GUIDANCE ON TRAFFIC CONTROL DEVICES AT HIGHWAY-RAIL GRADE CROSSINGS

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

HIGHWAY/RAIL GRADE CROSSING TECHNICAL WORKING GROUP (TWG)

NOVEMBER 2002

U.S. Department of Transportation
Highway-Railroad Grade Crossing Technical Working Group

Guidance on Traffic Control at Highway-Rail Grade Crossings

EXECUTIVE SUMMARY

The Technical Working Group (TWG) established by the U.S. Department of Transportation, is led by representatives from the Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), Federal Transit Administration (FTA), and the National Highway Traffic Safety Administration (NHTSA). The cooperation among the various representatives of the TWG represents a landmark effort to enhance communication between highway agencies, railroad companies and authorities, and governmental agencies involved with developing and implementing policies, rules and regulations.

The report is intended to provide guidance to assist engineers in selection of traffic control devices or other measures at highway-rail grade crossings. It is not to be interpreted as policy or standards. Any requirements that may be noted in this guidance are taken from the Manual on Uniform Traffic Control Devices (MUTCD) or other document identified by footnotes. These authorities should be followed. This guide merely tries to incorporate some of the requirements found in those documents. A number of measures are included which may not have been supported by quantitative research, but are being used by States and local agencies. These are included to inform practitioners of an array of tools used or being explored.

The goal is to provide a guidance document for users who understand general engineering and operational concepts of highway-rail grade crossings. The Guide serves as a reference to aid in decisions to install traffic control devices or otherwise improve such crossings. Additional references are provided as resource for further information.

The Guide discusses a number of existing laws, regulations and policies of the FHWA and FRA concerning highway-rail grade crossings and railroad operations, driver needs concerning various sight distance, and highway and rail system operational requirements and functional classification. There is an extensive description of passive and active traffic control devices, including supplemental devices used in conjunction with active controls. Traffic control devices in the 2000 edition of the MUTCD are listed, together with a few experimental devices. An appendix provides limited discussion on the complex topic of interconnection and preemption of traffic signals near highway-rail grade crossings. There is also discussion concerning closure, grade separation and consideration for installing new grade crossings. A glossary defines a few less familiar and technical terms. (Please note that the term grade crossings is synonymous with both the terms "highway-rail grade crossings" and "highway-rail intersections" in this document.)

A traffic control device selection procedure and extensive list of quantitative guidance are the specific products of this document. However, due to the unique characteristics of each individual crossing, these procedures and practices should not be considered as warrants or standards. Therefore, selection decisions must be made based on engineering studies.

U.S. Department of Transportation
Highway-Railroad Grade Crossing Technical Working Group

Guidance on Traffic Control at Highway-Rail Grade Crossings

INTRODUCTION

The Technical Working Group (TWG) established by the U.S. Department of Transportation, is led by representatives from the Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), Federal Transit Administration (FTA), and the National Highway Traffic Safety Administration (NHTSA). The cooperation among the various representatives of the TWG represents a landmark effort to enhance communication between highway agencies, railroad companies and authorities, and governmental agencies involved with developing and implementing policies, rules and regulations.

The report is intended to provide guidance to assist engineers in selection of traffic control devices or other measures at highway-rail grade crossings. It is not to be interpreted as policy or standards and is not mandatory. Any requirements that may be noted in the report are taken from the Manual on Uniform Traffic Control Devices (MUTCD)[1] or other document identified by footnotes. A number of measures are included which may not have been supported by quantitative research, but are being used by States and local agencies. These are included to inform practitioners of an array of tools used or being explored.

The goal is to provide a guidance document for users who understand general engineering and operational concepts of public highway-rail grade crossings. The document will serve as a reference to aid in decisions to install traffic control devices or otherwise improve such crossings, and also provide information on additional references.

The report includes discussion of a number of existing laws, regulations and policies of the FHWA and FRA concerning highway-rail grade crossings and railroad operations, driver needs concerning various sight distance, and highway and rail system operational requirements and functional classification. There is extensive description of passive and active traffic control devices, including supplemental devices used in conjunction with active controls. Traffic control devices in the 2000 edition of the MUTCD are listed, together with a few experimental devices. An appendix provides limited discussion on the complex topic of interconnection and preemption of traffic signals near highway-rail grade crossings. There is also discussion concerning closure, grade separation and consideration for installing new grade crossings. Finally, an extensive list of quantitative recommend guidance is provided. (Please note that the term grade crossings is synonymous with highway-rail grade crossings in this document.)

EXISTING LAWS, RULES, REGULATIONS AND POLICIES

Several documents provided by the Federal Highway Administration, the Federal Railroad Administration, and other organizations, provide some guidelines for selecting traffic control devices. For example, the MUTCD, published by the Federal Highway

---

1 MUTCD is available at the following URL: http://mutcd.fhwa.dot.gov

Administration, contains detailed guidance on the design and placement of traffic control devices. The MUTCD is a Federal standard under title 23, United States Code 109(d) and is incorporated by reference into the Code of Federal Regulations (CFR). If a particular device is selected for use, the MUTCD will indicate what the size, color, and placement of that device should be. Considered by the FHWA as a national standard, the MUTCD has the force of law. Another document frequently used to assist in determining the need for certain traffic control devices is the *Railroad-Highway Grade Crossing Handbook - Second Edition, (RHGCH)*[2], also published by the FHWA. The handbook draws on a number of different sources (including the MUTCD and the AASHTO *A Policy on Geometric Design of Highways and Streets*[3] [Greenbook]) to provide an overview of highway-rail grade crossing legal and jurisdictional considerations. Included is a brief discussion of grade crossing design issues involving the physical and geometric characteristics of the crossing, and risk assessment formulas. The *RHGCH* provides guidelines for the identification and selection of active control devices. Also included are discussions of issues surrounding shortline railroads, high-speed rail corridors, and special vehicles such as trucks carrying hazardous materials and trucks having low-ground clearance.

These source documents provide limited guidance, mostly in the form of lists of factors "to be considered" for installing either flashing-lights or flashing-lights and gates; however, they lack specific guidance on how to determine the most appropriate type of highway traffic control at a given highway-rail crossing. For example, the *RHGCH* cites "high speed trains" as a factor, but does not define the conditions under which a train is considered "high speed." In another instance, the presence of school buses or vehicles carrying hazardous materials is cited as a factor, but every public crossing has the potential to carry both of these types of traffic. "Past collision history" is also frequently cited as a rationale for upgrading passive grade crossings to active control, or adding gates to "flasher only" grade crossings, but no specific guidance is provided.

