FEDERAL-AID RAILROAD-HIGHWAY
GRADE CROSSING PROGRAM

Use of a Benefit-Cost Ratio to Prioritize Projects for Funding

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Office of Rail Transportation
Modal Division
Iowa Department of Transportation

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Note: *The Iowa Department of Transportation prefers to use the term "crash" to refer to a collision involving a motor vehicle. However, throughout this report, the term "accident" is used in lieu of "crash" to be consistent with the reference material, historically used formulas and Federal Railroad Administration's source data.*

Executive Summary

The Iowa Department of Transportation (Iowa DOT) administers the Federal-Aid Railroad-Highway Grade Crossing Program for the State of Iowa.

The purpose of the Federal-Aid Railroad-Highway Grade Crossing Program is to eliminate hazards to vehicles and pedestrians at existing railroad crossings. This program is authorized by Title 23, United States Code, Section 130 (23 U.S.C. 130).

In Iowa, funding is application-based, and railroad and highway jurisdictions are eligible to submit applications. From the applications submitted, the Iowa DOT currently selects projects for funding using a two-tiered process, giving top priority to those projects with a predicted-accident calculation that equals or exceeds .075.

The Iowa DOT reviewed the existing selection process seeking a more sophisticated benefit-cost ratio calculation that would result in a more effective method of selecting projects for funding. As a result of the review, the Iowa DOT will use a benefit-cost ratio to prioritize projects competing for funding in the fall of 2006 (projects to be constructed in 2008).

The benefit-cost ratio calculation moves beyond a measure of the predicted accidents at a crossing to a calculation that allows the Iowa DOT to maximize the public benefit in relationship to the public investment. The Iowa DOT's use of the benefit-cost ratio to prioritize projects for selection is projected to result in five fewer fatalities and an increased safety benefit that totals nearly $10 million, over a 10-year period.

Current Application Selection Process

The Iowa DOT's Office of Rail Transportation administers the Federal-Aid Railroad-Highway Grade Crossing Program for the State of Iowa. Iowa does not have regulatory authority over crossing-safety improvements, except for the 185 crossings on the state's Primary Highway System. Consequently, the Iowa DOT uses an application-based system to select projects that will receive funding through the Federal-Aid Railroad-Highway Grade Crossing Program.

Applications are accepted throughout the year, and those received by August 1 are reviewed for potential funding. Selected projects are funded for preliminary engineering in the next fiscal year with funding for construction in the following calendar year. The appropriate highway authority or railroad may submit an application. A 10 percent match is required by either party or jointly. Unfunded applications remain active for consideration in future years.

Selection of projects for funding has historically used a two-tiered process.

1. Applications which include a predicted-accident (PA) calculation equal to or higher than .075 receive first priority for funding. The PA calculation, developed by the Federal Railroad Administration (FRA), computes the expected number of accidents at crossings based on information available in the grade-crossing inventory and accident history.

2. If funding is available after selection of projects with a qualifying PA, the applications are further ranked by dividing the estimated cost of the improvement by an exposure index[1]. This calculation encourages the completion of low-cost projects.

The current selection process is flexible and allows additional consideration for statewide initiatives and crossings with special circumstances, such as sight restrictions, increasing traffic density, rail passenger traffic, etc.

The current selection process does not take into consideration several significant factors.

- The risk of an accident at a crossing is identified by the PA, but a minor property damage incident and a fatal accident are weighted the same way in the formula. At any particular crossing there is the danger of an accident, but the unique combination of vehicle/train traffic and physical characteristics of a crossing make some crossings more likely to have accidents of a more serious nature.
- Any particular improvement at a crossing will increase the safety, but the effectiveness varies for different types of improvements. For example, adding lights at a passive crossing increases the safety; however, if both lights and gates are added to that same passive crossing, the effectiveness of that improvement would be far greater.
- The cost of improvements at crossings varies widely. Using the PA alone makes no distinction between a high-cost improvement that has limited effectiveness and a lower cost improvement that is very effective.

The Iowa DOT undertook a review of this selection process to determine if a methodology could be developed that would adequately address these deficiencies. As stewards of public funds, a methodology that more specifically targets funding to those projects that have the highest safety benefit, in relationship to the public investment, was the overriding goal.

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[1] The exposure index used in the second tier of the current selection process is a different calculation than the exposure calculation included as a portion of the predicted-accident calculation. See Appendix A for a definition of the exposure index calculation.

To achieve that goal, the Iowa DOT:

- examined, in detail, the current predicted-accident (PA) calculation to determine its strengths and weaknesses;
- evaluated how various factors affect the PA calculation (Appendix B includes a brief synopsis of the lessons learned from this analysis);
- reviewed pertinent literature; and
- studied the selection processes used by other states.

The Iowa DOT developed a new methodology for prioritizing future projects for federal-aid funding. The balance of this report details the newly developed benefit-cost ratio calculation approach.

Benefit-Cost Ratio Calculation in Brief

The benefit-cost ratio calculation (B-C) consists of seven steps. The specific calculations are fully detailed in the next section of this report, but in brief include the following steps.

Step 1: **Calculate exposure** (used as a variable in the predicted-accident calculation)

- The exposure calculation uses train traffic, annual average daily traffic counts and a time-of-day index to quantify the probability of a highway-railroad conflict at a crossing.
- The exposure calculation is adapted from *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration[2].

