



Video Based Studies of Highway-Railroad Grade Crossings in the South Florida Railroad Corridor

Final Report

**Prepared for the Florida Department of Transportation
Rail Office
By The University of Florida
Transportation Research Center**

June 2003

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<p>16. Abstract</p> <p>In an effort to enhance transportation safety and efficiency, the Florida Department of Transportation (FDOT) has initiated the deployment of advanced technology systems as part of a program to develop an intelligent rail corridor system between West Palm Beach and Miami. As a part of this program, FDOT undertook a study of traffic and train operations at five highway-railroad grade crossing sites in this corridor. This document presents the results of the study, which involved observation and analysis of a large number of video clips captured by Nestor Traffic Systems, Inc from their Rail CrossingGuard[®] System.</p> <p>Approximately 7,500 video clips were viewed to identify events of interest. Each clip covered two minutes of operation, yielding approximately 250 hours of video to be observed. Approximately 500 events of interest were isolated for further analysis. Each of these events had one or more of the characteristics of interest to the study. The events were divided into five categories, each of which reflected different modes of travel or undesirable road user behavior: The key attributes of each event were recorded in spreadsheet format. The results were summarized in tabular and graphic format.</p> <p>Because of the site specific nature of this study, it is difficult to draw conclusions that could be applied in a general way to all highway-railroad grade crossings. It is clear from these observations that many undesirable and unsafe movements took place. The most conspicuous events were of an anecdotal nature and were therefore not amenable to a quantitative analysis. Nevertheless, it is likely that the information in this report will provide useful support to the FDOT in their continuing efforts to achieve a higher rate of compliance with grade crossing warning systems.</p>					
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**Development and Deployment of a Portable Highway-
Railroad Grade Crossing Surveillance System**

FDOT Contract BD243

University of Florida Project 4504-891

**Volume III
Video Based Studies of Highway-Railroad Grade Crossings
in the South Florida Railroad Corridor**

Kenneth Courage and

Brian Kirkpatrick

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PREFACE

The Florida Department of Transportation (FDOT) Contract BD243 addresses an immediate requirement for a study of traffic and train operations at highway-railroad grade crossing sites in Florida. This requirement is accompanied by a longer term need to develop a simple video surveillance system by which FDOT personnel can conduct similar studies in the future on short notice, and for a specific study to be performed at five locations in a railroad corridor in south Florida.

The results of the project are presented in a series of three volumes:

- Volume I: A Portable Highway-Railroad Grade Crossing Surveillance System for Operational and Safety Studies
- Volume II: Video Based Studies of Flexible Traffic Separators at Highway-Railroad Grade Crossings
- Volume III: Video Based Studies of Highway-Railroad Grade Crossings in the South Florida Railroad Corridor

This document contains Volume III of the series. It describes the results of observation of approximately 7,500 video clips of train passage at five highway railroad grade crossings in the South Florida rail corridor. The study focused on identifying and categorizing the types or undesirable road user behaviors found at these crossings.

ACKNOWLEDGEMENTS

The University of Florida Transportation Research Center (TRC) conducted this study. The overall effort was coordinated by Prof. Ken Courage, with significant technical support from Mr. Brian Kirkpatrick. Mr. H. Michael Dowell, P.E. was the FDOT technical coordinator. Several University of Florida students spent many hours observing the video clips and documenting the events that took place. The student assistants were Carlos Cesar, David Kirschner, Luke McLeod, Jose Sanda, Jason Starr and Tania Thurston.

The project team acknowledges and appreciates the cooperation of Nestor Traffic Systems, Inc. who provided captured video clips from their Rail CrossingGuard[®] system installed in the south Florida rail corridor.

DISCLAIMER

The opinions and findings expressed in this document are those of the authors and not necessarily those of the Florida Department of Transportation or any other government agency.

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1. INTRODUCTION

In an effort to enhance transportation safety and efficiency, the Florida Department of Transportation (FDOT) has initiated the deployment of advanced technology systems under a program to develop an intelligent rail corridor system between West Palm Beach and Miami. As a part of this program, FDOT has identified an immediate requirement for a study of traffic and train operations at five highway-railroad grade crossing sites in this corridor. This document presents the results of the study.

One of the advanced technology applications to be deployed in the corridor is the Rail CrossingGuard[®] (RCG) system developed by Nestor Traffic Systems, Inc. Rail CrossingGuard[®] is Nestor's product for monitoring highway-rail grade crossings using video cameras and computer vision to identify unsafe crossing events and conditions. The prototype system has been installed at five locations.

1.1. Project Objectives

One application of the RCG installation that is immediately available is its use in capturing video of crossing activations. This video has been captured from the monitored crossings and has been stored in digital format. The objective of the project described in this report was to study these video segments and identify all events that could provide insight into the crossing operations in general and unsafe road user behaviors in particular. This information will provide input to FDOT to support their continuing efforts to achieve a higher rate of compliance with the grade crossing warning systems.

1.2. Events of Interest

The main events of interest in this study were those that could suggest improper operation or use of the crossing. The specific events targeted by the observers included:

- U-Turns on the crossing area,
- Gates hitting vehicles,
- Gate breakage from vehicles,
- Any tampering with the traffic control devices,
- Driving around the gate systems,
- Premature crossing of the train prior to the gate being fully deployed,
- Vehicles stopping on or near the tracks because of traffic queues,
- Vehicles in the crossing while the gates are in motion,
- Pedestrian or bike violations,
- Cars stopped on the wrong side of the gate system after the gate has been fully deployed,
- Pedestrians or drivers placing items on the rail,
- Any collisions by vehicles in the crossing area,
- Gate system malfunction and
- Vehicle train collisions.

2. STUDY METHODOLOGY

The study involved observation and analysis of a large number of video clips captured by Nestor Traffic Systems, Inc from the Rail CrossingGuard[®] System. An overview of the project tasks is presented graphically in Figure 1. The specific tasks are summarized as follows:

2.1. Project Tasks

- Approximately 7,500 video clips were viewed to identify events of interest. Each clip covered two minutes of operation, yielding approximately 250 hours of video to be observed. Most of the clips included an interval containing the passage of a train.
- Approximately 500 events of interest were isolated for further analysis. Each of these events had one or more of the prescribed characteristics of interest to the study. Each of these clips was truncated to focus on the event of interest.
- The events were divided into five categories, each of which reflected different modes of travel or road user behavior:
 - Pedestrians
 - Bicycles and motorcycles
 - Stopping on tracks
 - Passing through gates in motion
 - Anecdotal events
- The key attributes of each event were recorded in spreadsheet format. A separate spreadsheet was developed for each event category because the attributes differed among the event categories.
- The results were summarized in tabular and graphic format. The results are presented in Section 3 of this report.

2.2. Summary of Crossing Sites

The five highway-railroad crossing sites that were studied included:

- Cypress Creek Road (CCR),
- McNab Road (McN),
- Commercial Boulevard (Com),
- Powerline Road (Pow),
- Prospect Road (Pro),

The notation given in parenthesis for each of these sites will be used as an abbreviation in the headings and site identification labels when results of the observations are presented later in graphic format. Each of these sites is in Broward County. Each site will be discussed separately in this section.