Several previous attempts have been made to quantify the relative emphasis these factors should have in evaluating the need to improve a crossing. The *RHGCH* contains several examples of formulae that have been developed to help determine the likelihood of a collision occurring at a particular crossing. Use of these formulae, however, is far from universal. Some States use either exposure factors or a minimum expected accident frequency (EAF) to determine whether a given crossing "qualifies" for public funding for improved traffic control devices. Illinois, for example, uses a modified New Hampshire formula to "qualify" crossings for improvement or upgrade whenever the EAF exceeds 0.02; Iowa gives "priority" to those crossings having a USDOT Accident Predictor Model EAF of 0.075 or higher. A number of States have established their own criteria for determining when or where active devices are deployed, but their rationale for establishing such criteria is not commonly known nor is there much consistency from State to State.

Current FHWA regulations specifically prohibit at-grade intersections on highways with full access control. The FRA's rail safety regulations require that crossings be separated or closed where trains operate at speeds above 125 mph (49 CFR

---

2 Railroad-Highway Grade Crossing Handbook - Second Edition is available at the following URL: http://www.fhwa.dot.gov/tfhrc/safety/pubs/86215/intro.htm

3 A Policy on Geometric Design of Highways and Streets is available at the following URL: http://www.ite.org/bookstore/lp323b.html

213.347(a)). Additionally, if train operation is projected at FRA track class 7 (111 – 125mph) an application must be made to the FRA for approval of the type of warning/barrier system. The regulation does not specify the type of system, but allows the petitioner to propose a suitable system for FRA review.

In 1998, the FRA issued an Order of Particular Applicability for high-speed rail service on the Northeast Corridor. In the Order, the FRA set a maximum operating speed of 80 mph over any highway-rail crossing where only conventional warning systems are in place and a maximum operating speed of 95 mph where 4-quadrant gates and presence detection are provided and tied into the signal system. Grade crossings are prohibited on the Northeast Corridor if maximum operating speeds exceed 95 mph.

Current statutory, regulatory and Federal policy requirements are summarized in Table 1.

TABLE 1
FEDERAL LAWS, RULES, REGULATION & POLICIES

	Active	**Warning/Barrier W/FRA Approval**	**Grade Separate or Close**
Controlled Access Highways	Not allowed	Not allowed	Required
High Speed Rail	> 79 MPH	111-125 MPH	> 125 MPH

Note: 1 mph = 1.61 km/h

HIGHWAY-RAIL GRADE CROSSING PERSPECTIVE

A highway-rail grade crossing differs from a highway/highway intersection in that the train always has the right of way. From this perspective, the process for deciding what type of highway traffic control device is to be installed, or to even allow that a highway-rail grade crossing should exist is essentially a two-step process: 1) What information does the vehicle driver need to be able to cross safely? and, 2) Is the resulting driver response to a traffic control device "compatible" with the intended system operating characteristics of the highway and railroad facility?

MOTOR VEHICLE DRIVER NEEDS ON THE APPROACH

The first step involves three essential elements required for "safe" passage through the crossing, which are the same elements a driver needs for crossing a highway-highway intersection:

ADVANCE NOTICE - STOPPING SIGHT DISTANCE

The first element pertains to "stopping" or "braking" sight distance, which is the ability to see a train and/or the traffic control device at the crossing ahead sufficiently in advance so that a driver can bring the vehicle to a safe, controlled stop at least 4.5 m (15 ft) short of the near rail, if necessary. This applies to either a passive or active controlled crossing. Stopping sight distance is measured along the roadway and is a function of the distance required for the "design" vehicle, traveling at the posted speed limit to safely stop[1]. Insufficient stopping sight distance is often due to poor roadway geometry and/or surrounding topography.

TRAFFIC CONTROL DEVICE COMPREHENSION

The second element is a function of the type of traffic control device at the highway-rail crossing. There are typically three types of control devices, each requiring a distinct compliance response per the Uniform Vehicle Code2, various Model Traffic Ordinances and State regulations.

1. A crossbuck is a type of YIELD sign: the driver should be prepared to stop at least 4.5 m (15 ft) before the near rail if necessary, unless and until the driver can make a reasonable decision that there are no trains in hazardous proximity to the crossing, and it is safe to cross.

---

[1] *A Policy on Geometric Design of Highways and Streets.* American Association of State Highway Transportation Officials (AASHTO). 2001 Edition. P. 449, available at www.ite.org, or 202-289-0222 and www.aashto.org

2 Uniform Vehicle Code is available at the following URL: http://mutcd.fhwa.dot.gov/

2. Operating flashing lights have the same function as a STOP sign: a vehicle is required to stop completely at least 4.5 m (15 ft) short of the near rail. Then, even though the flashing lights may still be operating, the driver is allowed to proceed after stopping (subject to State or local laws), when safe to do so.

3. Flashing lights with lowered gates are equivalent to a red vehicular traffic signal indication: a vehicle is required to stop short of the gate and remain stopped until the gates go up.

Motorist comprehension and compliance with each of these devices is mainly a function of education and enforcement. The traffic engineer should make full use of the various traffic control devices as prescribed in the MUTCD to convey a clear, concise and easily understood message to the driver, which should facilitate education and enforcement.

DECIDING TO PROCEED

The third element concerns the driver's decision to safely proceed through the grade crossing. It involves sight distance available both on the approach and at the crossing itself.

Approach (Corner) Sight Distance

On the approach to the crossing with no train activated traffic control devices (or STOP sign) present, in order to proceed at the posted speed limit, a driver would need to be able to see an approaching train, from either the left or right, in sufficient time to stop safely 4.5 m (15 ft) before the near rail. This would require an unobstructed field of vision along the approach sight triangle, the extent of which is dependent upon train and vehicle speed. These sight distances are available in the RHGCH. However, view obstructions often exist within the sight triangle, typically caused by structures, topography, crops or other vegetation (continually or seasonal), movable objects or weather (fog, snow, etc.). Where lesser sight distances exist, the motorist should reduce speed and be prepared to stop not less than 4.5 m (15 ft) before the near rail unless and until they are able to determine, based upon the available sight distance, that there is no train approaching and it is safe to proceed. Wherever possible, sight line deficiencies should be improved by removing structures or vegetation within the affected area, regrading an embankment, or realigning the highway approach.

Many conditions however cannot be corrected because the obstruction is on private property, or it is economically infeasible to correct the sight line deficiency. If available corner sight distance is less than what is required for the legal speed limit on the highway approach, supplemental traffic control devices such as enhanced advance warning signs, STOP or YIELD signs, or reduced speed limits (advisory or regulatory) should be evaluated. If it is desirable from traffic mobility criteria to allow vehicles to travel at the legal speed limit on the highway approach, active control devices should be considered.

Clearing Sight Distance

At all crossings, except those with gates, a driver stopped 4.5 m (15 ft) short of the near rail must be able to see far enough down the track, in both directions, to determine if sufficient time exists for moving their vehicle safely across the tracks to a point 4.5 m (15 ft) past the far rail, prior to the arrival of a train. Required clearing sight distance along both directions of the track, from the stopped position of the vehicle, is dependent upon the maximum train speed and the acceleration characteristics of the "design" vehicle.