Step 2: **Calculate predicted accidents**

- The number of predicted accidents at a crossing is calculated by using the exposure calculation from Step 1, a number of train-movement factors, roadway and crossing characteristics, and type of crossing protection. An adjustment factor is applied to take into account the accident history at the crossing.
- The predicted-accident calculation is derived from *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration.

Step 3: **Calculate the severity**

- The severity calculation uses the number of train movements and environment factors associated with the crossing to further refine the number of predicted accidents and project the number of accidents that will involve fatalities, injuries and property damage at a crossing.
- The severity calculation is adapted from *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration.

Step 4: **Calculate the societal cost**

- Using Iowa's historical accident data, fatality and injury rates were calculated.
- The cost to society of a fatality, injury or property damage was determined.
- The fatality and injury rates and societal costs are used to calculate the total cost to society for accidents of varying severities.
- The total cost to society for each type of accident is multiplied by the number of each type of accident projected at a crossing.
- The societal cost is a modification of the methodology used by the Iowa Department of Transportation's Office of Traffic Safety to determine societal costs for highway crashes.

Step 5: **Calculate benefit**

- In determining the benefit of the improvement, the societal cost is adjusted to reflect the projected benefit of the proposed improvement. An effectiveness factor estimates the accident reduction that would occur as a direct result of the proposed improvement. The societal cost is multiplied by the effectiveness factor and the assumed lifespan of the improvement to derive the lifespan benefit in dollars.
- The effectiveness factor is a modification of that included in *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration.

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[2] The calculations in *Reference Manual for GradeDec 2000, version 2.0* were in large part based on an earlier study, *Summary of the DOT Rail-Highway Crossing Resource Allocation Procedure – Revised*, Edwin Farr, June 1987

Step 6: **Calculate cost**

- The cost is the estimated improvement cost, as supplied on the funding application. If the proposed improvement involves upgrading from a passive to an active crossing, the public share of the cost of the average annual signal maintenance (see Appendix C), calculated over the assumed lifespan of the improvement, is included in the calculation.

Step 7: **Calculate the benefit-cost ratio**

- The benefit-cost ratio is calculated by dividing the benefit by the cost.

Benefit-Cost Ratio Calculation in Detail

Step 1 - Calculate Exposure

The exposure calculation, as in the past, is based upon the AADT (Average Annual Daily Traffic) times the number of daily trains. The value has been refined to account for the time of day. The purpose of this is to better reflect the probability of highway-railroad traffic conflict. For example, a train that only operates during daylight hours could not collide with a motor vehicle using the crossing at night. To make this calculation two values must be used: (1) a constant with the value of 1.35; and (2) the variable EF (time-of-day exposure correlation factor). If the grade crossing inventory includes only a "Total Train" value, an equal time distribution will be assumed.

EF =

[(% of AADT between 12:00 AM and 6:00 AM) * (% of TRAINS between 12:00 AM and 6:00 AM)]
+ [(% of AADT between 6:00 AM and 12:00 PM) * (% of TRAINS between 6:00 AM and 12:00 PM)]
+ [(% of AADT between 12:00 PM and 6:00 PM) * (% of TRAINS between 12:00 PM and 6:00 PM)]
+ [(% of AADT between 6:00 PM and 12:00 AM) * (% of TRAINS between 6:00 PM and 12:00 AM)]

divided by the GREATER of

[(% of AADT between 12:00 AM and 6:00 AM)^2 + (% of AADT between 6:00 AM and 12:00 PM)^2]
+ [(% of AADT between 12:00 PM and 6:00 PM)^2 + (% of AADT between 6:00 PM and 12:00 AM)^2]

OR

[(% of TRAINS between 12:00 AM and 6:00 AM)^2 + (% of TRAINS between 6:00 AM and 12:00 PM)^2]
+ [(% of TRAINS between 12:00 PM and 6:00 PM)^2 + (% of TRAINS between 6:00 PM and 12:00 AM)^2]

EXPOSURE = (1.35 * EF) * AADT * Total Trains

Step 2 - Calculate Predicted Accidents

The calculation for predicted accidents (PA) remains the same as it has been in the past. The exposure value has been modified as described in Step 1. The adjustment to the PA for accident history also remains unchanged. This calculation uses a mathematical constant, *e*, the natural logarithmic base, which is equal to 2.71828. The paved variable equals two, if the crossing is on a dirt or gravel road; and one, if on a paved road. The calculation varies slightly depending on the type of existing crossing protection as detailed below.

<u>Passive Crossings</u>

Predicted Accidents (PA) $= 0.0006938 * [(\text{Exposure}+0.2)/0.2]^{0.37} * [(\text{DayThruTrains}+0.2)/0.2]^{0.1781} * e^{(0.0077*\text{MaxTimeTable})} * e^{[-0.5966*(\text{Paved}-1)]}$

Adjustment of Predicted Accidents $= \dfrac{(\{PA * [1/(0.05+\text{Predicted Accidents})]\}+\text{Number of Accidents in the Last 5 Years})}{\{[1/(0.05+\text{Predicted Accidents})]+5\}} * 0.65$

<u>Flashing Lights</u>

Predicted Accidents (PA) $= 0.0003351 * [(\text{Exposure}+0.2)/0.2]^{0.4106} * [(\text{DayThruTrains}+0.2)/0.2]^{0.1131} * e^{(0.1917*\text{NumberofTracks})} * e^{[0.1826*(\text{Lanes}-1)]}$

