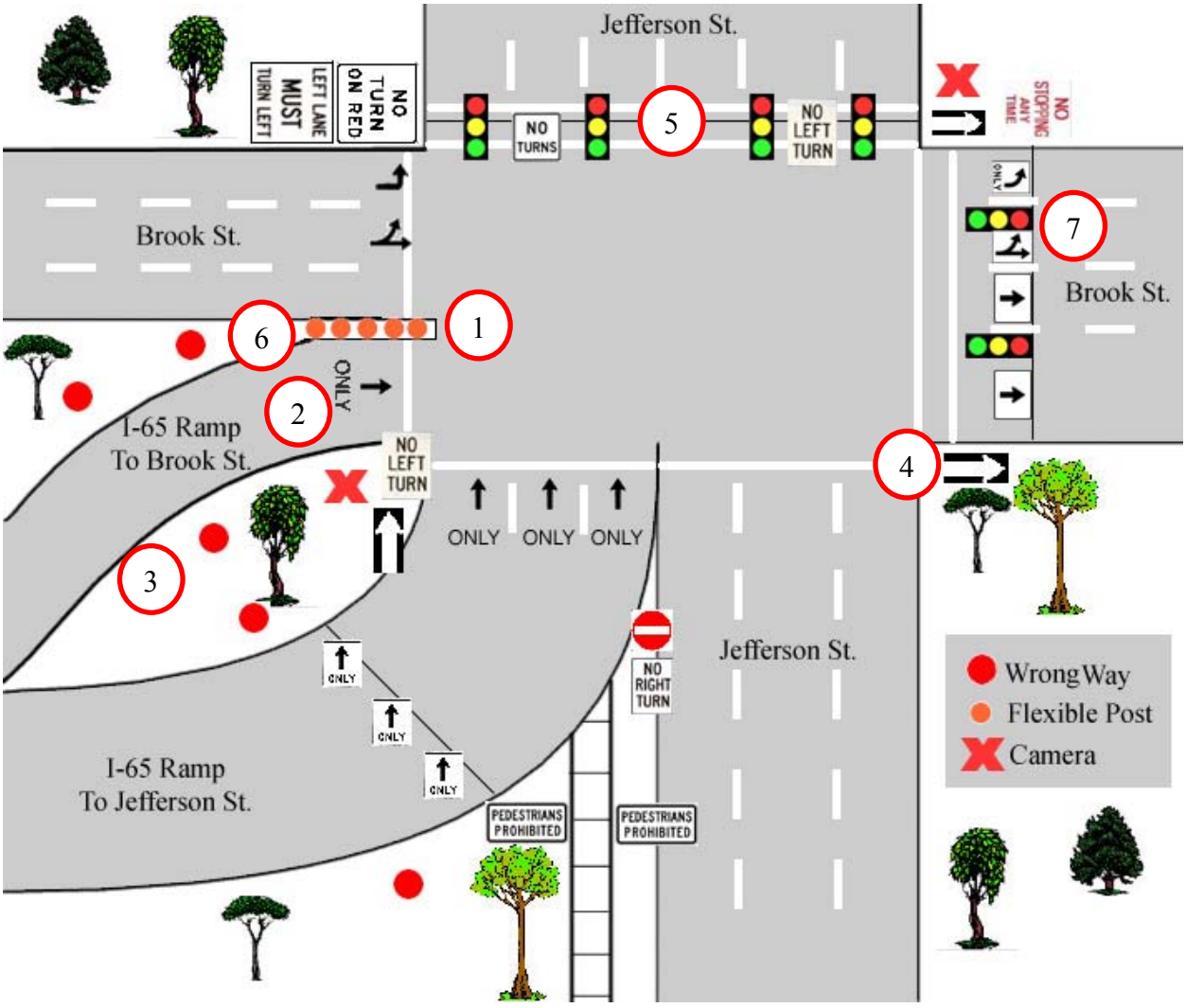

Figure 4. AIRS signage and traffic control (trees not representative of actual locations).

Data before and after the various improvements made in November 2001 were compared to determine if any changes occurred in the number of crashes. Following is a summary of the number of crash reports from 1998 through 2004. The summary shows total crashes as well as the types of crashes the improvements should have directly affected.

	Number of Crashes							
				2001				
Crash Code	1998	1999	2000	Before[1]	After[2]	2002	2003	2004
4	8	18	4	7	1	10	2	7
5	3	8	5	6	0	8	4	8
11	3	1	2	6	0	1	2	2
12	2	6	7	5	0	4	0	2
13	7	8	3	1	0	3	6	1
All	30	48	27	33	1	36	28	26

[1]Period from 01/01/2001 to 11/05/2001
[2]Period from 11/06/2001 to 12/31/2001

If the crashes occurring in 2001 are excluded, there are three years of data before and after the improvements were made in 2001. It should be noted that in order to provide consistency in the before and after data, the crash code used came from a review of the police reports and not the AIRS video. This was necessary since AIRS data were not available for almost all of the before data. There was an average of 35 crashes at the intersection in the three-year period of 1998 through 2000 compared to an average of 30 crashes in the three-year period of 2002 through 2004, resulting in a 14 percent reduction in total crashes. Many of the improvements were made in response to the improper right turn from the I-65 Jefferson Street exit ramp (code 4) and the improper left turn from the I-65 Brook Street exit ramp (code 5). The annual average number of code 4 crashes changed from 10 before to 6.3 (37 percent decrease) after. The annual average number of code 5 crashes changed from 5.3 before to 6.7 after (26 percent increase).

The AIRS data support a redesign of the intersection. The redesign will eliminate improper left and right turns coming off the interstate (codes 4 and 5), which were found to be the most common crash type based on the AIRS data. The redesign for the intersection is shown below.