At multiple track highway-rail grade crossings of two or more in-service railroad tracks through the roadway, and where two or more trains can operate simultaneously over or in close proximity to the crossing, the presence of a train on one track can restrict or obscure a driver's view of a second train approaching on an adjacent track. Such crossings must be treated the same as any other crossing having insufficient clearing sight distance. Even where there is only one track through the crossing, but additional tracks (such as a siding) are located adjacent to, but terminate before reaching the crossing, the sight distance to the limit of where railroad cars or equipment could be stored should be evaluated. Figure 1 is a diagram designed to illustrate some unusual conditions that would merit special consideration at a single-track highway-rail grade crossing.

Figure 1

This figure shows an aerial view of a highway-rail grade crossing. A single-rail track stretches across the width of the figure. A locomotive is located on both the right and left-ends of the track. There is a second track on right side of the crossing with a locomotive on it. This track ends before the roadway. An automobile is stopped behind a "stop line" in the middle of the figure. On both sides of the intersection there is a symbol for a flashing light signal. In the lower left quadrant, a building is shown that restricts sight the sight of a locomotive approaching from the left. There is a 45-degree line between the automobile and the locomotive on the left end of the track that demonstrates the obstructed clearing sight distance caused by the building. Another 45-degree line stretches from the automobile to the locomotive on the right end of the track that demonstrates the obstructed clearing sight distance caused by the locomotive on the second track. There is a box between the automobile and locomotive that says, "D is the minimum unobstructed viewing distance to determine if the crossing should be considered for upgrade to automatic gate control."

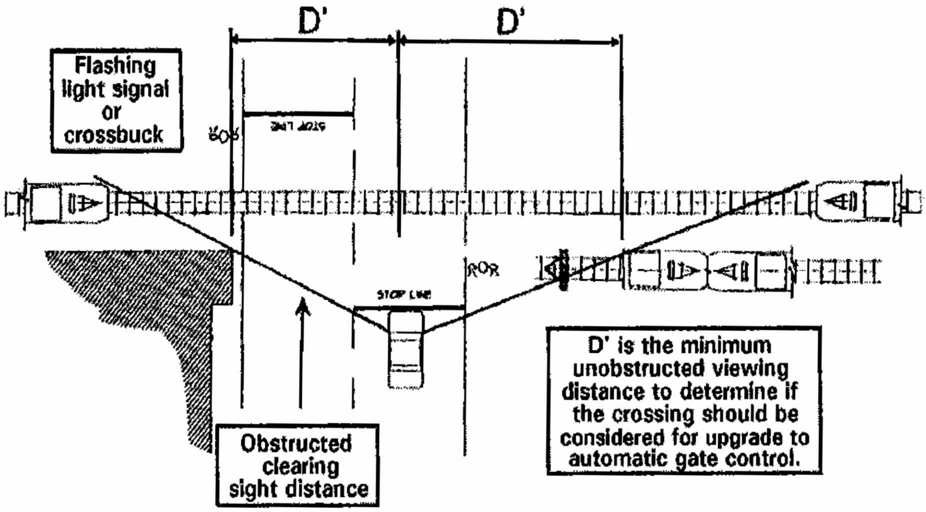


FIGURE 1

Table 2, prepared by members of the TWG, relates the typical minimal clearing sight distances for various train speeds and vehicle types. (It should be noted the column for 65 foot double trucks generally corresponds to the distances listed in table 36 on page 133 of the *RHGCH*, under the column for vehicle speed of "0 MPH." Vehicle acceleration data has been interpreted from the *Traffic Engineering Handbook*.[3]) The person or agency evaluating the crossing should determine the specific design vehicle, pedestrian, bicyclist, or other non-motorized conveyance and compute clearing sight distance if it is not represented in the table. Also note the table values are for a level, 90-degree crossing of a single track. If other circumstances are encountered, the values <u>must</u> be <u>re-computed</u>.

TABLE 2
CLEARING SIGHT DISTANCE (in feet) *

Train	Car	Single Unit-Truck	Bus	WB-50 Semi-Truck	65-ft Double Truck	Pedestrian
10	105	185	200	225	240	180
20	205	365	400	450	485	355
25	255	455	500	560	605	440
30	310	550	600	675	725	530
40	410	730	795	895	965	705
50	515	910	995	1120	1205	880
60	615	1095	1195	1345	1445	1060
70	715	1275	1395	1570	1680	1235
80	820	1460	1590	1790	1925	1410
90	920	1640	1790	2015	2165	1585

* A single track, 90-degree, level crossing.

** walking 1.1 mps (3.5 fps) across <u>2</u> sets of tracks feet apart, with a two second reaction time to reach a decision point 3 m (10 ft) before the

[3] *Traffic Engineering Handbook - Fourth Edition.* Institute of Transportation Engineers. Washington D.C.: 1990. available at www.ite.org, or 202-289-0222

center of the first track, and clearing 3 m (10 ft) beyond the center line of the second track. Two tracks may be more common in commuter station areas where pedestrians are found. (See Figure 2).

Note: 1 meter = 0.3048 feet.

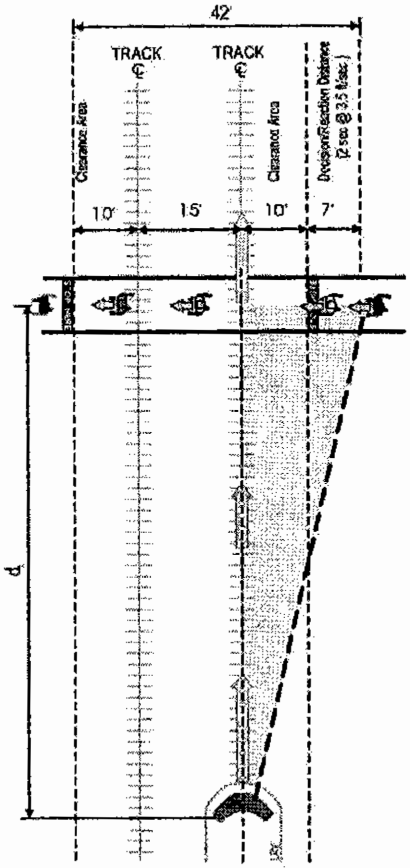
Figure 2: Pedestrian Sight Triangle

A highway-rail grade crossing is displayed depicting a pattern for the pedestrian sight triangle. The distance the pedestrian travels from one side of the crossing to the other is 42 feet. There are two tracks in the crossing. The distance is broken up into the following respective categories:

– 7 ft. Decision/Reaction Distance of 2 seconds @3.5 feet per second;
– 10 ft. Clearance Area just before a rail track;
– 15 ft. between two rail tracks;
– 10 ft. from last rail track to clearance area.

A locomotive is approaching from the south in the diagram. The pedestrian is on the immediate right of the crossing starting at the Decision/Reaction Distance category-space. The figure of the pedestrian is shown several times to represent the movement over the crossing. There is a "STOP HERE" label on both sides of the crossing immediately prior to the beginning of the clearance area. There is a dotted line reaching from the pedestrian's figure to the first track that demonstrates the sight distance to an approaching locomotive. The area inside the triangle is shaded. The sight triangle demonstrates that the pedestrian is 17 ft. from the center of the first track.