Adjustment of Predicted Accidents $= \dfrac{(\{PA * [1/(0.05+\text{Predicted Accidents})]\}+\text{Number of Accidents in the Last 5 Years})}{\{[1/(0.05+\text{Predicted Accidents})]+5\}} * 0.5001$

<u>Lights and Gates</u>

Predicted Accidents (PA) $= 0.0005745 * [(\text{Exposure}+0.2)/0.2]^{0.2942} * [(\text{DayThruTrains}+0.2)/0.2]^{0.1781} * e^{(0.1512*\text{NumberofTracks})} * e^{[0.142*(\text{Lanes}-1)]}$

Adjustment of Predicted Accidents $= \dfrac{(\{PA * [1/(0.05+\text{Predicted Accidents})]\}+\text{Number of Accidents in the Last 5 Years})}{\{[1/(0.05+\text{Predicted Accidents})]+5\}} * 0.5725$

Step 3 - Calculate Severity

The severity calculation is a new enhancement. Using the train speed, number of tracks, number of through trains, number of switching trains and type of location (rural or urban), the probability of a fatal accident or a casualty accident can be projected. The predicted accidents remain the same, so the probability of an injury accident is the casualty accidents minus the fatal accidents. The probability of property damage-only accidents is the predicted accidents minus the casualty accidents.

$$\textbf{Predicted Fatal Accidents} = \frac{\text{Adjusted Predicted Accidents}}{1 + [440.9 * (\text{MaxTimeTable}^{-0.9931}) * (\text{ThruTrains}+1)^{-0.0873} * (\text{Switches}+1)^{0.0872} * e^{(0.3571*\text{Urban})}]}$$

$$\textbf{Predicted Casualty Accidents} = \frac{\text{Adjusted Predicted Accidents}}{1 + [4.481 * (\text{MaxTimeTable}^{-0.343}) * (e^{(0.1153*\text{NumberofTracks})}) * e^{(0.2960*\text{Urban})}]}$$

Predicted Injury Accidents = Predicted Casualty Accidents – Predicted Fatal Accidents

Predicted Property Accidents = Adjusted Predicted Accidents – Predicted Casualty Accidents

Step 4 – Calculate the Societal Cost of Accidents

The fatality and injury rates were calculated using the Federal Railroad Administration's Highway-Railroad Grade Crossing Accident/Incident Data for Iowa from 1977 to 2004. All non-casualty accidents are assumed to have damage to a single vehicle. The fatality and injury rates are:

	Fatalities	Injuries	Property Damage Only (PDO)
Average per Fatal Accident	1.6	1.0	1.0
Average per Injury Accident	0.0	1.3	1.0

A societal cost was determined for each type of accident as shown in the following table.

Accident Type	Societal Cost
Fatality	$1,000,000
Injury	$320,000
Property Damage	$26,000

These values were adapted from the methodology used by the Iowa DOT's Office of Traffic Safety.

- **Fatalities -** The rail program will be using the same societal cost for a fatality used in the highway crash methodology ($1,000,000.)
- **Injuries** - The highway crash methodology uses a value of $160,000 per injury. The highway crash methodology averages the cost of a large number of relatively minor highway crashes, as well as those that are more critical. The DOT's Office of Rail Transportation believes that injuries sustained in a highway-railroad accident are likely to be more severe on average, than those sustained solely on the highway system. For purposes of this calculation, the value used in the highway crash methodology was doubled to $320,000 for highway-railroad accidents.
- **Property Damage -** The highway crash methodology uses a value of $26,000 for property damage associated with a highway intersection crash that typically involves multiple vehicles. Damage at a highway-railroad crossing is likely to involve only a single motor vehicle, but that damage is likely to be more severe than that at a highway intersection, so the Office of Rail Transportation chose to retain the same value as that used for a highway intersection crash ($26,000).

Using the societal costs of an accident and the fatality/injury rates, the annual societal cost is calculated for each type of accident.

	Fatalities	**Injuries**	**Property Damage Only**	**Total Cost per Accident**
Average per Fatal Accident	1.6	1.0	1.0	
	$1,000,000	$320,000	$26,000	
	$1,600,000	$320,000	$26,000	$1,946,000
Average per Injury Accident	0.00	1.3	1.00	
	$1,000,000	$320,000	$26,000	
	$0	$416,000	$26,000	$442,000

Every accident is assumed to involve property damage valued at $26,000.

Annual Societal Cost = (Predicted Fatal*$1,946,000) + (Predicted Injury * $442,000) + $26,000

Step 5 – Calculate the Benefit

The benefit for a crossing upgrade is defined as the "societal cost" multiplied by the reduction in accident rate at the crossing expected from the proposed improvement. The reduction in accident rate is the effectiveness factor. This calculation is multiplied by the expected life of the improvement to determine a lifetime benefit. For purposes of this calculation, the life span of any crossing improvement is assumed to be 25 years.

The effectiveness values were derived from *Summary of the DOT Rail-Highway Crossing Resource Allocation Procedure – Revised*, Edwin Farr, 1987, (also included in *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration), with some modifications by the Iowa DOT. Since the publication of Farr's 1987 report, improvements in circuitry, in particular the more common use of constant warning time, have taken place. The effectiveness values were modified by the Iowa DOT to account for these changes, as shown in the following table.

