

THE EFFECTS OF TRAIN DELAY ON CROSSING-DIAMOND ECONOMICS

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Summary

An economic study of crossing diamonds at the Transportation Technology Center indicates that development of improved-performance designs which eliminate speed restrictions and reduce train delays over these track components is desirable. The findings and analysis tools developed under the Advanced Crossing Diamond Research Project project will be used to evaluate and develop improved-performance crossing-diamond designs for Association of American Railroads members.

The most beneficial improvement to existing crossing diamonds would be to eliminate speed restrictions, which are currently in effect over most high-angle diamonds in mainline service. Most existing diamond designs cannot withstand the impact loadings of up to three or four times static wheel loads developed at speeds above 40 mph. These train-delay costs are conservatively estimated to be between \$300 and \$400 million annually.

Train-delay costs are a significant factor for most mainline crossing diamonds. These costs may be larger than installation or maintenance for heavy-usage diamonds with speed restrictions. The train-delay costs consist of train time and fuel, with fuel dominating. These costs can be as high as \$500 to \$1,500 per million gross ton. An economic analysis model for crossing diamonds was developed for the study. The model accounts for the costs associated with installation, maintenance and train operations over a crossing diamond. The model uses life-cycle costing to allow evaluation of several crossing-diamond types at a given location and provides guidance to select the most economical.

The best types of crossing diamonds for given applications vary with the tonnage levels and speeds of trains on those routes. The flange-bearing frog (FBF) concept, even with a cost premium over conventional diamonds, may be viable for a wide range of locations. The benefits of FBFs are the reduction of impact forces through the elimination of unsupported flangeway gaps on high-angle diamonds. Thus FBFs may be operated at track speed, greatly reducing train-delay costs.



Suggested Distribution:

- Train Handling
- Maintenance of Way
- Planning and Analysis
- Track Maintenance

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INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) has conducted a study of the economics of crossing diamonds under the Advanced Crossing Diamond research project at the Transportation Technology Center. Crossing diamonds are considered to be a weak link in the system, resulting in considerable track-maintenance expense and operational inefficiencies. Crossing diamonds may also be a barrier to implementation of heavy-axle-load equipment on many lines. The findings and analysis tools developed under this project will be used to evaluate and develop improved-performance crossing-diamond designs for AAR member railroads.

The most beneficial improvement that could be made over existing crossing diamonds would be to eliminate speed restrictions. Many high-angle diamonds have speed restrictions that are frequently due solely to the inability of the existing diamond designs to withstand the impact loadings developed at speeds above 40 mph. These train-delay costs are conservatively estimated at \$300 to \$400 million per year. The key to improving crossing-diamond performance is the elimination of impacts caused by the unsupported flangeway gap in high-angle diamonds.

An economic analysis model for crossing diamonds was developed for the study. The

model accounts for the costs associated with installation, maintenance and train operations over a crossing diamond. Several crossing-diamond types can be evaluated at a given location to select the most economical. The model can be used to develop use policy for crossing diamonds for a line segment or an entire railroad, and to develop the desired performance characteristics for new crossing-diamond designs.

The best types of crossing diamonds for given applications vary with the tonnage levels and speeds of trains on those routes. The flange-bearing frog (FBF) concept, by virtue of its ability to eliminate speed restrictions, appears to be viable for a wide range of locations, even with a cost premium over conventional diamonds. The FBF supports the wheel across the flangeway gap on a raised flangeway bottom. The wheel rides on its flange, instead of jumping the flangeway gap. The continuous support across the frog eliminates high-impact forces and, thus, the need for speed restrictions across diamonds.

TRAIN ENERGY MODEL STUDY

The slow order associated with a crossing diamond was modeled using the AAR's Train Energy Model (TEM). This was done by modeling train operations over a low-grade, low-curvature, 30-mile route. Then, a 1,000-foot

TRAIN	CONSIST	LOADED TONNAGE	EMPTY TONNAGE	MAXIMUM SPEED (MPH)	
				LOADED	EMPTY
UNIT	5 locos, 90 263 kip cars	12,874	3,874	50	60
INTERMODAL	3 locos, 60 double-stack platforms	4,163	1,763	70	70
MIXED	1 loco, 50 cars (5 tank, 5 gon, 5 hopper, 35 box)	5,624	1,814	40	40

Exhibit 1. Trains Modeled in TEM Crossing Diamond Study

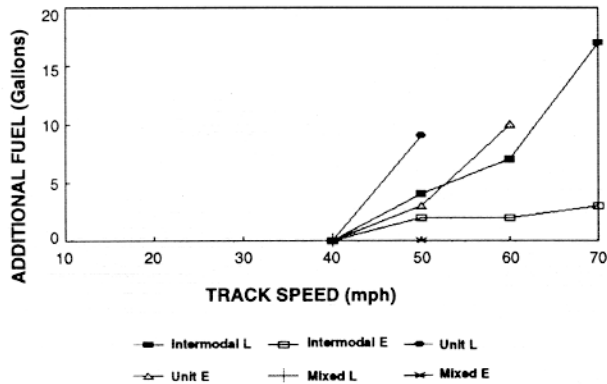


Exhibit 2. Predicted Additional Fuel Usage Results from TEM Crossing Diamond Study

slow order was added to the route. Comparison of transit times and fuel usage showed the effect of the slow order on various types of trains. Exhibit 1 lists the trains modeled. A parametric study of track speeds and speed restrictions was conducted for each type of train. Exhibit 2 shows the results of a fuel-consumption study with a 40-mph crossing-diamond speed restriction in tracks with speed limits of 50 to 70 mph. The range of track speeds and slow orders used covers typical North American mainline freight operations.