If there is insufficient clearing sight distance, and the driver is unable to make a safe determination to proceed, the clearing sight distance needs to be improved to safe conditions, or flashing light signals with gates, or closure, or grade separation should be considered. (See Recommendation, "3.F.3".)



PEDESTRIAN SIGHT TRIANGLE
FIGURE 2

SYSTEMS OPERATING REQUIREMENTS AND OBJECTIVES

The second step involves a traffic control device selection process considering respective highway and rail system operational requirements. From a highway perspective, concerns for roadway capacity and drivers= expectations may mandate the type of traffic control present. There are circumstances when train interference can be so disruptive to highway operations that a highway-rail grade crossing is incompatible with system objectives. From the rail perspective, there can also be circumstances when the potential for highway traffic interference can be sufficiently disruptive, or potentially so catastrophic, that closure, grade separation, or activated control would be considered. It is within these contexts where operation and safety variables should be considered, such as:

a) Highway - AADT (Annual Average Daily Traffic), legal and/or operating speed;

b) Railroad - train frequency, speed and type (passenger, freight, other);
c) Highway - Functional classification and/or design level of service;
d) Railroad - FRA Class of Track and/or High Speed Rail corridors;
e) Proximity to other intersections;

f) Proximity to schools, industrial plants and commercial areas;
g) Proximity to rail yards, terminals, passing tracks and switching operations;
h) Available clearing and corner sight distance;
i) Prior accident history and predicted accident frequency;
j) Proximity and availability of alternate routes and/or crossings; and
k) Other geometric conditions.

Special consideration should also be given to situations where highway-rail crossings are sufficiently close to other highway intersections that traffic waiting to clear the adjacent highway intersection can queue on or across the tracks. Additionally, special consideration is required when there are two or more sets of tracks sufficiently close to each other that traffic stopped on one set could result in a queue of traffic across the other.

HIGHWAY SYSTEM OBJECTIVES

Roads and streets which are planned, designed, constructed, maintained and operated by public agencies serve two important but conflicting functions: land access and mobility. Overriding these interests should be a concern for safety.

An example of a facility constructed primarily for mobility is the Interstate highway. Access is only by interchanges, with ramps and acceleration/deceleration lanes. These allow vehicles to enter and leave the highway with minimal effect on the through traffic stream. Interstate highways do not have direct driveway access to adjacent properties, grade level intersections, transit stops, pedestrian and bicycle facilities or highway-rail grade crossings, all of which interfere with the free flow of traffic.

A local street is at the other end of the spectrum. It provides direct access to adjacent land, with driveways to parking facilities and provision of services such as on-street deliveries and trash pickup. The

low-type design of local streets, including presence of parked vehicles, pedestrians and bicycles, makes travel at any significant speed undesirable.

Many roads and highways fall in the spectrum between Interstate highways and local roads, and fulfill their purpose with varying degrees of success. Mobility is affected by providing adequate access to adjacent development in an environment complicated by driveways and street intersections, and other modes of transportation such as transit, bicycles, pedestrians and railroads. The concept is illustrated in Figure 3.[4]

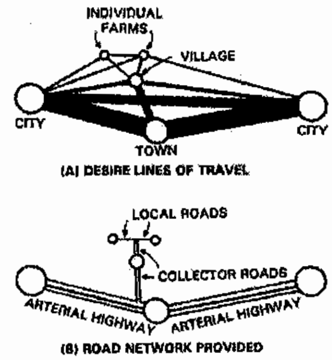


FIGURE 3

Figure 3:

A) Desired Lines of Travel

The figure depicts the desired lines of travel between several points and is depicted in the form of an irregular pentagon. A circle, representing "City", "Town", and "City", respectively is shown on each of the three southern points of the figure. On the left and right points of the irregular pentagon, there is a label that reads "City." The far-south point of the pentagon reads "Town." In the center of the pentagon there is a circle with an arrow pointing to it labeled "Village." Above "Village" are two smaller circles that are labeled "Individual Farms". Twelve lines connect the various circles of the pentagon indicating the desired lines of travel between the various points. There are thick black lines leading from each "City" to the "Town".

B) Road Network Provided

The figure shows the same pattern of circles as Figure A that are labeled the same as in A). There are five lines connecting the points indicating the roadway network. "Arterial Highway" is written for the segments connecting both "City" circles to the "Town". To the left of the "Town" is a vertical line labeled "Collector Roads" which runs to the "Village" circle and extends slightly beyond the village. Horizontally placed atop the "Collector Roads" is a small "local roads" line with the two "Individual Farms" circles on each endpoint. Each line represents travel between the various points.

A highway-rail grade crossing can impede highway traffic flow based on several factors. The most obvious is, of course, blockages by trains. The geometry of the crossing and approaches, and the condition of the surface can present additional impediments.

LEVELS OF SERVICE

---

[4] *A Policy on Geometric Design of Highways and Streets.* American Association of State Highway Transportation Officials (AASHTO). 2001 Edition. pages 4 and 5, available at www.ite.org, or 202-289-0222 and www.aashto.org.

The performance of a road or street is normally described in terms of "Level of Service.[5]" The Level of Service is a concept that describes the operational characteristics of the traffic stream and how they are perceived by drivers and passengers. Speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience are factors that characterize levels of service. Traffic flow characteristics are described by letter designations; "A" the best, corresponding to a free flow condition, and "F" the worst, corresponding to a breakdown of flow or "stop and go" condition. Table 3 provides guidance for selecting Level of Service for particular locations.

TABLE 3
GUIDE FOR SELECTION OF DESIGN LEVELS OF SERVICE

	Type of Area and Appropriate Level of Service			
Highway	**Rural**	**Rural**	**Rural**	**Urban and**
Freeway	B	B	C	C
Arterial	B	B	C	C
Collector	C	C	D	D
Local	D	D	D	D

Note: General operating conditions for levels of service:

A - free flow, with low volumes and high speeds.

B - reasonably free flow, but speeds beginning to be restricted by traffic conditions.

C - in a stable flow zone, but most drivers restricted in freedom to select their own speed.

D - approaching unstable flow, drivers have little freedom to maneuver.

E - unstable flow, may be short stoppages.

F - forced flow, congested stop-and-go operation.

(Source: A Policy on Geometric Design of Highways and Streets. AASHTO. 2001. Page 90)

The nominal level of service normally considered acceptable during the planning and design of a new or reconstructed roadway is "C" which is within the range of stable flow. The presence of a highway-rail grade crossing can drop the level of service below "C".