	Ten or Fewer Trains Per Day		***More than 10 Trains Per Day***	
Proposed Improvement	**Single Track**	**Multiple Tracks**	**Single Track**	**Multiple Tracks**
Passive to flashing lights	75%	65%	60%	55%
Passive to lights and gates	90%	85%	80%	80%
Flashing lights (with accidents in past five years) to gates and constant warning time (CWT)*	90%	65%	70%	65%
Flashing lights (with accidents in past five years) to gates*	65%	50%	50%	45%
Flashing lights (no accidents in past five years) to gates and CWT*	50%	50%	50%	60%
Flashing lights (no accidents in past five years) to gates*	40%	40%	40%	45%
Upgrade to CWT*	25%	25%	25%	25%
Median at crossings with gates	80%	80%	80%	80%

* Effectiveness values modified by Iowa DOT

Therefore the benefit calculation is:

Benefit = Annual Societal Cost * effectiveness factor * 25 (the longevity of the crossing upgrade)

Step 6: Calculate Project Cost

The estimated project cost of the improvement as supplied on the application (based on the specifics of the crossing improvement) will be used in the calculation for funding determination. If the improvement is an upgrade from a passive crossing to an active crossing, the public cost of the signal maintenance over the assumed life of the crossing is included (currently calculated at $1850 annually - See Appendix C). A 25-year life span for the improvement is assumed.

Improvement from a Passive to Active crossing: **Cost** = improvement cost + (annual maintenance cost*25)

Improvements to Active Crossing: **Cost** = improvement cost

Step 7: Calculate the Benefit-Cost Ratio

The earlier calculations resulted in a single value that quantifies the benefits of an improvement, taking a large number of factors into consideration. Likewise, a single cost has been determined. The "benefit-cost ratio" is simply the ratio between these two values.

Benefit-cost ratio = benefit/cost

Project Selection Process for Future Federal-Aid Funding

The benefit-cost ratio calculation methodology outlined in this document will replace the current method of application selection for federal-aid crossing safety projects beginning in the fall of 2006 (for projects slated for construction in 2008). The benefit-cost ratio will be calculated for each project application. Applications will be ranked from those with the highest benefit-cost ratio to those with the lowest. The estimated project cost included on the funding application will be used in the analysis.

Flexibility will be retained to allow consideration for statewide initiatives or projects that exhibit other characteristics or safety deficiencies that are not reflected in the benefit-cost ratio. These could include sight obstructions, rail passenger traffic or unique physical characteristics of the crossing that lead to motorist confusion or errors in judgment. A site review, in conjunction with the benefit-cost ranking, will be used to document and assess those unique characteristics that may warrant special consideration.

The impacts of the change in the selection process include the following.

1. **The use of the benefit-cost ratio in the selection process will allow the Iowa DOT to target crossing improvements toward those crossings that are more likely to have a fatal accident.**

   The use of "predicted accident" in the past to prioritize projects for crossing improvements was effective in targeting crossings that were likely to have an accident, but did not provide any weighting for the type of accident. There is a significant difference in the impact and cost to society between a property damage accident and one that results in a fatality.

   By including a calculation of the expected severity of an accident at the crossing, the benefit-cost ratio gives priority to those crossings that are the most likely to experience casualties.

2. **The use of the benefit-cost ratio in the selection process yields a greater benefit for the same expenditure of public funds.**

   The use of a benefit-cost ratio will allow the Iowa DOT to determine where limited funding can best be spent to generate the most public benefits. By better targeting those crossings that are more likely to result in a fatality (which carries higher societal costs), and factoring in the cost and effectiveness of the improvement, the funding will be utilized in a way that generates greater safety benefits for each dollar spent.

   The use of the benefit-cost ratio in project selection is projected over a 10-year period to reduce fatalities by five and yield increased benefits of nearly $10 million.

   Figure 1 (next page) shows the accidents projected out to 2015, in two different ways:

   - projected accidents, injuries and fatalities, if improvements were selected for funding using the benefit-cost ratio; and
   - projected accidents, injuries and fatalities, if improvements were selected for funding using the current selection process.

   Note that the number of accidents and injuries are similar, but five fewer fatalities are projected with improvements selected using the benefit-cost ratio.

Figure 1

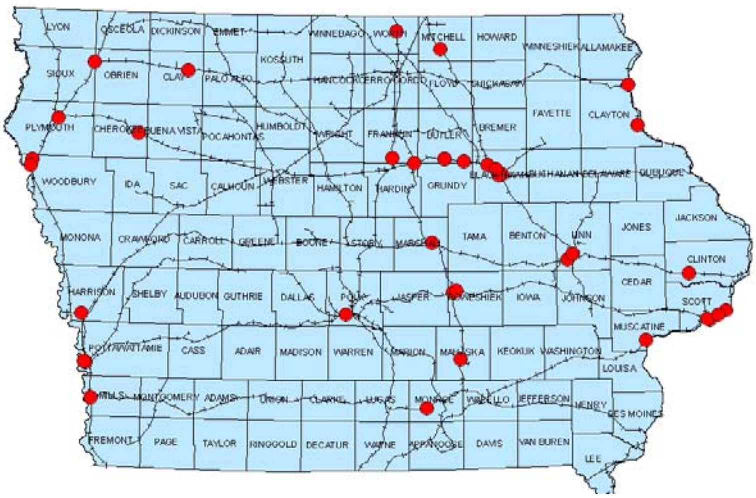
Year	Benefit-cost Ratio System			Current System		
	Accidents	Fatalities	Injuries	Accidents	Fatalities	Injuries
2005	65	8	25	65	8	25
2006	65	8	25	65	8	25
2007	62	8	24	62	8	24
2008	61	7	23	60	8	23
2009	59	7	22	58	8	22
2010	58	7	22	57	7	22
2011	57	7	21	56	7	21
2012	56	7	21	55	7	21
2013	55	6	20	54	7	20
2014	54	6	20	53	7	20
2015	53	6	20	52	7	20
10-Year Projection (2006-2015)	**645**	**77**	**243**	**637**	**82**	**243**