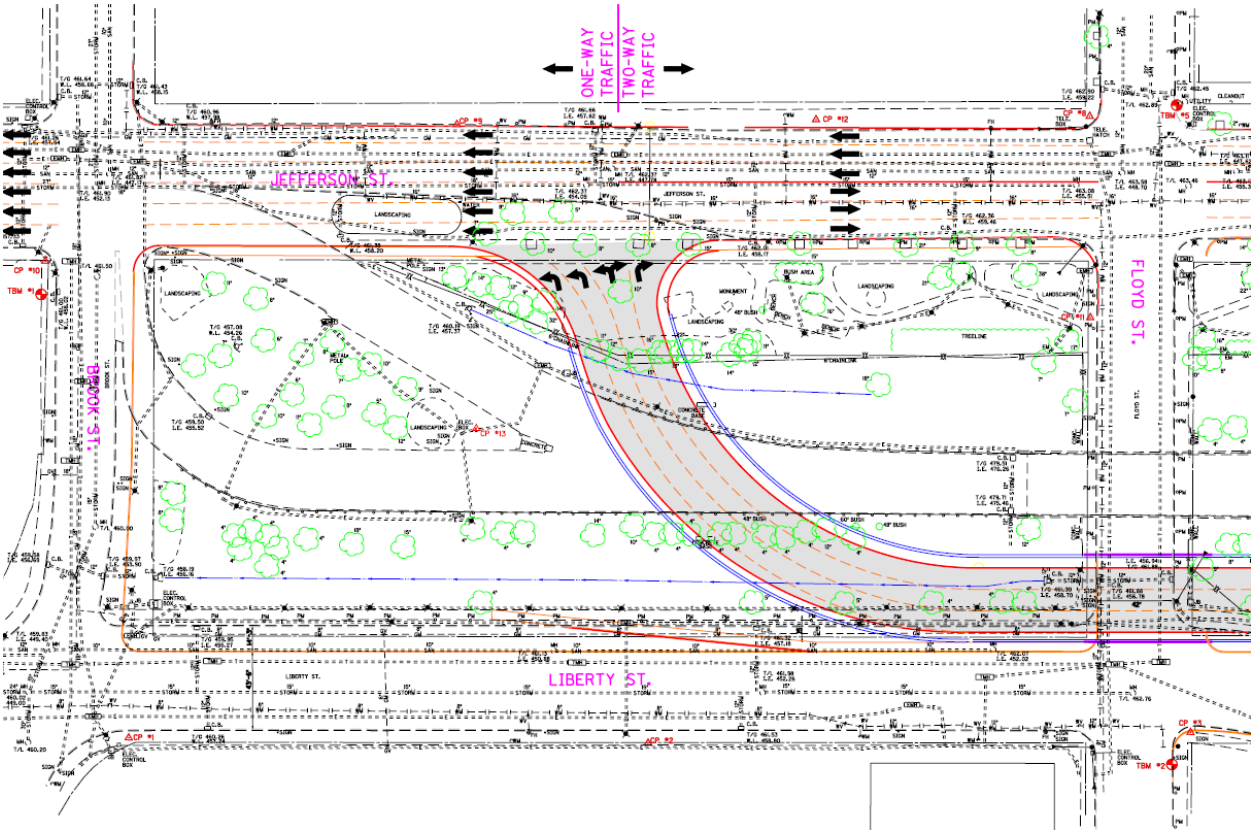

Figure 5. Brook and Jefferson intersection redesign. Shaded roadway represents the new alignment.

3.7 Benefit Cost Analysis

There was an average reduction of five crashes per year after installation of the original improvements. Using an average cost per crash of $16,500 (7) based on the economic cost of traffic crashes from the National Safety Council, this represents an annual crash savings of $82,500. This shows that the crash savings would pay for the system in less than one year.

For comparison, intersection conflict studies (data collection, analysis, and reporting) have been conducted for approximately $15,000 to $20,000 while an intersection audit could be made for about $5,000 to $10,000. The characteristics of the intersection and the information which could be obtained using AIRS, a conflict study, or a safety audit must be considered when determining the most cost effective method of collecting data.

4.0 CONCLUSIONS

The following conclusions can be made:

1. AIRS is capable of documenting crashes at an intersection.
2. AIRS data can be used as a reliable surrogate for crash data.
3. The near-incidents identified by AIRS were very similar to the incidents recorded by AIRS and the crash report data.
4. An excessive number of false incidents were recorded.
5. A large number of crashes (47) occurred that were not recorded by AIRS with no explanation found to explain the failure for approximately one third of those crashes.
6. The AIRS data were a more reliable surrogate of crash data than the conflict data.
7. AIRS provides a time efficient method of analyzing intersection collisions compared to a conflict analysis or a continuous videotaping. However, the efficiency is limited somewhat by the large number of false incidents found by AIRS. A method to minimize these false incidents should be developed.
8. The improvements made as a result of the AIRS data resulted in a reduction in crashes at the study intersection.
9. The crash savings in one year would pay for the cost of an AIRS installation. This shows that AIRS had a high benefit-cost ratio.
10. Given the costs and limitations of both AIRS and conflict studies, an alternative which should be considered is the completion of an intersection safety audit.

5.0 RECOMMENDATIONS

The success of AIRS as an effective data collection tool warrants additional installations. Efforts should be made to reduce the number of false incidents and to ensure that all crashes are recorded. Installations should be made at a variety of intersections with varying size and geometric conditions to verify the versatility of AIRS to record data. The most cost-effective applications of AIRS would be at locations where traditional on-site observations could not easily be conducted.

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