SAFE APPROACH SPEED

Passive crossings with a restricted sight distance require an engineering study to determine the safe approach speed based upon available stopping and/or corner sight distance. As a minimum, an advisory speed posting may be appropriate, or a reduced regulatory speed limit might be warranted (if it can be effectively enforced). (See Guidance Section of this Report, "3.F.2c.") Active devices improve highway capacity and level of service in the vicinity of a

[5] *Highway Capacity Manual, Special Report 209, 3rd Edition.* Transportation Research Board. Washington, D.C.: 1994, available at www.ite.org or 202-289-0222 or www.trb.org.

crossing, particularly where corner sight distances are restricted. When flashing lights are active however, a driver is required to stop and look for a train.

The effects of such delay increases as volume increase. Queues become longer and vehicle delay increases proportionally. These delays are observed by the driver as a reduction in the facility=s level of service. The type of control installed at highway-rail crossings needs to be evaluated in the context of the highway system classification and level of service.

RAILROAD SYSTEMS - FUNCTIONAL CLASSIFICATION

A commonly used means of classifying freight and "heavy rail" passenger rail routes is by their respective FRA designations for class of track. This Federal designation establishes the maximum authorized speed for freight and passenger trains, and places requirements on the track maintenance criteria, vehicle standards, and train control signal systems. In some respects, the FRA Class of Track may be viewed as a surrogate for rail traffic volume. In general, railroads are not likely to make the additional investment required to maintain tracks to a higher standard absent sufficient traffic volume to justify the added expense. Table 4 indicates maximum permissible train speeds for various classes of track.

TABLE 4
MAXIMUM TRAIN SPEEDS BY CLASS OF TRACK *

Class of Track	Freight	Passenger
Class 1	10 MPH	15 MPH
Class 2	25 MPH	30 MPH
Class 3	40 MPH	60 MPH
Class 4	60 MPH	80 MPH
Class 5	80 MPH	90 MPH
Class 6	110 MPH	110 MPH
Class 7	125 MPH	125 MPH
Class 8	160 MPH	160 MPH
Class 9	200 MPH	200 MPH

* If train operations exceed 177 km/h (110 mph) for a track segment that will include highway-rail grade crossings, FRA=s approval of a complete description of the proposed warning/barrier system to address the protection of highway traffic and high speed trains must be obtained in advance. All elements of the warning/barrier system must be functioning.
Source: 49 CFR 213
Note: 1 mph = 1.61 km/h

Not unlike the system specification that all highway-rail crossings on full control access highways be grade separated, it is only logical that certain rail systems should have similar status. In 1994, the FRA defined a core railroad system of approximately 128,800 km (80,000 mi) known as the Principal Railroad Lines (PRLs). These lines have one or more of the following attributes: Amtrak service; defense essential; or, annual freight volume exceeding 20 million gross tons. This core network was described in the Department of Transportation's 1994 Action Plan to improve highway-rail grade crossing safety. The Action Plan set forth a long-term goal of eliminating (grade separating or realigning) intersections of PRLs and highway routes on the National Highway System (NHS - defined as "an interconnected system of principal arterial routes to serve major population centers, intermodal transportation facilities and other major travel destinations; meet national defense requirements; and serve interstate and interregional travel").

FUNCTION, GEOMETRIC DESIGN AND TRAFFIC CONTROL

Functional classification is important to both the highway agency and railroad operator. Even though geometric criteria can be determined without reference to the functional classification, the designer should consider the function that the highway is expected to serve. The functional classification of the highway defines the geometric criteria to be used in its planning, design and construction. Where the highway intersects a railroad, the crossing, whether grade separated or at-grade, should be designed consistently with the functional classification of the highway or street. These design considerations can also extend to traffic control.

Drivers form expectancies based on their training and experience; that is, situations which occur in similar environments and in similar ways are incorporated into the driver=s knowledge base, along with successful responses to the situations. Drivers on a US or state-numbered route, or on a facility having a higher functional classification, have higher expectancies for operating characteristics, level of service and traffic control than do those same drivers on local roads and streets. These higher classed roads and streets also tend to serve a more diverse cross-section of vehicles and lading, including transit buses, intercity buses and haz-mat carriers. For these reasons, functional classification of the road or street should be considered in the decision-making process concerning geometric design and traffic control devices.

TRAFFIC CONTROL DEVICES

GENERAL DISCUSSION

The purpose of traffic control at highway-rail grade crossings is to permit safe and efficient operation of rail and highway traffic over such crossings. Highway vehicles approaching a highway-rail grade crossing should be *prepared to yield and stop if necessary* if a train is at or approaching the crossing.

PASSIVE DEVICES

A passive highway-rail grade crossing is described as follows:

> **All highway-rail grade crossings having signs and pavement markings (if appropriate to the roadway surface) as traffic control devices that are not activated by trains.**

The following tables describe a variety of devices that can be used at a passive controlled highway-rail grade crossing, or supplement active devices. Table 5A are devices currently referenced in the 2000 MUTCD edition. Table 5B lists devices that are not currently proposed in the MUTCD, and any jurisdiction wishing to use these devices to experiment must request permission from the FHWA.

TABLE 5A - CURRENT MUTCD DEVICES

MUTC	Traffic Control	Application or Indication of Need
R15-1	CROSSBUCK sign	Required device
R15-2	"Multiple Tracks" sign	Standard device, with 2 or more tracks; optional with gate.
W10-1	Advance warning sign	Required device, with MUTCD exceptions
	RR Pavement Markings	All paved roads, with MUTCD exceptions
R1-1	STOP sign	As indicated in MUTCD reference 1993 memorandum.
W3-1, 1a	STOP AHEAD sign	Where STOP sign is present at crossing.
R1-2	YIELD sign	As indicated in MUTCD reference 1993 memorandum.
W3-2, 2a	YIELD AHEAD sign	Where YIELD sign is present at crossing.
R3-1, -2	Turn Restriction sign *	Use with interconnected, preempted traffic signals. Install on the nearby parallel highway to control turns toward the tracks.
R3-4	U-Turn Prohibition sign	Use in median of divided highways at highway-rail grade crossings to inhibit turning vehicles from using the track zone for illegal movement as necessary.
R4-1, W14-3	DO NOT PASS sign	Where passing near the tracks is observed.
R8-8	DO NOT STOP ON TRACKS sign	Where queuing occurs, or where storage space is limited between a nearby highway intersection and the tracks. May be supplemented with a flashing light activated by queuing traffic in the exit lane(s) from the crossing. (See discussion on Queue Cutters Signals.)
R8-9	TRACKS OUT OF SERVICE sign	Applicable when there is some physical disconnection along the railroad tracks to prevent train using those tracks.
R10-5	STOP HERE ON RED sign	Use with pre-signal and/or Stop Line pavement markings to discourage vehicle queues onto the track.
R10-11	NO TURN ON RED sign	Use with pre-signal and/or where storage space is limited between a nearby-interconnected traffic signal controlled intersection.
R15-3, W10-1	EXEMPT sign	School buses and those commercial vehicles that are usually required to stop at crossings are not required to do so where authorized by ordinance.
R15-4	Light Rail Transit Only Lane sign series	For multilane operations where roadway users might need additional guidance on lane use and/or restrictions.
R15-5, 5a	DO NOT PASS Light Rail Transit signs	Where vehicles are not allowed to pass LRT vehicles loading or unloading passengers where no raised platform physically separates the lanes.