1. Approximately 7,500 video clips were viewed to identify events of interest



2. Approximately 500 events of interest were isolated for further analysis



4. The key attributes of each event were recorded in spreadsheet format. A separate spreadsheet was developed for each event category.

3. The events were divided into five categories, each of which reflected different modes of travel or road user behavior:

- Pedestrians
- Bicycles and motorcycles
- Stopping on tracks
- Passing through gates in motion
- Anecdotal events

5. The results were summarized in tabular and graphic format.

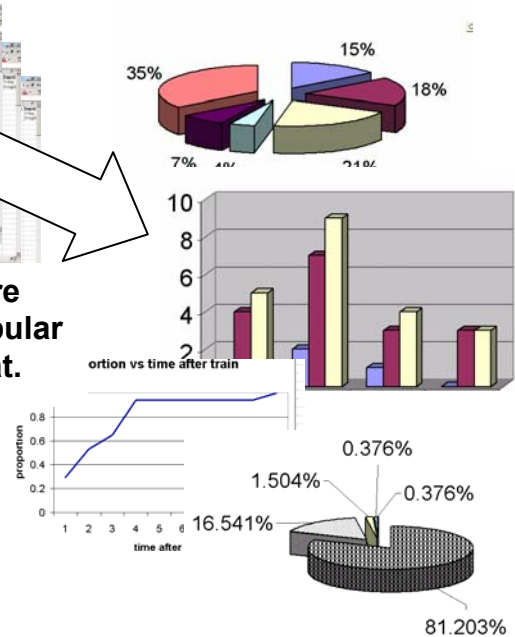
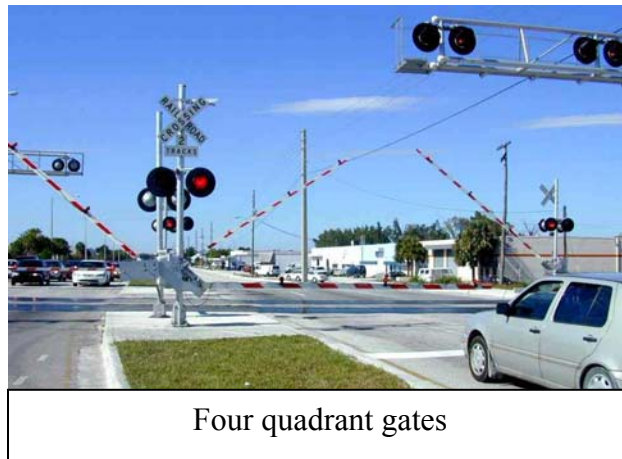


Figure 1. Overview of the Project Tasks

McNab Road

The McNab Road site is a six lane divided highway crossing two tracks at a 75 degree angle. There is a median opening with storage bay for the EBLT approximately 150 feet west of tracks. The area contains sparse industrial development. Four quadrant gates are in place at this crossing. A “No Train Horn 10PM to 6AM” warning sign has been installed.



Commercial Boulevard

The Commercial Blvd. site is a six lane divided highway crossing three tracks. Auxiliary turning lanes are also provided. The third track is not frequently used, but there is evidence from the video clips that trains arrive on this track before the warning gates are fully deployed. The area contains a mixture of industrial and commercial development. Conventional gates are in place at this crossing. The crossing is in close proximity to the Interstate Highway 95 interchange and traffic queues regularly back up into the crossing area from the traffic signal. A “Do Not Stop on Tracks” regulatory sign with traffic-actuated flashing beacons has been installed.



Cypress Creek Road

The Cypress Creek Road site is an eight lane divided highway crossing two tracks at an 80 degree angle. Only the westbound approach was observed at this crossing. The eastbound view was disabled because of camera mounting issues.

This crossing is close to the Tri-Rail Station and experiences occasional traffic delays as a result of trains stopped at the station. Passive “Do Not Stop on Tracks” signs are installed.



Powerline Road

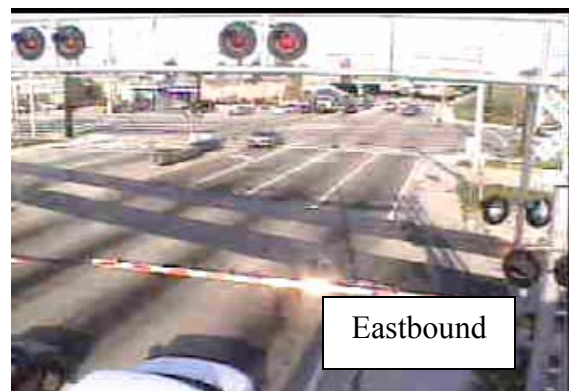
The Powerline Road site is a six-lane divided highway crossing two tracks at a 70 degree angle. Only the southbound approach was observed at this crossing. Passive “Do Not Stop on Tracks” signs are installed.



Prospect Road

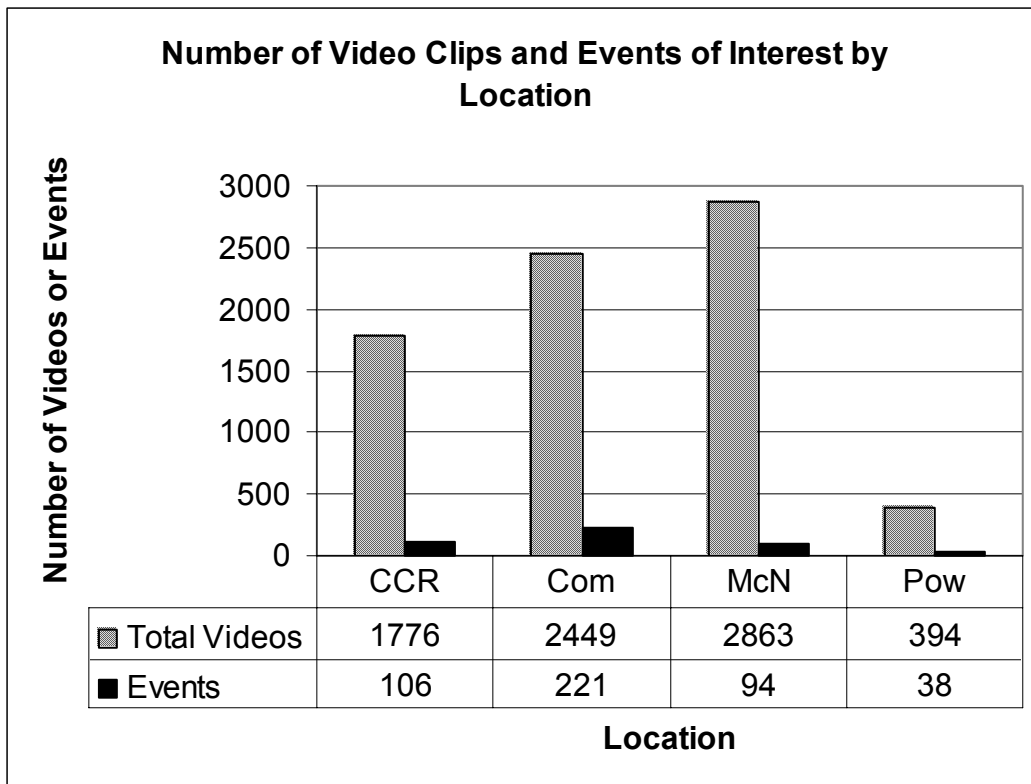
Prospect Road site is a six-lane divided highway crossing two tracks at a 70 degree angle. The Powerline Road and Prospect Road crossings are very close together and form a triangle with the railroad tracks as the third side. Passive “Do Not Stop on Tracks” signs are installed. The intersection of these two streets forms one corner of the triangle. Because of the proximity of the traffic signal at the intersection, it was decided not to install cameras for the northbound approach on Powerline Road or for the westbound approach on Prospect Road to avoid confounding issues of traffic signal and railroad crossing violations.