3. **Selection of projects for funding using the benefit-cost ratio will change the character of those projects that receive priority consideration for funding by identifying those projects where the most public benefit is gained in relationship to the public cost. Good projects that were not considered in the past will now be funding candidates.**

   Figures 2 and 3 on the next page illustrate the potential pool of applicants that have a favorable benefit-cost ratio. The calculations for these maps use the “average improvement costs” (see table in Appendix C), which may vary considerably from the estimated costs included in an application due to the unique characteristics of an improvement.

Figure 2 shows those crossings that currently are eligible for funding with a PA that is equal to or greater than .075. Using the "average improvement costs" (see table in Appendix C), all of the crossings in Figure 2 ***also*** have a positive benefit in relationship to cost (a B-C greater than 1).

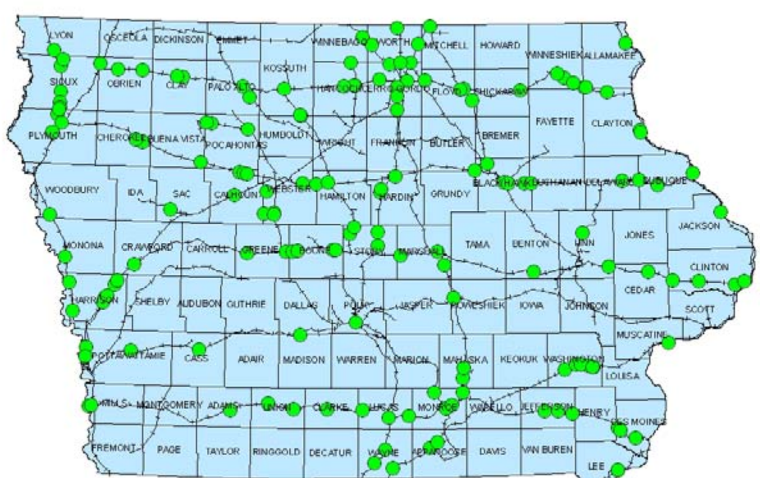
Figure 2



PA > .075 and Benefit-Cost Ratio > 1

Figure 3 illustrates the crossings that are not currently funding candidates (a PA less than .075) that have a positive benefit in relationship to cost (a B-C greater than 1) using the "average improvement costs" (see table in Appendix C).

Figure 3

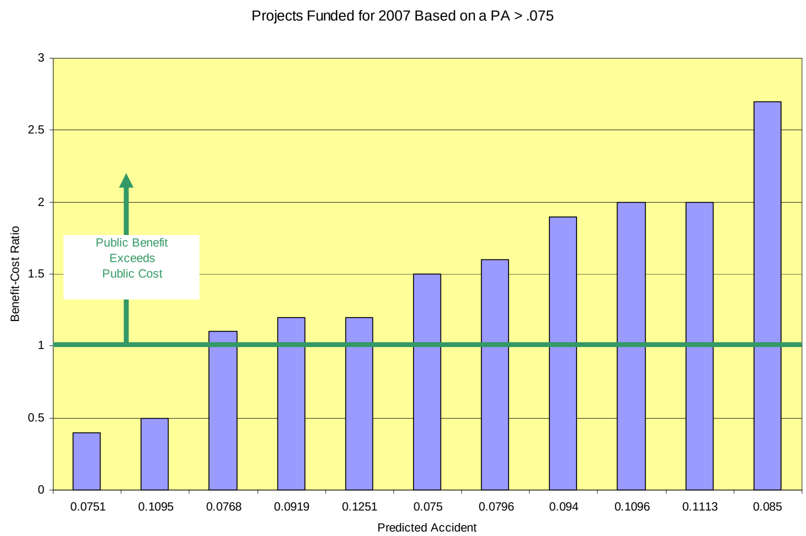


PA < .075 and Benefit-Cost Ratio > 1

Average improvement costs can vary significantly from the estimated cost of an improvement included on an application due to the unique physical characteristics at a crossing. Figure 4 illustrates a more "real-life" scenario. The benefit-cost ratio was calculated for those projects selected for funding in FY2007 that qualified based on having a PA equal to or greater than .075.

Most of the projects have a positive benefit-cost ratio, where benefits exceed cost. The probability of these projects being funded under the new selection process would depend upon where they fell within the overall priority list. Note that two projects selected for funding in 2007 show a negative cost-benefit ratio, where public cost exceeds public benefit. Though these potential projects would be prioritized with all others, it is very unlikely that these would be funded under the new process since they do not appear to be cost effective.

Figure 4



Figures 5 and 6 on the next page illustrate the number of crossings by type, where improvement benefits would outweigh costs (i.e. that have a benefit-cost ratio of 1 or greater) assuming the average cost of an improvement (see table in Appendix C).

- Figure 5 indicates that over 200 passive crossings would have positive benefits, if upgraded to flashing lights and gates.
- Figure 6 indicates that nearly 200 crossings with existing flashing lights would have a positive benefit, if upgraded to include gates.