R15-6, 6a	No Vehicles on Tracks signs	Used where there are adjacent vehicle lanes separated from the LRT lane by a curb or pavement markings.
R15 -7, 7a	DIVIDED HIGHWAY sign	Use with appropriate geometric conditions.
R15-8	LOOK, Supplementary sign	➢ Multiple tracks ➢ Collision experience ➢ Pedestrian presence
W10-2, 3, 4	Advance Warning Signs Series	Based upon specific situations with a nearby parallel highway.
W10-5	LOW GROUND CLEARANCE CROSSING sign	As indicated by MUTCD guidelines, incident history or local knowledge.
W10-8, 8a	TRAINS MAY EXCEED 80 MPH (130 KM/H) sign	Where train speed is 80 mph (130 km/h) or faster
W10-9	NO TRAIN HORN sign	Shall be used only for crossings in FRA-authorized quiet zones.
W10-10	NO SIGNAL sign	May be used at passive controlled crossings.
W10-11, 11a	Storage Space signs	Where the parallel highway is close to crossing, particularly with limited storage space between the highway intersection and tracks.
W13-1	"Advisory Speed" plate	➢ May be used with any advance warning sign where appropriate, e.g. advance warning, humped crossing, rough crossing, super-elevated track or other condition where a speed lower than the posted speed limit is advised.
I-12	Light Rail Station sign	Used to direct road users to a light rail station or boarding location.
I-13, 13a	Emergency Notification sign	Post at all crossings to provide for emergency notification.
	Dynamic Envelope Delineation, pavement markings	Where there is queuing or limited storage space for highway vehicles at a nearby highway intersection..
	Signs on both sides of highway	➢ For extra emphasis ➢ Multi lane ➢ One-way roads ➢ Curved approaches
	Increased retroreflectivity on highway signs	➢ Nighttime train operations.
	Roadway delineators, post-	➢ Frequent inclement weather ➢ Crossing narrower than approach pavement

	mounted on shoulders	➢ Isolated crossings ➢ May be used as an alternative to illumination
	Flashing lights on signs and lighted signs	➢ Presence of competing stimuli, "visual clutter" ➢ Restricted sight distance to the crossing ➢ High speed highway traffic approach ➢ Isolated crossing ➢ Heavy volume or queued traffic in advance of the crossing
	Overhead signs	➢ Multi-lane approach ➢ High speed highway approach ➢ If a sign cannot be placed on the roadside ➢ May be used as an alternative to the double signs
	Crossing illumination:	➢ Nighttime train operations ➢ Crossings are blocked for long periods ➢ Train speeds are low ➢ Nighttime collision experience ➢ Curved approach (vertical and horizontal curves) ➢ Frequent occurrence of fog or smoke.
	Stop and flag	➢ Railroad option, but may be considered by traffic engineer. ➢ Combination of low train frequency, short trains, high-volume highway traffic, multilane highway
TABLE 5B - NOT CURRENTLY PROPOSED IN THE MUTCD - *EXPERIMENTAL DEVICES*		
	SECOND TRAIN and other supplemental signs	➢ Multiple tracks ➢ Collision experience ➢ Pedestrian presence
	Buckeye	Among a number of special signs under current research.

HIGHWAY-RAIL GRADE CROSSING (CROSSBUCK) SIGNS

The MUTCD states, "The Highway-Rail Grade Crossing (R15-1) sign, commonly identified as the Crossbuck Sign, shall be retroreflectorized white with the words RAILROAD CROSSING in black lettering. As a minimum, one Crossbuck sign shall be used on each highway approach to every highway-rail grade crossing, alone or in combination with other traffic control devices. If automatic gates are not present and if there are two or more tracks at the highway-rail grade crossing, the number of tracks shall be indicated on a supplemental Number of Tracks (R15-2) sign of inverted T shape mounted below the Crossbuck sign in the manner and at the height indicated in the MUTCD."

STOP and YIELD SIGNS

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) (Public Law 102-240; 105 Stat 1914; December 18, 1991) required that the FHWA revise the MUTCD to enable State or local governments to install STOP or YIELD signs at any passive highway-rail grade crossing where two or more trains operated daily. In response, the FHWA published a final rule in the Federal Register (57 FR 53029), which incorporated the new standards into the MUTCD. This final rule, published in March 1992, was effective immediately.

The FHWA and the FRA published a memorandum containing guidelines for when the use of STOP or YIELD signs is appropriate. According to the jointly-developed document, "it is recommended that the following considerations be met in every case where a STOP sign is installed: [1]"

1. Local and/or State police and judicial officials commit to a program of enforcement no less vigorous than would apply at a highway intersection equipped with STOP signs.
2. Installation of a STOP sign would not occasion a more dangerous situation (taking into consideration both the likelihood and severity of highway-rail collisions and other highway traffic risks) than would exist with a YIELD sign.

According to this memorandum, any of the following conditions indicate that the use of a STOP sign might reduce risk at a crossing:

1. Maximum train speeds equal, or exceed, 48 km/h (30 mph).
2. Highway traffic mix includes buses, hazardous materials carriers and/or large (trash or earth moving) equipment.
3. Train movements are 10 or more per day, five or more days per week.
4. The rail line is used by passenger trains.
5. The rail line is regularly used to transport a significant quantity of hazardous materials.
6. The highway crosses two or more tracks, particularly where both tracks are main tracks or one track is a passing siding that is frequently used.
7. The angle of approach to the crossing is skewed.

---

[1] U.S. Department of Transportation; Federal Highway Administration; Federal Railroad Administration. 1993. Recommended Guidance for Stop and Yield Sign at Highway-rail Grade Crossings. Washington, DC. 3 p. [Attachment 2 to a July 8, 1993 memorandum from the Associate Administrator for Safety and Systems Applications, FHWA, and the Associate Administrator for Safety, FRA, to the FHWA Regional Administrators and the FRA Regional Directors of Railroad Safety.]

8. The line of sight from an approaching highway vehicle to an approaching train is restricted such that approaching traffic is required to substantially reduce speed.

The memorandum also states, however, that the above conditions should be weighed against the possible existence of the following factors:

1. The highway is other than secondary in character. Recommended maximum of 400 ADT in rural areas, and 1,500 ADT in urban areas.
2. The roadway is a steep ascending grade to or through the crossing, sight distance in both directions is unrestricted in relation to maximum closing speed, and heavy vehicles use the crossing.

A footnote in this joint document also states that "a crossing where there is insufficient time for any vehicle, proceeding from a complete stop, to safely traverse the crossing within the time allowed by maximum train speed, is an inherently unsafe crossing that should be closed."

ACTIVE DEVICES

An active highway-rail grade crossing is described as follows:

All highway-rail grade crossings equipped with warning and/or traffic control devices that gives warning of the approach or presence of a train.