Video coverage of the eastbound approach at this site was discontinued early in the project because of camera placement issues. Only 22 video clips were received and no events of interest were noted. For all intents, this site was not included in the study and no further reference will therefore be made to it.



3. SUMMARY OF OBSERVATIONS

This section summarizes the observations produced by the study. The following chart shows the overall distribution of video clips and events of interest at each location. Note that, while McNab Road had the largest number of video clips, Commercial Boulevard produced the largest number of events. The heavy traffic volume on this route combined with the auxiliary turning lanes and the proximity of the signal at the Interstate Highway 95 interchange created the potential for behaviors that were of interest to the study.



3.1. Summary of Events of Interest

An overall summary of the events targeted by the observers will be presented first. A summary of the events in each of the five categories will follow.

U-Turns within the Crossing Area

Several events of this type were observed and were included as a special case of the “Anecdotal” category. U-Turns within the crossing were well distributed among the various locations.

Driving Around the Gate Systems

The combination of medians and four quadrant gates made it very difficult for vehicles to drive around a fully deployed gate. All of the violations involving circumvention of a gate were committed by pedestrians and bicycles. Pedestrians, bicycles and motorcycles were also observed entering the crossing between the gates at locations that used two gates (one from each side of the roadway).

Premature Crossing Of The Train Prior to the Gate Being Fully Deployed

This phenomenon was observed at the Commercial Boulevard crossing and documented in the “Anecdotal” category. Trains that were probably involved in switching operations were seen entering the crossing on two occasions without proper advance warning time. In each case, the train was on what appeared to be an auxiliary track in this crossing. The trains were moving slowly and therefore did not present the same hazard that would have resulted from a similar phenomenon on one of the main tracks.

Vehicles Stopping on or Near the Tracks Because of Traffic Queues

Several events of this type were observed and were included in a separate category. The majority of these events took place on the eastbound approach to the Commercial Boulevard crossing because of the heavy traffic volume and the proximity of the traffic signal.

Vehicles in the Crossing While the Gates Are in Motion

Several events of this type were observed and were included in a separate category. The majority of these events took place after the train departed from the crossing.

Pedestrian or Bicycle Violations

Several events of this type were observed and were included in their own categories. Separate categories were created for pedestrian and bicycle-related events. The bicycle category also included motorcycles and skateboards.

Cars Stopped on the Wrong Side of the Gate System After the Gate Has Been Fully Deployed

A total of 14 events of this type were observed and are included in the “stopping on or near tracks” category.

Tampering with The Traffic Control Devices

Only one event of this type was observed and is included in the “Anecdotal” category. A pedestrian attempted to move one of the gates after it had been down for some time in connection with what appeared to be a switching operation.

Gate System Malfunction

All of the observed malfunctions were due to damage from vehicles. The most notable occurrence of such damage involved a collision between a truck and a gate. In this case, the truck passed under an ascending gate that descended unexpectedly. The entry gate was broken and the quad gate fail-safe feature prevented the exit gates from deploying during subsequent train arrivals. The collision and subsequent repairs were captured on video. The gate system was repaired after approximately three hours.

Pedestrians or Drivers Placing Items on the Rail

Only one event of this type was observed and is included in the “Anecdotal” category. Two pedestrians were observed placing what appeared to be a very small item on each of the tracks. The reason and the results were not discernable.

Vehicle-Gate Contact

Three events involving contact between vehicles and gates were observed. These events are reported in the “Anecdotal” category. In one case (noted above as a gate malfunction) the gate arm was demolished by a large truck and left lying on the track. In another case, a small truck pushed one of the gates out of place and created an opening large enough for other vehicles to enter the track while the gates were deployed. Other gate contact events were minor and the long-term results were not discernable.

Vehicle-Vehicle Collisions in the Crossing Area

No vehicle-vehicle collisions were observed.

Vehicle-Train Collisions

No vehicle-train collisions were observed.

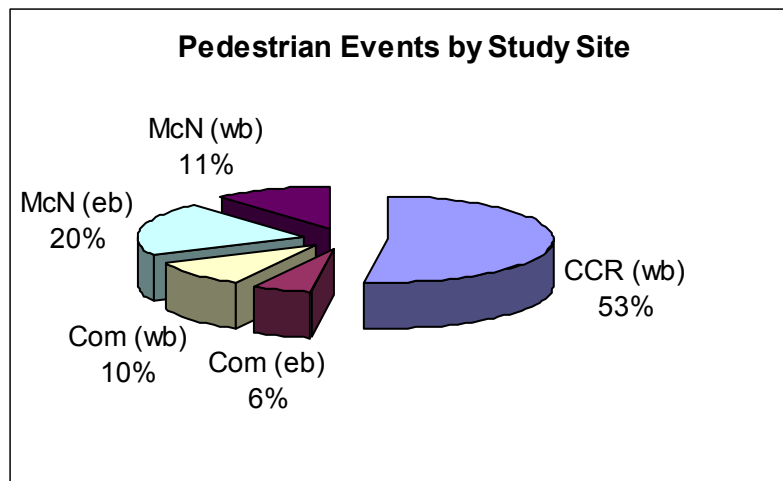
3.2. Summary of Event Categories

Each of the five event categories created for this project will now be summarized in terms of their attributes. Photographs captured from the video clips will be presented to illustrate the nature of the events in each category. Where appropriate, some self-explanatory graphics illustrating the relationships between the event attributes will be presented.

