TECHNOLOGY DIGEST

Timely Technology Transfer

A Preliminary Investigation of the Economics of Advanced Turnouts

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Summary

Comparisons of life-cycle costs indicate that advanced turnout designs with tangential switch points and movable-point frogs can be justified for freight service only for the highest density lines. Rigid-frog turnouts with improved geometry and premium components will be economical over a much wider variety of operating conditions. Standard AREA turnouts will continue to be the most economical for light density lines.

While advanced design turnouts are more expensive to acquire and install, their longer lives, lower maintenance requirements, and higher train speed through the turnout can lead to life-cycle savings. Based on information obtained from member railroads, advanced turnouts are currently two and a half to three times the installed cost of a standard AREA turnout. Our analysis indicates that at these cost levels, they can be justified for traffic densities ranging from approximately 75 million gross tons (MGT) to 100 MGT and greater, depending on what estimates are used regarding reductions in associated train delays. These findings were based on life-cycle cost estimates developed using the AAR's New and Untried Car Analytic Regime Simulation (NUCARS) model, the AAR Turnout Model, and limited field tests. Sensitivity analyses showed that to justify advanced turnouts in track with lower traffic density, it will be more important to reduce their costs than to further increase their performance. Based on this preliminary analysis, there appears to be potential for wider application and greater economic benefit from the development of improved rigid-frog turnouts with premium components than from the more costly advanced turnouts with tangential switch points and movable-point frogs. As more field-test data becomes available, the model assumptions as well as the analysis results will be further refined.

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INTRODUCTION AND CONCLUSIONS

Several advanced design turnouts are available to railroads. They include such features as movable-point frogs, tangential switch-points, and the use of premium components. The AAR Research and Test Department conducted a four-pronged effort to estimate the traffic conditions under which the higher costs of these advanced turnouts could be justified. First, we modified NUCARS, a sophisticated dynamic curving model, so that it can model the movement of cars through turnouts. Second, we tested an advanced design turnout and a number of improved design, rigid frogs at the Transportation Test Center (TTC). Third, the AAR is monitoring the performance of a number of advanced turnouts in revenue sites to evaluate a variety of advanced turnouts and to examine the effects of external factors on turnout performance that may not be evident at the controlled test environment at TTC. Fourth, we developed the AAR Turnout Model, a life-cycle costing model, to evaluate various turnouts under different traffic conditions.

Three main conclusions from this preliminary analysis are:

- *There are some economically justifiable applications for advanced turnouts with movable-point frogs. However, these applications are limited primarily to high density lines that carry at least 75 MGT annually.*

- *To justify these turnouts for a wider range of operating conditions, installed cost reductions will be more important than further extensions in component lives.*

- *The best way to improve turnout economics is through the use of premium components and less drastic modifications in turnout design. For most operating conditions, a premium, rigid-frog turnout that has more durable materials and improved geometry is likely to provide a better financial return than a movable-point frog.*

ECONOMIC METHODOLOGY

We estimated the life-cycle costs for standard and improved turnouts. The *standard* turnout was a typical AREA #20 mainline turnout. We examined two categories of improved turnouts: an *advanced* turnout consisting of tangential switch-points and a movable-point frog built with premium components, and a *premium* turnout consisting of a fixed-point or rigid-frog built with premium components.

North American railroads have limited experience with improved turnouts. We therefore estimated turnout component lives using NUCARS and the AAR Turnout Model. These estimated lives were consistent with limited field-test results. We also had very little cost information. For this preliminary analysis, we conducted sensitivity analyses for the cost and performance of improved turnouts.

We conducted the economic analysis for two cases. The first considered only the costs of installing and maintaining turnouts. The second also included the costs of train delays associated with installation, maintenance activities, and speed reductions.

BASE CASE RESULTS

The base case analysis assumed 100-ton coal operations over a standard AREA #20 turnout with an installed cost of just under \$60,000. We assumed routine maintenance on a regular schedule, with grinding and welding based on the rate of deterioration of the points and the frog. We based the replacement of the points and the frog upon the predictions of the AAR Turnout Model, while the intervals for production grinding, undercutting and surfacing varied with MGT. We based the unit costs and the maintenance intervals upon the responses to a survey of Class I railroads.

We estimated the component lives for a

coal line. Each coal train consisted of three 6-axle locomotives and one hundred 100-ton cars. For the loaded direction, we assumed 95% of the traffic to take the straight path through the turnout and 5% the divergent path. For the empty direction, we assumed 25% to take the divergent path. For the standard AREA #20 turnout, the turnout model predicted 103 MGT as the frog life, 337 MGT as the straight switch-point life, and 620 MGT as the overall turnout life.

Given the initial installation cost and the frequency and cost of the maintenance activities, we computed the equivalent uniform annual cost (EUAC) over the life of the standard turnout using a 10% discount rate (Exhibit 1). When computing the EUAC with train delay costs we assumed the cost per hour of train delays to be $180/hour, a figure used by a member railroad in studies of dispatching delays. We believe this is a conservative estimate. One needs to be careful in estimating train delays because actual train delays are a function of specific site situations including train schedules, line capacity, and whether the traffic is diverted to a mainline or to a siding.