Figure 5

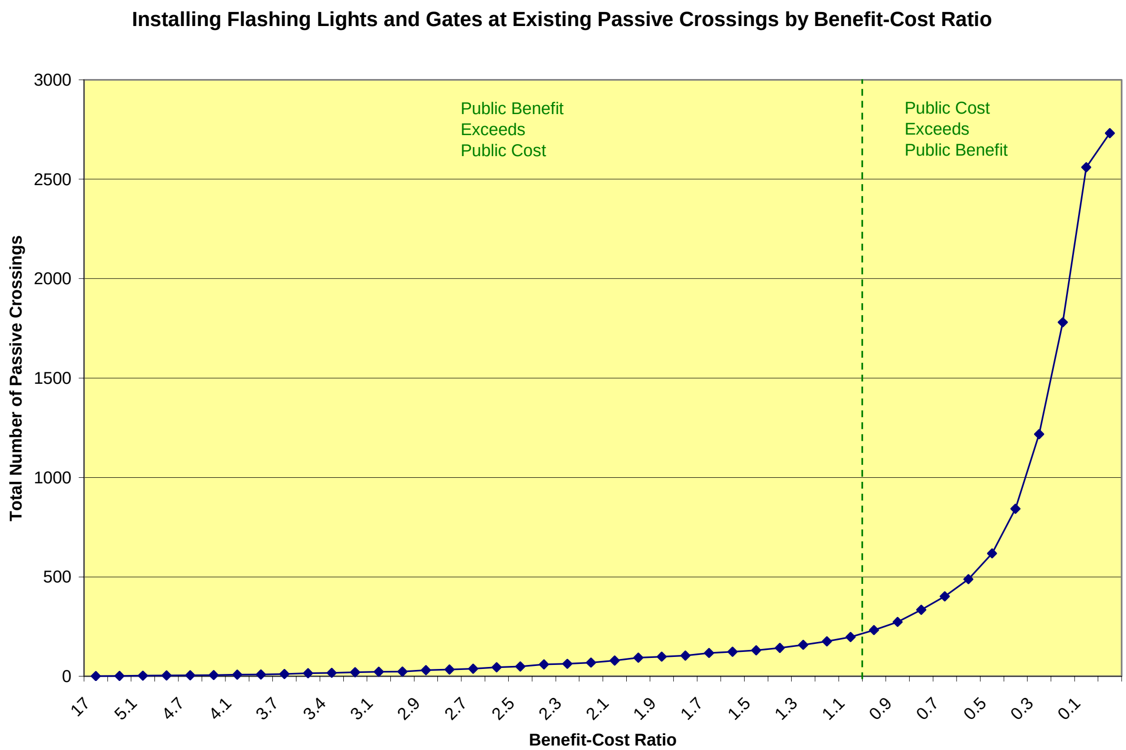
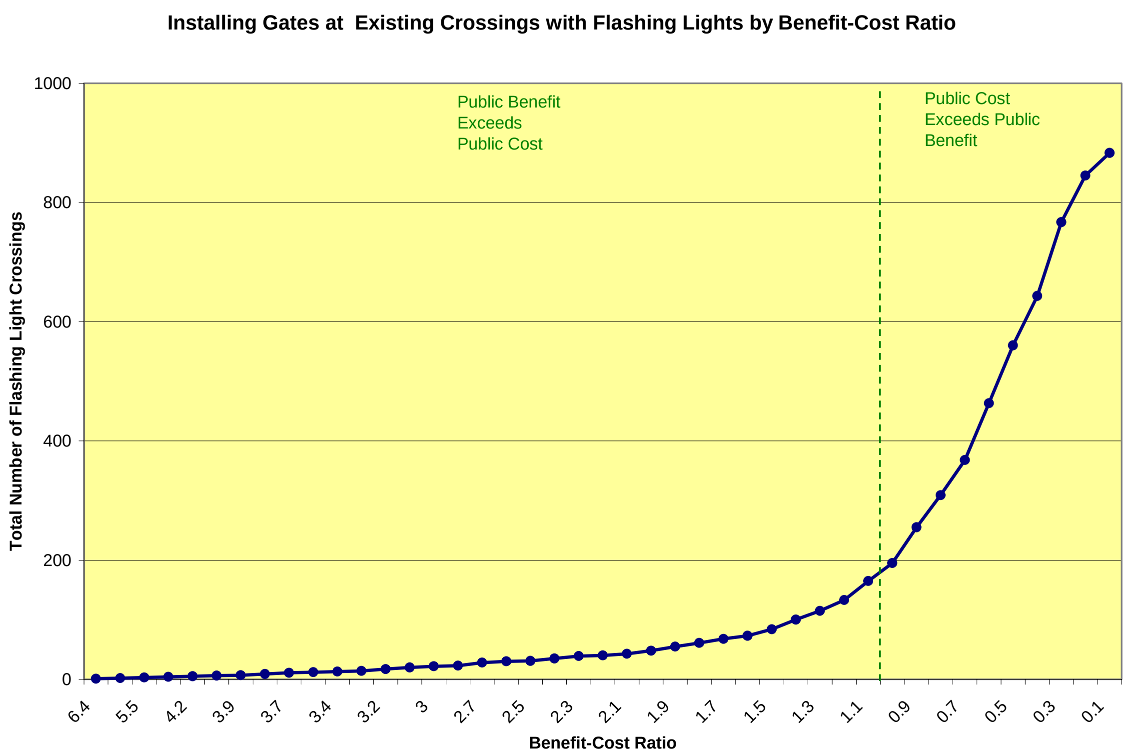