Events Involving Pedestrians

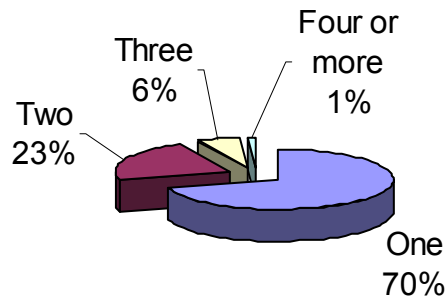
A total of 88 events involving pedestrians was observed. The recorded attributes for each event included:

- File name of the video clip
- Location
- Direction
- Time
- Weather
- Day/Night
- Time Before or After Train
- Path
 1. Around gate
 2. Between Gates
 3. Under gate
- # of Pedestrians in the group
- Adult/Child

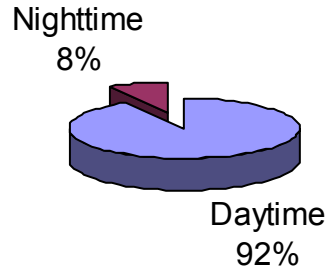


Event Relationships for Pedestrians

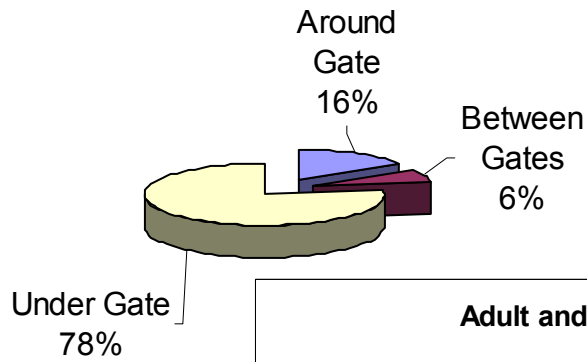
Number of Pedestrians per Group



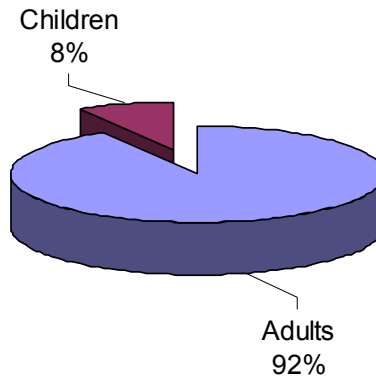
Daytime and Nighttime Pedestrians



Path Taken by Pedestrians



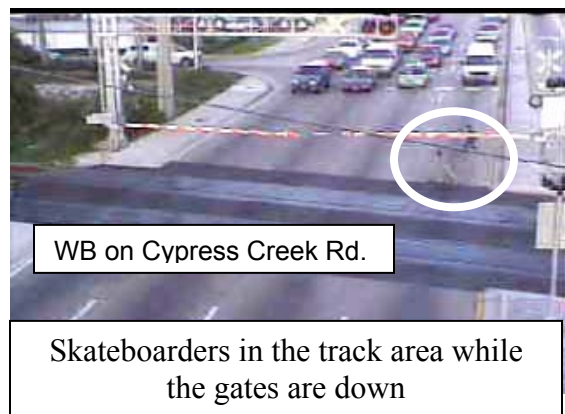
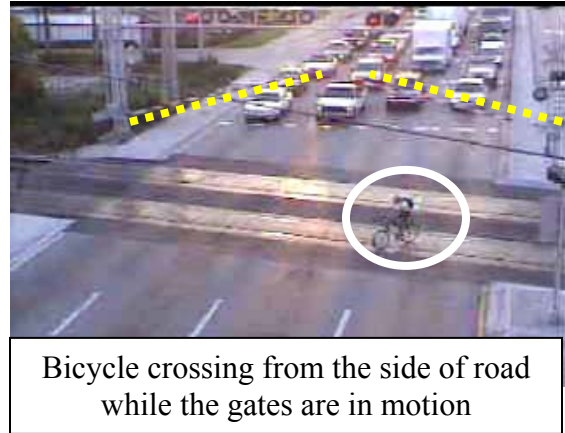
Adult and Child Pedestrians



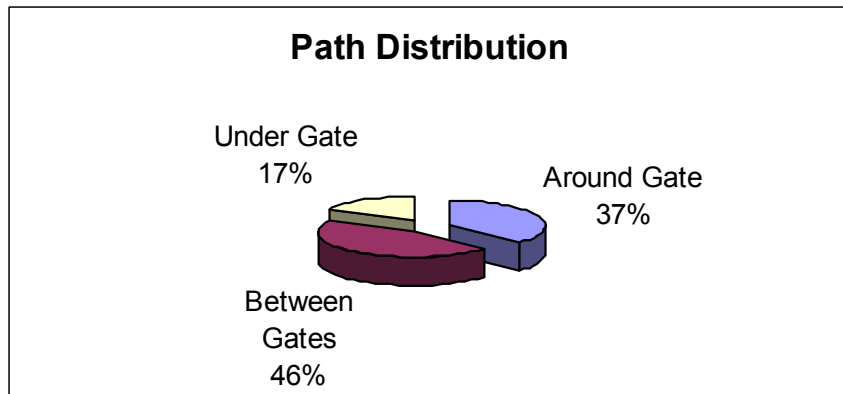
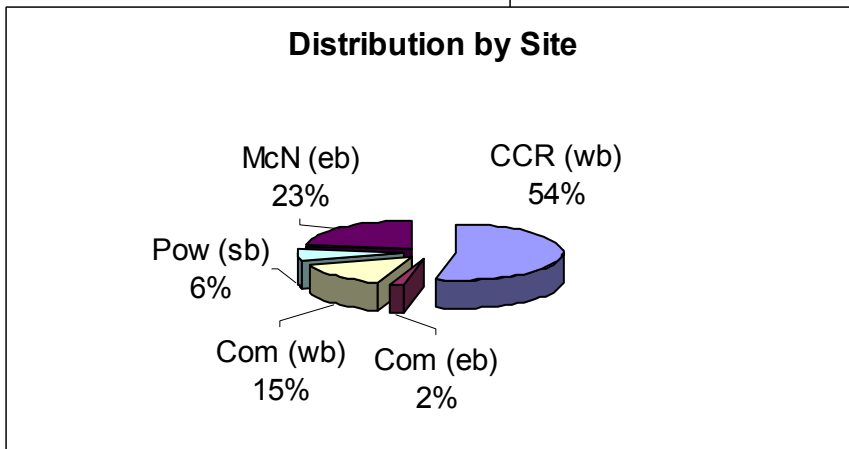
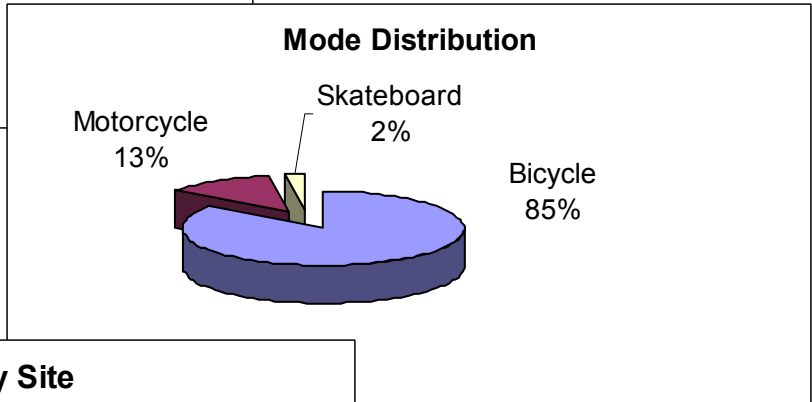
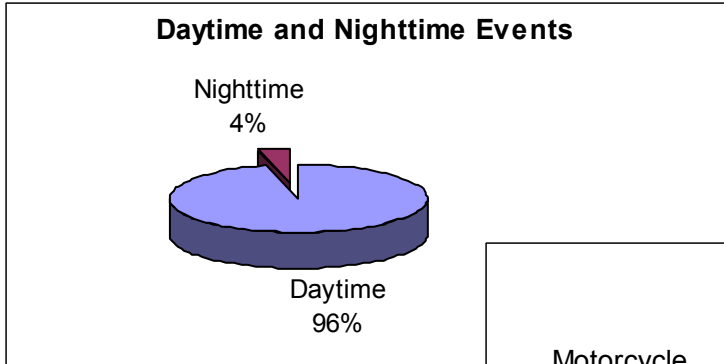
Events Involving Bicycles, Motorcycles and Skateboards