Due to the variables which should be considered, an engineering and traffic investigation is required to determine the specific application of active devices at any given highway-rail grade crossing. Guidance is provided in the following sections for the application of the many active traffic control system devices available for grade crossing design, in addition to various median treatments that can supplement these devices. The following is a list of active devices that can be considered for use at a highway-rail grade crossing. The first four commonly found at many grade crossings are designated as "standard devices."

STANDARD ACTIVE DEVICES

Flashing-Light Signal

A standard flashing-light signal consists of two red lights in a horizontal line flashing alternately at approaching highway traffic. At a crossing with highway traffic approaching in both directions, flashing-lights are installed facing oncoming traffic in a back-to-back configuration in accordance with the MUTCD. The support used for the lights should also include a standard crossbuck sign and, where there is more that one track, an auxiliary "multiple tracks" R15-2 sign. Back lights may be eliminated with one-way highway traffic, based on engineering judgment. An audible control device may be included.

Cantilever Flashing-Light Signal

This device supplements the standard flashing-light signal. Cantilever flashing-lights consist of an additional one or two sets of lights mounted over the roadway on a cantilever arm and directed at approaching highway traffic. Cantilevered lights provide better visibility to approaching highway traffic, particularly on multi-lane approaches. This device is also useful on high-speed two-lane highways, where there is a high percentage of trucks, or where obstacles by the side of the highway could obstruct visibility of standard mast mounted flashing-lights. An example is where the terrain or topography of the approaching highway is such that the sight of a roadside mounted signal light could not be readily seen by an approaching driver due to vertical or horizontal curves.

Cantilever flashing-light signals may be mounted back-to-back and should also have an additional crossbuck added to the overhead structure, based on site conditions and engineering judgment.

Automatic Gate

The automatic gate provides supplemental visual display when used with both road side mounted flashing-lights and cantilever flashing-light signals. The device consists of a drive unit and a gate arm. The drive mechanism can be mounted on flashing-light posts or cantilever pole supports, or on a stand-alone support. The gate arm is fully reflectorized on both sides with 45 degree diagonal red and white stripes and has at least three lights; the tip light is continuously lit and the others alternately flash when the gate is activated and lowered. When lowered, the gate should extend across approaching highway traffic lanes. Special consideration should be given to clearances for movement of the counter weight arm portion of the gate drive unit in a median and adjacent to sidewalk locations with pedestrians, particularly with the requirements of the Americans with Disabilities Act (ADA) of 1990.

Additional Flashing-Light Signals

Additional approaches to active highway-rail grade crossings require additional flashing-light signals be directed at the approaching traffic. These lights can be mounted on existing flashing-light masts, extension arms, additional traffic signal masts, cantilever supports, in medians or other locations on the left side of the roadway.

SUPPLEMENTAL ACTIVE DEVICES

Active Advance Warning Signs with Flashers

A train activated advance warning sign (utilizing the W-10 sign) should be considered at locations where sight distance is restricted on the approach to a crossing, and the flashing-light signals cannot be seen until an approaching driver has passed the decision point (the distance to the track from which a safe stop can be made).[2] Two yellow lights can be placed on the sign to warn drivers in advance of a crossing where the control devices are activated. The continuously flashing yellow "caution" lights can influence driver speed and/or provide warning for stopped vehicles ahead. An Advisory Speed Plate sign indicating the safe approach speed also should be posted with the sign.

If the advance flashers are connected to the railroad control circuitry, and only flash upon the approach of a train, they should be activated prior to the control devices at the crossing so that a driver would not pass a dark flasher and then encounter an activated flashing-light at the crossing. (Track circuits may need to be revised to handle this.) A few States use a supplementary message such as TRAIN WHEN FLASHING. In order to allow the traffic queue at the crossing time to dissipate safely, the advance flashers should continue to operate for a period of time after the active control devices at the crossing deactivate, as determined by an engineering study.

If such an advance device fails, the driver would not be alerted to the activated crossing controls. If there is concern for such failure, some agencies use a passive, RAILROAD SIGNAL AHEAD sign to provide a full time warning message. The location of this supplemental advance warning sign is dependant on vehicle speed and geometric conditions of the roadway.

Active Turn Restriction Signs

An active turn restriction sign (blank-out sign with internal illumination) displaying "No Right Turn" or "No Left Turn" (or appropriate international symbol) should be used in the following instances; on a parallel street within 15 m (50 ft) of the tracks where a turning vehicle from that parallel street could proceed around lowered gates; at a signalized highway intersection, where traffic signals at a nearby highway intersection are interconnected and preempted by the approach of the train, and all existing turn movements toward the grade crossing should be prohibited. These signs shall be visible only when the restriction is in effect.

MEDIAN SEPARATION

Despite the dangers of crossing in front of oncoming trains, drivers continue to risk lives and property by driving around crossing gates. At many crossings a driver is able to cross the center line pavement marking and drive around a gate with little difficulty. The numbers of crossing gate violations can be reduced by restricting driver access to the opposing lanes. Highway authorities have implemented various median separation devices, which have shown a significant reduction in the number of vehicle violations at crossing gates.

---

[2] *Manual on Uniform Traffic Control Devices For Streets and Highways* - 2000 Edition. FHWA. Sections 2C.26 and 4K.01. Official website is http://mutcd.fhwa.dot.gov or 202-289-0222

There are limitations common to the use of any form of traffic separation at highway-rail grade crossings. These include restricting access to intersecting streets, alleys and driveways within the limits of the median and possible adverse safety effects. The median should be designed to allow vehicles to make left turns or U-turns through the median where appropriate, based on engineering judgment and evaluation.

BARRIER WALLS SYSTEMS

Concrete barrier walls and guardrails generally prevent drivers from crossing into opposing lanes throughout the length of the installation. In this sense they are the most effective deterrent to crossing gate violations. But, the road must be wide enough to accept the width of the barrier and the appropriate end treatment.[3] Sight restrictions for vehicles with low driver eye heights and any special need for emergency vehicles to make a U-turn maneuver should be considered (but not for the purpose of circumventing the traffic control devices at the crossing). Installation lengths can be more effective if they extend beyond a minimum length of 46 m (150 ft).

WIDE RAISED MEDIANS

Curbed medians generally range in width from 1.2 to more than 30 m (4 - 100 ft). While not presenting a true barrier, wide medians can be nearly as effective since a driver would have significant difficulty attempting to drive across to the opposing lanes. The impediment becomes more formidable as the width of the median increases. A wide median, if attractively landscaped, is often the most aesthetically pleasing separation method.

Drawbacks to implementing wide raised medians include availability of sufficient right-of-way, and maintenance of surface and/or landscape. Additions such as trees, flowers and other vegetation higher than .9 m (3 ft) above the roadway can restrict the drivers' view of approaching trains. Maintenance can be expensive depending on the treatment of the median. Limitation of access can cause property owner complaints, particularly for businesses. Non-mountable curbs can increase total crash rate and severity of accidents when struck by higher speed vehicles (>64 km/h [40 mph]).[4]

NON-MOUNTABLE CURB ISLANDS

Non-mountable curb islands are typically six to nine inches in height and at least .6m (2 ft) wide, and may have reboundable, reflectorized vertical markers.