Exhibit 1 Base Case Life-cycle Costs (Standard AREA #20 Turnout)

Annual Traffic	Equiv. Uniform Annual Costs Without Train Delays	Equiv. Uniform Annual Costs With Train Delays
25 MGT	$13,100	$14,800
50 MGT	$18,800	$24,900
75 MGT	$24,900	$37,300
100 MGT	$31,000	$55,300

ADVANCED TURNOUT RESULTS

For the advanced turnout analysis, we assumed the same traffic stream as in the base case analysis. Since we assumed the advanced turnout to have no guard rail, no guard rail adjustments were required. We reduced the rate of grinding per MGT and assumed little or no welding. Based upon NUCARS output and the AAR Turnout Model, both the straight and curved switch-points were predicted to last well over 1,000 MGT and the frog was predicted to last nearly 800 MGT. We assumed the other elements of routine maintenance to occur with the same frequency and unit cost as for the standard turnout. We also conducted a sensitivity analysis assuming that the movable-point frog was replaced at 772 MGT, with the turnout lasting up to 1500 MGT.

Based on the survey data, we estimated the advanced turnouts currently cost (installed) roughly two and a half to three times as much as standard turnouts, plus a one-time cost of $25,000 for signalling work and adding a switch machine for the movable-point frog.

Breakeven Analysis

A breakeven analysis was conducted to determine the installed cost for which the advanced turnout was predicted to have the same EUAC as the standard AREA #20 turnout. Exhibit 2 summarizes the results of the breakeven analysis. As the expected turnout life increases, a higher installed cost can be justified; when the cost ratio of an advanced turnout (currently estimated to be 2.5 to 3) is below the breakeven cost ratio as shown in Exhibit 2, then the advanced turnout is economically attractive.

Exhibit 2 shows that if an advanced turnout is expected to last 1400 MGT and its installed cost ranges between 2.5 to 3 times that of a standard AREA #20 turnout, then it is well justified for the 125 MGT line, marginally justified for the 100 MGT line, and not justified for the 75 and 50 MGT lines. If we include the effects of train delays, the advanced turnout can be justified for lower traffic densities, i.e., it is then justified for 100 MGT and above and marginally justified for the 75 MGT lines.

For the 25 and 50 MGT density lines, the breakeven installed cost for the advanced turnout (compared to the standard turnout) is much lower, especially if the potential for reducing train delays is not considered. Reductions in costs would be more effective than extensions in component life in making advanced turnouts more attractive for these lower density lines.

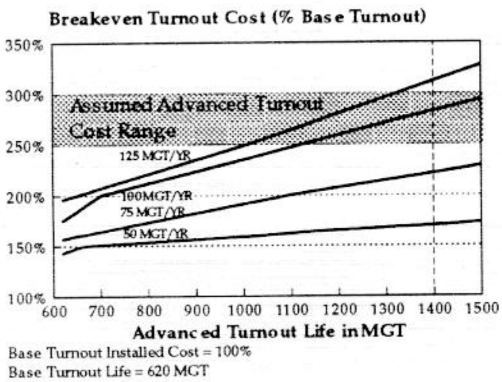

Exhibit 2 Breakeven Analysis for Advanced Turnouts Without Train Delays

PREMIUM RIGID-FROG TURNOUT

An advanced turnout with a movable-point frog is by no means the only possible type of improved turnout. Experience at TTC has shown that a significant improvement over the base case AREA #20 turnout is achievable by less drastic modifications in design and by the use of premium components. Exhibit 3 shows the breakeven cost ratios (without train delay costs) for premium frogs with lives ranging from 103 to 309 MGT for different traffic density levels. Exhibit 3 shows that if a premium frog lasts 206 MGT, then it is economically justified to pay as much as 1.2 times the cost of a standard AREA #20 turnout for the 100 MGT line; if we include the effects of train delays, then it is justifiable to pay as much as 1.7 times the cost of a standard turnout.

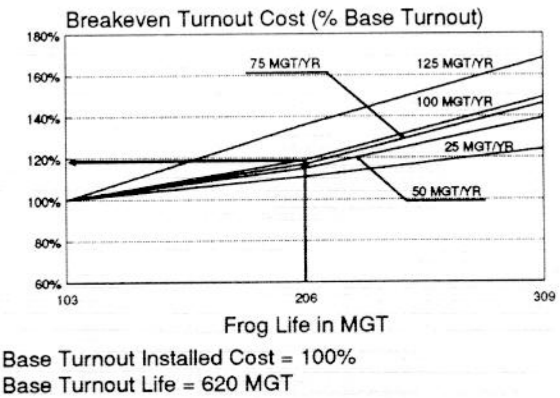

Exhibit 3 Breakeven Analysis for Premium Turnouts Without Train Delays

Unlike the expensive advanced turnouts, the premium component turnouts appeared to have greater economic potential across the wider range of traffic volumes analyzed. The comparative analysis of the EUACs for several assumed combinations of price and performance of turnouts with premium rigid frogs showed that these turnouts are superior not only to the standard turnouts, but also to advanced turnouts on lines of less than 75 MGT annually. The turnouts with premium rigid frogs may be competitive even for the 100 MGT line and are clearly inferior to the advanced turnout only for the 125 MGT line.

Note: Contact Dharma R. Acharya at (202) 639-2257 with questions or comments about this document.