A total of 47 events involving bicycles, motorcycles and skateboards was observed. The recorded attributes for each event included:

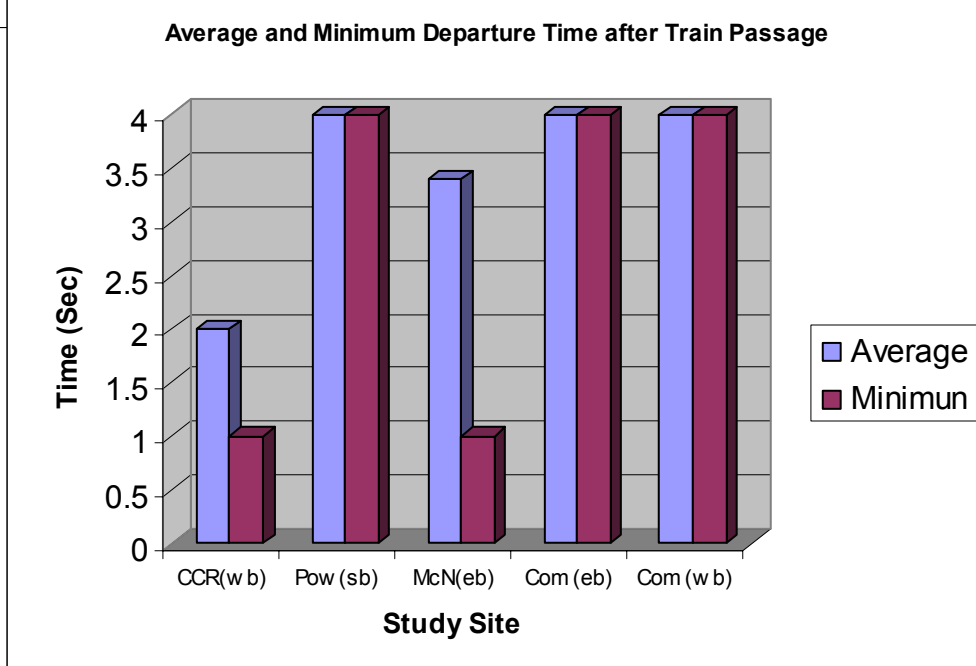
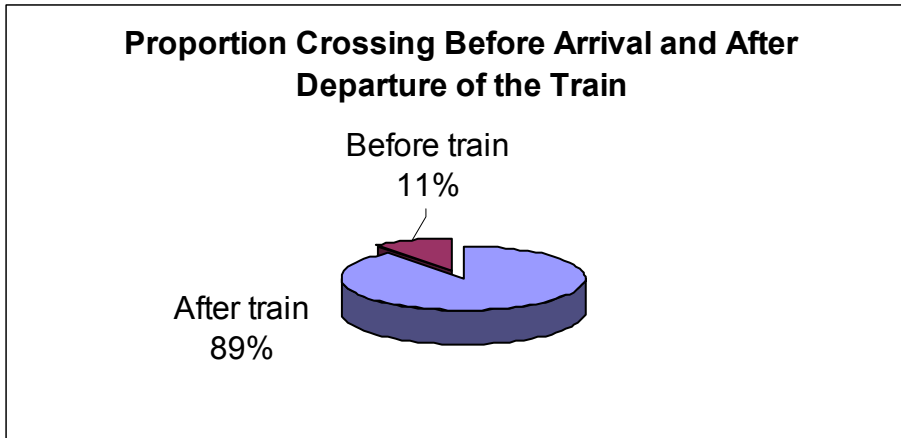
- File name of the video clip
- Location
- Direction
- Time
- Weather
- Day/Night
- Time Before or After Train
- Type
 1. Bicycle
 2. Motorcycle
 3. Skateboard
- Path
 1. Around gate
 2. Between Gates
 3. Under gate



Event Relationships for Bicycles, Motorcycles and Skateboards



Event Relationships for Bicycles, Motorcycles and Skateboards (cont)



Events Involving Vehicles Stopping on or Near the Tracks

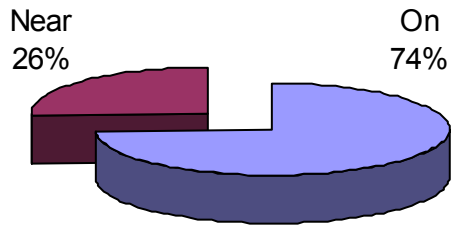
A total of 201 events involving vehicles stopping on or near the tracks was observed. The recorded attributes for each event included:

- File name of the video clip
- Location
- Direction
- Time
- Weather
- Day/Night
- Time Before or After Train
- Type
 1. Passenger car
 2. Truck
 3. Semi trailer
 4. Tractor
 5. Bus
- Lane
 1. Inside
 2. Center
 3. Outside
 4. Parallel to tracks
 5. Shoulder
- On or near track
- Number of vehicles stopped
- Action taken by driver
 1. Change lane
 2. Reverse
 3. Wait (i.e., no action)
 4. Move slowly
 5. Cross over track

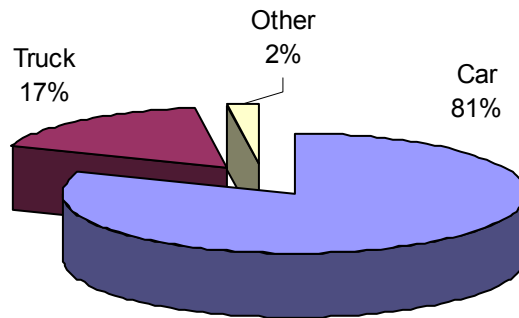


Event Relationships for Vehicles Stopping On or Near Tracks

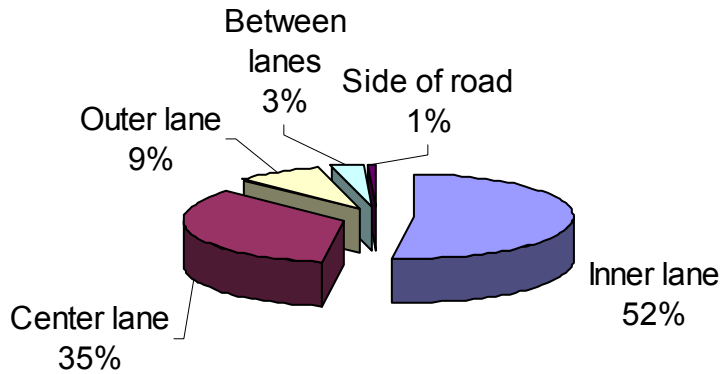
Proportion Stopping on and Near the Tracks