---

3 *Roadside Design Guide*. American Association of State Highway and Transportation Officials (AASHTO). Washington D.C.; 1996, www.aashto.org, 202-624-5801

4 Ibid.

Drivers have significant difficulty attempting to violate these types of islands because the six to nine inch heights cannot be easily mounted and crossed.

There are some disadvantages to be considered. The road must be wide enough to accommodate a two foot median. The increased crash potential should be evaluated. AASHTO recommends special attention be given to high visibility if such a narrow device is used in higher speed (>64 km/h [40 mph]) environments. [5] Care should be taken to assure that an errant vehicle cannot bottom-out and protrude into the oncoming traffic lane. Sight restrictions for low driver eye heights should be considered if vertical markers are installed. Access requirements should be fully evaluated, particularly allowing emergency vehicles to cross opposing lanes (but not for the purpose of circumventing the traffic control devices at the crossing). Paint and reflective beads should be applied to the curb for night visibility.

MOUNTABLE RAISED CURB SYSTEMS

Mountable raised curb systems with reboundable vertical markers present drivers with a visual impediment to crossing to the opposing traffic lane. The curbs are no more than six inches in height, less than twelve inches in width, and built with a rounded design to create minimal deflection upon impact. When used together, the mountable raised median and vertical delineators discourage passage. These systems are designed to allow emergency vehicles to cross-opposing lanes (but not for the purpose of circumventing the traffic control devices at the crossing). Usually such a system can be placed on existing roads without the need to widen them.

Because mountable curbs are made to allow emergency vehicles to cross, and are designed to deflect errant vehicles, they also are the easiest of all the barriers and separators to violate. Large, formidable vertical markers will inhibit most drivers. Care should be taken to assure that the system maintains its stability on the roadway with design traffic conditions, and that retro-reflective devices or glass beads on the top and sides of the curb are maintained for night visibility. Curb colors should be consistent with location and direction of traffic adjacent to the device.

OTHER BARRIER DEVICES

FOUR-QUADRANT TRAFFIC GATE SYSTEMS

Four-quadrant gate systems consist of a series of automatic flashing-light signals and gates where the gates extend across both the approach and

[5] *A Policy on Geometric Design of Highways and Streets.* American Association of State Highway Transportation Officials (AASHTO). 2001 Edition., available at www.ite.org, or 202-289-0222 or www.aashto.org, 202-624-5801

departure side of roadway lanes. Unlike two-quadrant gate systems, four-quadrant gates provide additional visual constraint and inhibit nearly all traffic movements over the crossing after the gates have been lowered. At this time, only a small number of four-quadrant gate systems have been installed in the U.S., and incorporate different types of designs to prevent vehicles from being trapped between the gates.

VEHICLE ARRESTING BARRIER SYSTEM - BARRIER GATE

A moveable barrier system is designed to prevent the intrusion of vehicles onto the railroad tracks at highway-rail grade crossings. The barrier devices should at least meet the evaluation criteria for a NCHRP Report 350 (Test Level 2) attenuator; [6] stopping an empty: 4500-pound pickup truck traveling at 70 km/h (43 mph). However, it could injure occupants of small vehicles during higher speed impacts, and may not be effective for heavy vehicles at lower speeds.

Two types of barrier devices have been tested and used in the U.S.; vehicle arresting barriers and safety barrier gates.

The vehicle arresting barrier (VAB) is raised and lowered by a tower lifting mechanism. The VAB in the down position consists of a flexible netting across the highway approaches that is attached to an energy absorption system. When the netting is struck, the energy absorption system dissipates the vehicle=s kinetic energy and allows it to come to a gradual stop. This device was tested at three locations in the high-speed rail corridor between Chicago, IL and St. Louis, MO.

The safety barrier gate is a movable gate designed to close a roadway temporarily at a highway-rail crossing. A housing contains electro-mechanical components that lower and raise the gate arm. The gate arm consists of three steel cables, the top and bottom of which are enclosed aluminum tubes. When the gate is in the down position the end of the gate fits into a locking assembly that is bolted to a concrete foundation. This device has been tested to safely stop a pickup truck traveling at 72 km/h (45 mph) and has been installed in Madison, WI and Santa Clara County, CA.

A barrier gate could also be applied in those situations requiring a positive barrier e.g., in a down position, closing off road traffic and opening only on demand.

---

[6] National Cooperative Highway Research Program NCHRP Report 350. *Recommended Procedures for the Safety Performance Evaluation of Highway Features.* Transportation Research Board. National Research Council. Washington, DC: 1993, contact TRB at www.trb.org.

TRAIN DETECTION SYSTEMS

WARNING TIME AND SYSTEM CREDIBILITY

Reasonable and consistent warning times re-enforce system credibility. Unreasonable or inconsistent warning times may encourage undesirable driver behavior. Research has shown when warning times exceed 40-50 seconds, drivers will accept shorter clearance times at flashing lights, and a significant number will attempt to drive around gates.[7] Although mandated maximum warning times do not yet exist, efforts should be made to ensure traffic interruptions are reasonable and consistent without compromising the intended safety function of an active control device system's design. Excessive warning times are generally associated with a permanent reduction in the class of track and/or train speeds without a concomitant change in the track circuitry and without constant warning time equipment. When not using constant warning train detection systems, track approach circuits should be adjusted accordingly when train speeds are permanently reduced. Another frequent cause of excessive warning times at crossings without constant warning time equipment is variable speed trains, e.g., inter-city passenger trains or fast commuter trains interspersed with slower freight trains.

A major factor affecting system credibility is an unusual number of false activations at active crossings. Every effort should be made to minimize false activations through improvements in track circuitry, train detection equipment, and maintenance practices. A timely response to a system malfunction coupled with repairs made without undue delay can reduce credibility issues. Remote monitoring devices are an important tool.

Joint study and evaluation is needed between the highway agency and railroad to make a proper selection of the appropriate train detection system.

Train detection systems are designed to provide the minimum warning time for a crossing. In general, the MUTCD states that the system should provide for a minimum of 20 seconds warning time. When determining if the minimum 20 seconds warning time should be increased, the following factors should be considered:

- track clearance distances due to multiple tracks and/or angled crossings; (add one second for each 3 m [10 ft] of added crossing length in excess of 10.7 m [35 ft]);
- the crossing is located within close proximity of a highway intersection controlled by STOP signs where vehicles have a tendency of stopping on the crossing;

---

[7] *Warning Time Requirements at Railroad-Highway Grade Crossings with Active Traffic Control.* Report No. FHWA SA-91-007, Federal Highway Administration. Washington, DC: February 1991, www.fhwa.dot.gov.