Figure 6



Appendix A – Definitions

Accident data – see U.S. DOT's Highway-Railroad Grade-Crossing Accident/Incident Data

Annual average daily traffic (AADT) – traffic counts obtained on Iowa's streets and highways by Iowa DOT's Office of Transportation Data using a series of traffic counters

Benefit-cost ratio (B-C) – a ratio derived from dividing identified and quantifiable benefits by the estimated project cost

Casualty – an injury or death

Accident history – a record of accidents at highway-railroad grade crossings obtained from the U.S. DOT's Highway-Railroad Grade-Crossing Accident/Incident Data, which is maintained by the Federal Railroad Administration

Crossing – see highway-rail grade crossing

DOT's accident and severity prediction formula (PA) – commonly called "predicted accident"; a formula developed by the Federal Railroad Administration to compute the expected number of accidents at crossings based on information available in the grade-crossing inventory and crossing accident data files. The formula utilizes five years of accident history at the crossing, highway and train traffic, number of through trains per day, maximum timetable train speed, number of main tracks through crossing, highway paved (yes or no), and number of highway lanes. (More information may be found in the August 1987 FRA/FHWA User's Guide, Third Edition, "Rail-Highway Crossing Resource Allocation Procedure".)

Exposure index – a method of measuring the conflict of highway traffic with train traffic at highway-railroad grade crossings for developing accident rates; the formula takes into account the number of trains, crossing angle, maximum train speed, and number of tracks; the exposure index is calculated as follows:

Calculating the Exposure Index

Trains = ((day through + night through) + ((day switch * 0.5) + (night switch * 0.5)))
If trains = 0, assign 0.5 to trains

If crossing angle < 30, then AF = 2
If crossing angle > 29 and angled < 60, then AF = 1.2
If crossing angle > 59, then AF = 1

If typical maximum speed > 59, then SF = 1
If typical maximum speed < 60 and speed > 39, then SF = 0.9
If typical maximum speed < 40 and speed > 24, then SF = 0.8
If typical maximum speed < 25, then SF = 0.7

If main tracks > 1, then RF = 1
If main tracks = 1 and other tracks > 0, then RF = 0.85
If main tracks = 1 and other tracks = 0, then RF = 0.8
If main tracks = 0 and other tracks > 0, then RF = 0.75

Exposure = ((Trains * AADT) * AF * SF *RF)

Grade-crossing inventory – see U.S. DOT/AAR National Highway-Railroad Crossing Inventory

GradeDec **(GD)** - a highway-rail crossing investment analysis tool developed by the Federal Railroad Administration to provide a full set of standard benefit-cost metrics for a rail corridor, region or an individual crossing; the calculations in *GradeDec* were in large part based on an earlier study, *Summary of the DOT Rail-Highway Crossing Resource Allocation Procedure – Revised*, Edwin Farr, June 1987

Highway crash – a collision that does not involve on-track railroad equipment

Highway-railroad grade crossing – a location where a public highway, road, street or private roadway, including associated sidewalks and pathways, crosses one or more railroad tracks at the same grade

Highway-railroad grade-crossing accident - an impact between on-track railroad equipment and a highway user at a designated crossing site; sidewalks, pathways, shoulders, and ditches associated with the crossing are considered to be part of the crossing site; the term "highway user" includes automobiles, trucks, buses, motorcycles, and other types of motor vehicles, bicyclists, pedestrians, and all other modes of surface transportation

Inventory – see U.S. DOT/AAR National Highway-Railroad Crossing Inventory

Passive traffic control device – those types of traffic control devices, including signs, markings and other devices, located at or in advance of grade crossings to indicate the presence of a crossing, but which do not change aspect upon the approach or presence of a train

Predicted accident (PA) – see DOT's accident and severity prediction formula

U.S. DOT/AAR National Highway-Railroad Crossing Inventory – an inventory of all highway-railroad crossings that is maintained by the Federal Railroad Administration, an agency within the United Stated Department of Transportation; crossing inventory data is updated by the railroads and state agencies responsible for rail transportation

U.S. DOT's Highway-Railroad Grade-Crossing Accident/Incident Data - a database of all rail-related accidents or incidents, including highway-rail crossing accidents, maintained by the Federal Railroad Administration; accidents are self-reported by the railroad(s) involved in an incident

Appendix B - Lessons Learned About the Predicted-Accident Calculation (PA)

The benefit-cost ratio uses as a portion of the calculation the “predicted-accident” calculation. As a preface to developing a revised project selection process, the Iowa DOT undertook an analysis of the PA to better understand the factors included in the calculation and their influence on the outcome.

Projected increase in AADT
The AADT in Iowa is expected to see only modest growth from 1.494 percent per year over the next 20 years[3].

The projected growth in the AADT is not expected to have enough impact to significantly increase the value of the PA or increase projected accident rates.

Train speed
Higher train speeds increase the probability of a casualty when an accident occurs at a crossing.

The predicted accident formula uses train speed as a factor only at passive crossings, despite having an impact on the casualty rate at all crossings.

Increase in number of trains
It is not an increase in the number of trains, but the percentage of the increase in train traffic that is most significant. For example, if the train numbers are low and subsequently double, the PA is very sensitive to this change (example four to eight trains per day). However, on rail lines with 40 to 60 trains a day, an increase of four trains per day has a relatively low impact on the PA.