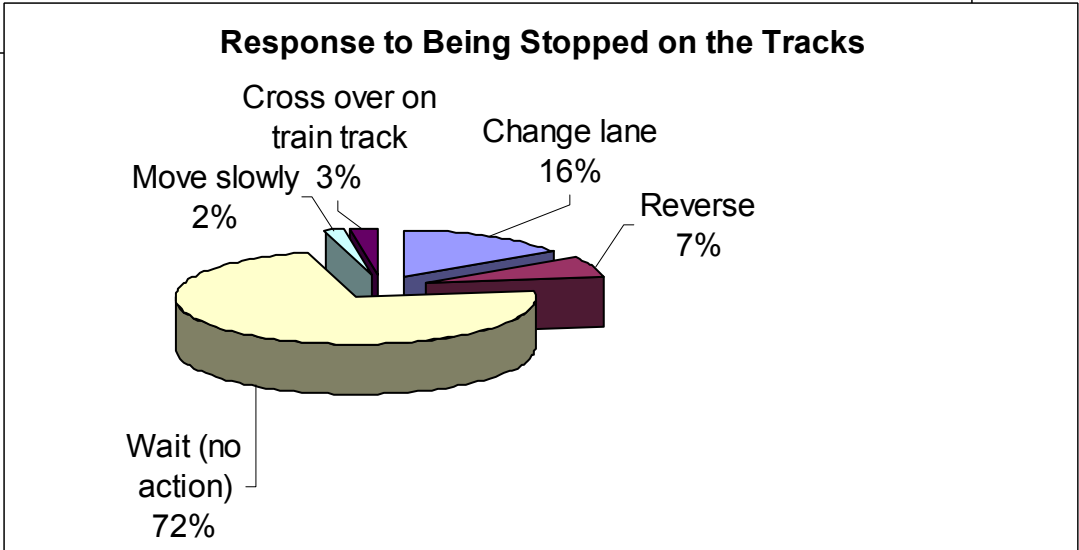
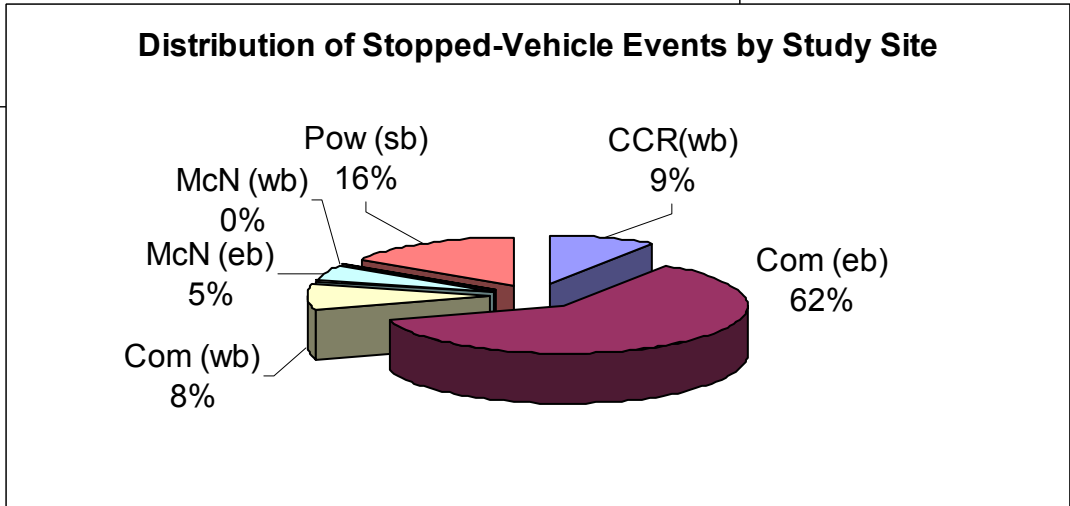
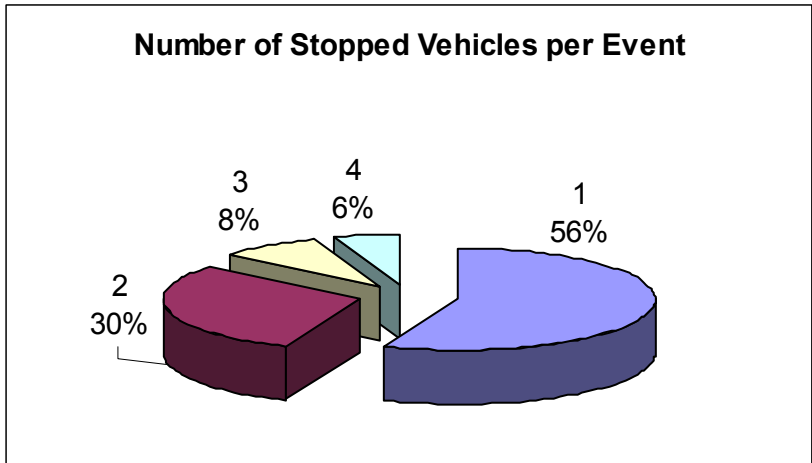
Distribution of Stopped Vehicle Types



Lane Distribution for Stopped Vehicles



Event Relationships for Vehicles Stopping On or Near Tracks (cont)



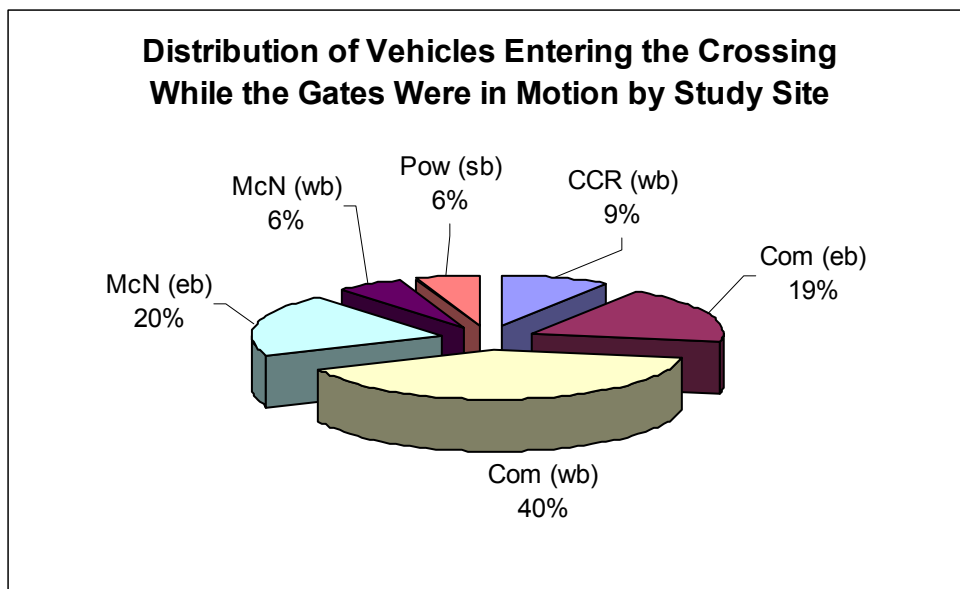
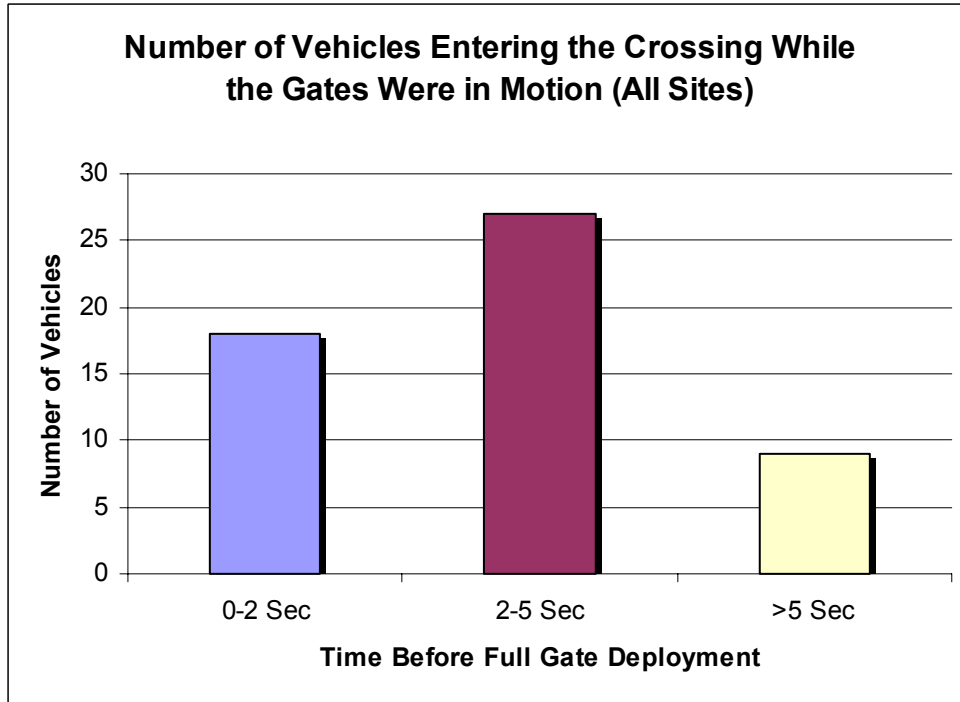
Events Involving Vehicles Crossing While Gates are in Motion