CROSSING-DIAMOND ECONOMICS MODEL

A crossing-diamond cost model was developed for purposes of evaluating new concepts. The model determines the cost of operating a crossing diamond by considering initial purchase and installation, maintenance and train-delay costs. These costs can be input by a user or selected from the default values. The default values are derived from industry average costs. Train-delay times and additional fuel usage were derived from a parametric study of slow orders and track speeds using the TEM.

Train-delay costs can be considered for both crossing lines, one line or neither line, and also may be used to determine total operating costs, total costs for one line, or direct track-maintenance expenses for one line. By projecting the likely performance characteristics of new crossing-diamond designs, one is able to evaluate the relative strengths and weaknesses of each concept. The likely potential market or range of site characteristics for each type can be determined.

A sensitivity study of the relative contribution of various cost components (i.e. purchase cost, maintenance and train delay) vs. number of trains was conducted. Industry average values were used:

- Purchase and installation: \$100,000.
- Maintenance: \$700 per million gross ton.
- Train-delay: \$275 per hour, per train.

Results of the study are shown in Exhibit 3. Train-delay costs are a significant portion of the total costs in all cases. This portion rises as cross traffic increases for the mainline cases (25 trains per day and 50 trains per day) because traffic interference delay adds to the train delay caused by slow orders.

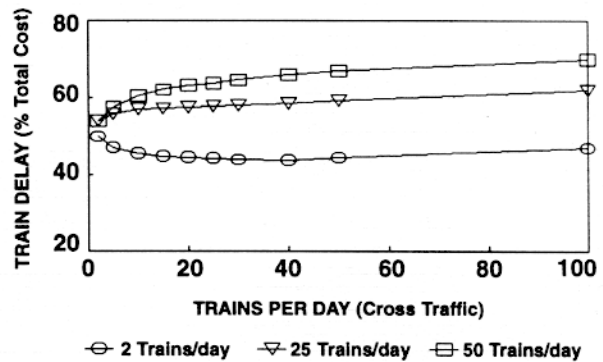


Exhibit 3. The Relative Contribution of Train-Delay Cost as a Function of Cross Traffic

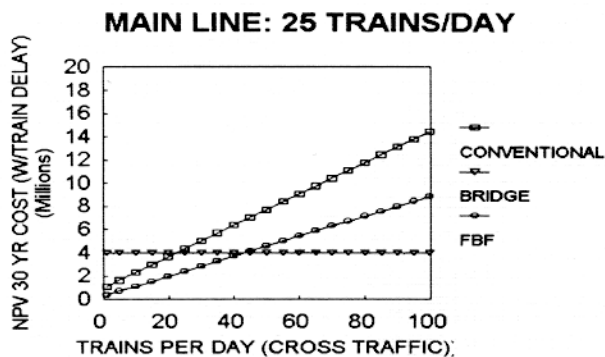


Exhibit 4. Crossing Diamond Economics Model Sample Output

THE MAINLINE CASE

We have modeled a mainline case to demonstrate the capabilities of the model. The model shows the relative costs of three crossing-diamond alternatives; performance characteristics can be defined by the user. Exhibit 4 shows an example. As the number of trains is varied on the main route, one can see that the lowest-cost crossing-diamond type also changes from a conventional design, to a flange-bearing frog, to a grade separation (i.e. bridge). The progression is from low initial-cost designs to higher initial-cost designs that reduce train delay.

The example cost breakdown in Exhibit 5 is for one of the cases plotted in Exhibit 4. This case shows the cost breakdown for a conventional-design crossing diamond with heavy traffic on both lines. The owning railroad has 50 trains per day, approximately 68 million gross tons (MGT) per year, and the crossing railroad averages 25 trains per day, approxi-

mately 36 MGT per year. The diamond has a slow order of 40 mph. Line 2 has a track speed of 50 mph and Line 1 has a track speed of 60 mph. The chart shows the amount of train delay incurred by the crossing railroad (Train Delay 2) with 25 trains per day and the train delay (Train Delay 1), crossing-diamond maintenance, and crossing-diamond capital costs incurred by the owning railroad. The train delay for the owning railroad is over \$89,000 per year. This amount is larger than either the maintenance or capital costs. For the owning road, the per MGT costs for train delay, maintenance and capital are \$852, \$700 and \$309 respectively for the 105 MGT of total traffic over the frog. If Line 2's train-delay costs are also included, the total train-delay costs are \$1,919 per MGT.

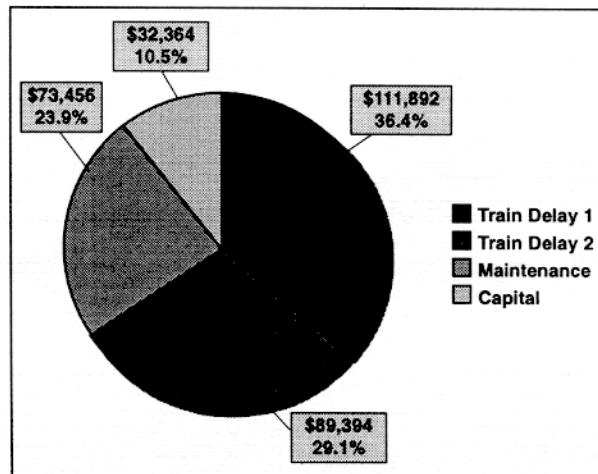


Exhibit 5. Example Case Cost Breakdown

Note: Contact Dave Davis at (719) 584-0754 with questions or comments about this document.

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