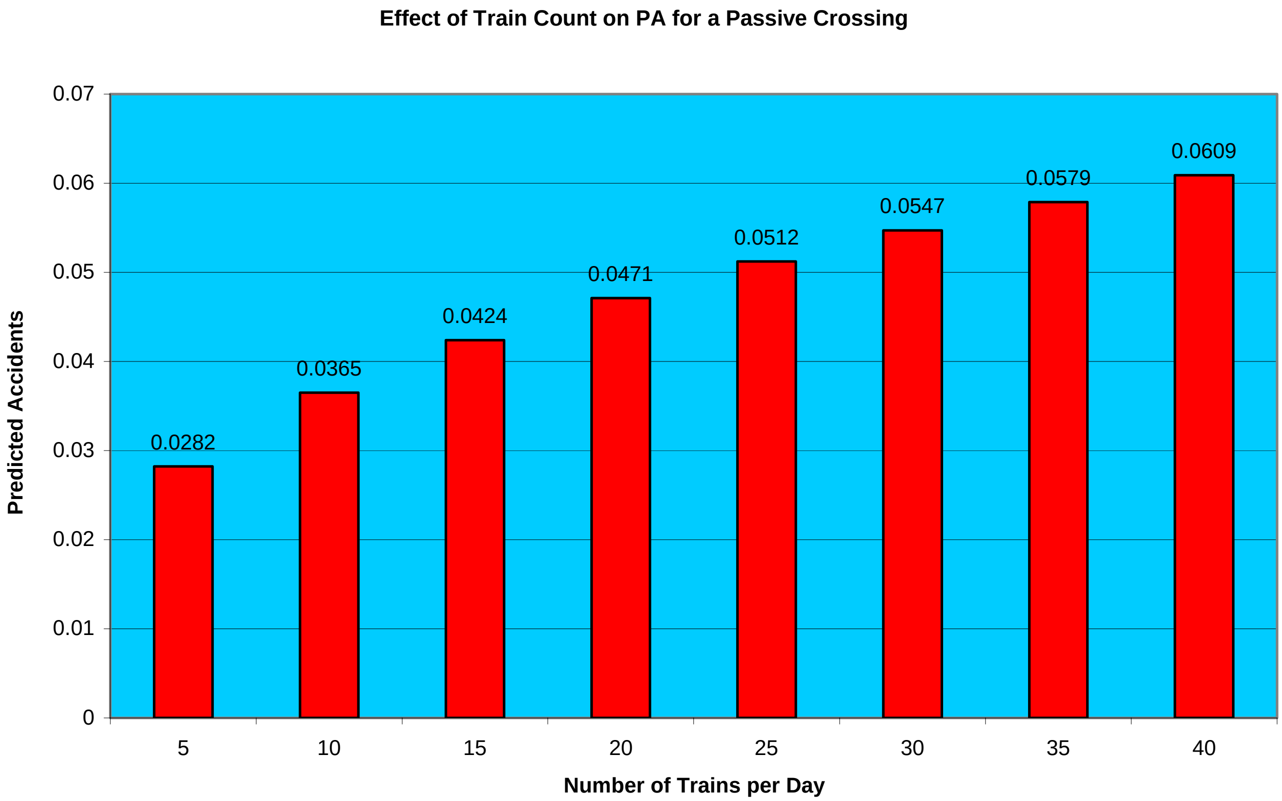
Whereas, the AADT for the most part experiences gradual growth, the increase in train traffic is more subject to sudden and abrupt changes, i.e. as the result of a new or expanded industry, routing changes, etc.

Proper calculation of the PA and newly developed benefit-cost ratio (which includes the PA calculation) is highly dependent on accurate train traffic data in the grade-crossing inventory.

Figure 7 on the next page illustrates the impact on the PA when train counts are increased at a theoretical, typical Iowa passive crossing (mid-range AADT and no history of accidents).

3 The increase experienced in the past five years in the AADT was used to project traffic counts 20 years into the future.

Figure 7



Severity of highway-rail accidents

A comparison of the Iowa accidents that occur on the highway system, and those that occur at highway-railroad crossings for the years 1988 through 1998 showed a:

- 33.2 percent casualty rate for highway accidents;
- 32.6 percent casualty rate for highway-railroad accidents;
- 0.6 percent fatality rate for highway accidents; and
- 6 percent fatality rate for highway-railroad accidents.

Although casualty rates were very similar for highway and highway-railroad accidents, the fatality rate for highway-railroad accidents was 10 times higher than that of highway accidents.

Appendix C – Average Improvement Costs

The following average improvement costs were used in the data analysis as the Iowa DOT examined different methods and ways in which to include the costs of improvements in the selection process.

The table below includes the public cost of maintaining a signal system over 25 years (currently calculated at $1,850 per year), if the improvement is from a passive device to an active device.

Average Improvement Costs

Existing Protection	Improvement	Single Track	Multiple Tracks	Maintenance
Passive	Flashing lights	$95,000	$110,000	$46,250
Passive	Lights and gates	$130,000	$180,000	$46,250
Flashing lights	Lights and gates	$90,000	$105,000	
Lights and gates	Add median	$65,000	$65,000	

The calculation of the benefit-cost ratio for funding purposes will use the estimated cost of the improvement, as supplied on the application, rather than these average improvement costs.