A total of 58 events involving vehicles stopping on or near the tracks was observed. The recorded attributes for each event included:

- File name of the video clip
- Location
- Direction
- Time
- Weather
- Day/Night
- Time Before or After Train
- Type
 1. Passenger car
 2. Truck
 3. Semi trailer
 4. Tractor
 5. Bus
- Lane
 1. Inside
 2. Center
 3. Outside
 4. Parallel to tracks
 5. Shoulder
- Number of vehicles in the group



Event Relationships for Vehicles Crossing While Gates are in Motion



Anecdotal Events

A total of 68 events that could best be described in anecdotal terms was observed. The recorded attributes for each event included:

- File name of the video clip
- Location
- Direction
- Time
- Weather
- Day/Night
- Description of the event.

About one third of the anecdotal events involved U-Turns within the crossing area. A special case was therefore created for U-Turns. Captured photographs are presented in the following pages to illustrate some of the more conspicuous events. A graphical presentation of event relationships is also included.



Photographs showing vehicle-gate contact.
(Both EB on Commercial Blvd)



Photographs Illustrating Anecdotal Events



1. Vehicle breaks gate and enters crossing



2. First vehicle enters breach in gate



3. Second vehicle enters breach in gate

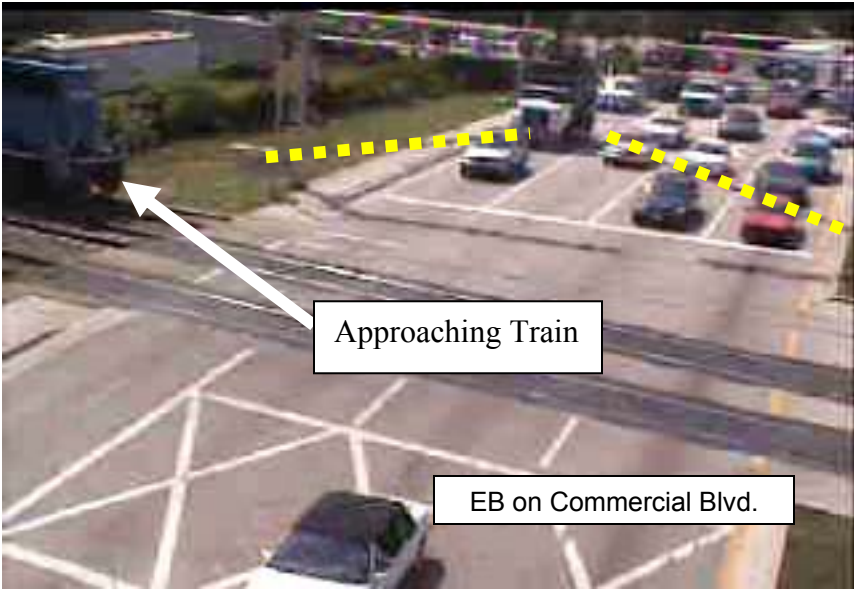
Two vehicles pass through a breach in the gate caused by another vehicle (EB on Commercial Blvd.)



Pedestrian attempting to move a gate by hand (EB on Commercial Blvd.).



Photographs Illustrating Anecdotal Events (cont)



Photographs Illustrating Anecdotal Events (cont)



Pedestrian crosses behind train starting approximately 1 sec after train passage.



Pedestrian crosses between gates (running) and clears the track approximately 2.5 sec before train arrival.

Photographs Illustrating Anecdotal Events (cont)



Here is a case in which motorists were trapped between the gate and the tracks while a train passed. In this case it is difficult to blame the motorist. Photo #1 shows that a vehicle stopped properly in advance of the tracks because of a downstream queue blockage. At that point, the warning gates were activated and descended behind the vehicle. Photo #2 shows the position of the vehicle when the train arrived. Photo #3, below, shows a large truck trapped between the gate and the train as a result of the same sequence of events. This is the southbound approach at Powerline Road.

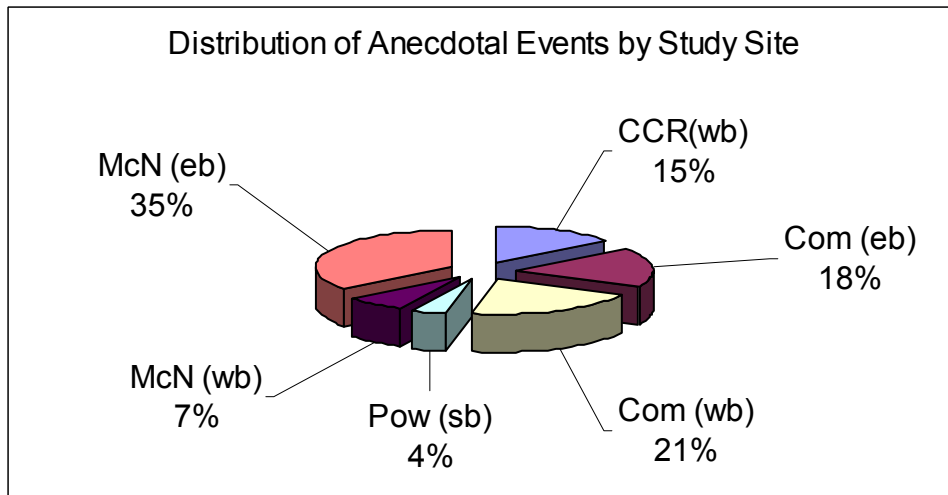
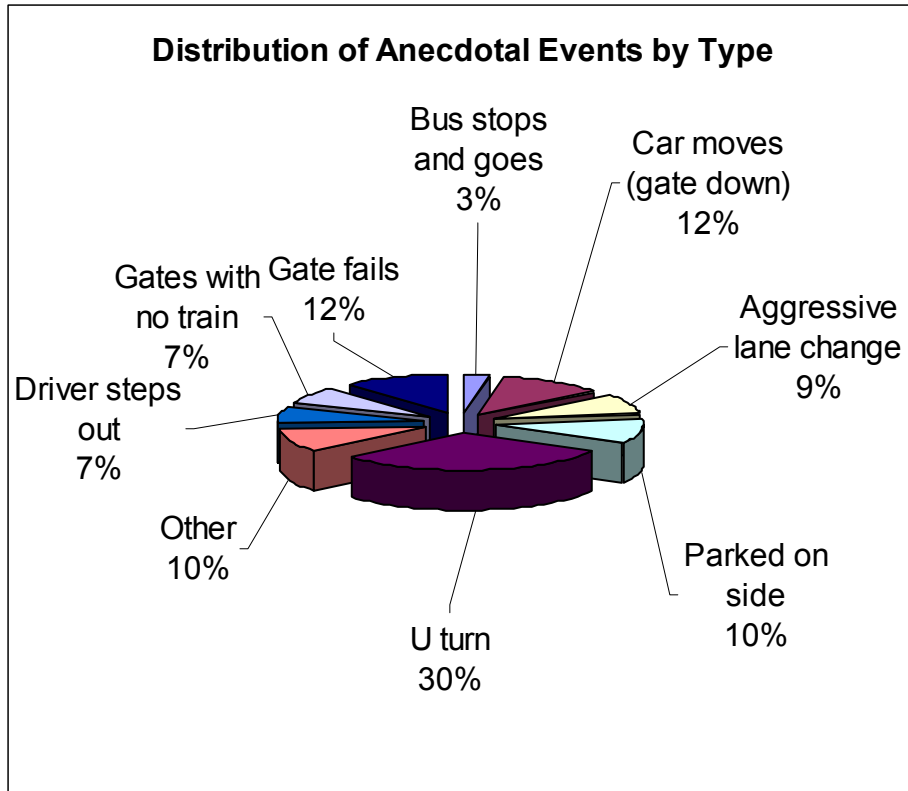


Photographs Illustrating Anecdotal Events (cont)

EB on Commercial Blvd.

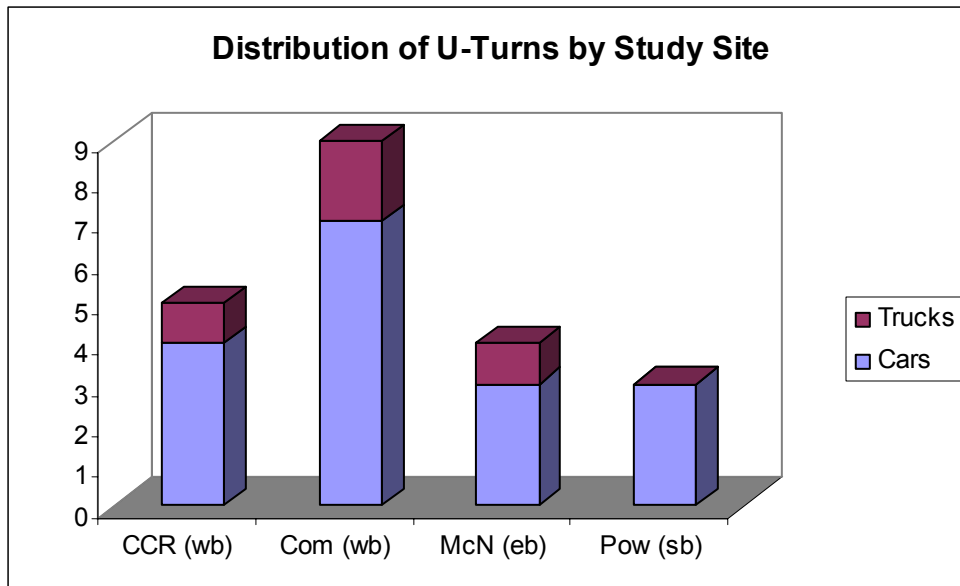


Anecdotal Event Relationships



U-Turns Across the Tracks

A total of 21 events of this type were observed and are included as a special case of anecdotal events. The photograph on this page illustrates a typical example of a U-Turn movement. The graphic chart on this page demonstrates that U-Turns within the crossing were well distributed among the various locations.



4. CONCLUSIONS AND RECOMMENDATIONS

The study focused on identifying and categorizing the types of undesirable road user behaviors found at five specific crossings in Broward County. The results should provide some insight into the crossing operations in general and unsafe road user behaviors in particular.

Because of the site specific nature of this study, it is difficult to draw conclusions that could be applied in a general way to all highway-railroad grade crossings. It is clear from these observations that many undesirable and unsafe movements take place. No actual collisions were observed. The most conspicuous events were of an anecdotal nature and were therefore not amenable to a quantitative analysis. Nevertheless, it is likely that the information in this report will provide useful support to the FDOT in their continuing efforts to achieve a higher rate of compliance with grade crossing warning systems.

The study confirmed that, in spite of such countermeasures as signing and warning lights, some drivers are stopping either on the tracks or very close to the tracks at all locations. This is a continuing problem of which FDOT is aware. Drivers also seem to be aware of the problem, since approximately 30 percent of drivers stopping on the tracks took some corrective action. In the remaining 70 percent, the drivers were either oblivious to the hazard, or the condition resolved itself before corrective action was taken. It is recommended that FDOT continue their efforts to mitigate this hazard through education and enforcement.

Another more subtle hazard that was evident from the study is that, when a train has passed, some drivers perceive the beginning of the gate ascent as an “all clear” signal. All of the observed incidents of contact between vehicles and gates involved an ascending gate that reversed its direction and came down on top of a vehicle which had crossed the stop line prematurely. This appears to contradict the common wisdom, which suggests that the dilemma zone phenomenon is the main cause of damaged gates.

This problem is different from that of vehicles stopping on the tracks. Drivers who stop on the tracks are generally aware that they are doing something wrong. Those who enter the crossing prematurely may not be aware that this action is improper. This situation is probably even more hazardous for pedestrians because of the “second train” problem. In one case a pedestrian stepped onto the tracks within one second after the train had passed, apparently accepting the passage of the train itself as an “all clear” signal.

Apart from the obvious hazards of premature entry, there is a secondary problem with the resulting gate damage that deprives the crossing of the benefits of the warning devices until the damage can be repaired. Education and enforcement measures may therefore be desirable to mitigate the hazards. Both of the problems mentioned here are well suited to automated enforcement by photographic methods.