THE PREVIOUSLY UNTOLD STORY ABOUT GRADE CROSSING COSTS

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This article was originally published in Railway Track and Structures in 2004.

Recent proposals have been put forth claiming to substantially reduce the cost of Highway-Rail Grade Crossings. AREMA Committee 36 is always interested in looking at these proposals and determining how (or if) they should be addressed through AREMA. Subcommittee 36-4 was tasked with establishing a baseline structure of costs so that these proposals could be consistently evaluated, particularly for evaluating current technology vs. future technology. The results proved to be surprising to many people involved. In addition to the results, this article will describe the process we went through in determining those costs.

At the start of the process, the group expressed substantial concern that dollar costs vary widely, depending on the specific installation, and that published dollar figure costs are frequently misinterpreted. As such, we decided to identify relative costs of various critical portions of a crossing rather than total dollar costs. The process of developing these costs consisted of identifying minimum design requirements (regulatory, recommended practices), defining a typical location and categories for the costs, and finally estimating a range of costs for each of those categories. The requirements and cost ranges were done by the subcommittee, which consisted of railroad members, equipment suppliers, system designers, and regulatory representatives. The full committee then had the opportunity to review and comment on the values.

Initially, We identified the requirements governing development and installation of crossing warning systems. As these impose a set of minimum requirements (both regulatory and industry practice), it is necessary that alternative systems satisfy these requirements. Otherwise, the comparison is the proverbial apples and oranges comparison. These minimum requirements include:

1. Federal Railroad Administration (FRA) Regulations

   FRA has regulatory authority concerning the safety of highway-rail grade crossings. FRA Part 234 imposes minimum maintenance, inspection, and testing standards for highway rail grade crossing warning systems, including the requirement that all control circuits operate on the fail-safe principle.

   In addition, FRA is considering a Notice of Proposed Rulemaking (NPRM) concerning safety of Processor-Based Systems used for Signal and Train Control. The NPRM was published in the August 10, 2001 issue of the

Federal Register and would require both a comprehensive safety analysis and a risk analysis for processor-based systems. While not yet a regulation, it is worth highlighting as an example of what may be required in the future, particularly as it may affect costs. In addition, an section was proposed to be added to Part 234 requiring that any highway rail grade crossing system using new or novel technology, or any highway rail grade crossing system interfacing the to train control system fully satisfy the safety and risk analysis requirements.

2. Federal Highway Administration (FHWA) Regulations

   The FHWA is involved in highway-rail grade crossings through the Manual of Uniform Traffic Control Devices (MUTCD), specifically Parts 8 and 10. The MUTCD is the "bible" for traffic control devices (defined as "all signs, signals, markings, and devices placed on, over, or adjacent to a street or highway"). Since 1966, traffic control devices in all states must be in conformance with the standards issued or endorsed by the Federal Highway Administrator through the MUTCD. As with FRA, MUTCD requires that all train detection systems be based on the fail-safe principle.

3. AREMA Manual of Recommended Practices for Communications and Signals

   The AREMA Manual provides Industry accepted practices for Highway-Rail Grade Crossing Warning Devices and Systems including Functional and Operating Guidelines; Application Guidelines; Design Criteria (including interfaces); and Maintenance / Test Guidelines. Design Guidelines include requirements for gates, bells, flashers, presence detection, controllers and monitoring equipment.

4. Safety Guidelines

   In addition to the guidelines and regulations discussed above, the following industry standards are generally accepted for verification of safety.

   a. Mil Std 882C (System Safety Program Requirements) addresses one method of implementing a complete system safety program.

   b. AREMA Manual of Recommended Practices Section 17 addresses Safety Assurance, Quality Assurance, and Reliability and Maintainability Assurance.

   c. IEEE Standard 1483-2000 (Verification of Vital Functions in Processor-Based Systems Used in Rail Transit Control) addresses one method of verifying that vital (fail-safe) functions are properly implemented in processor-based equipment.

After looking at the minimum design requirements, we defined a baseline case for a highway-rail grade crossing application to start our relative cost allocations. The following attributes were used to define the crossing. Attributes were based either on requirements or a typical installation as required by a railroad (e.g. most RR's request a bungalow for mounting equipment for ease of maintenance).

- Single Track Application with Dual Direction operation possible.

- The Warning Devices consist of Entrance gates, flashing lights and bells.

- Train Detection System consists of a uniform time warning system based on use of track circuits. They assume approximately 3000 feet approach circuits in each direction plus an island circuit overlay.

  Systems can include redundant train detection or not. Two categories are shown in the table to represent this. The first category consists of a uniform time warning system without any hot standby or automatic switchover. The second category consists of a uniform time warning system that is fully redundant and provides automatic switchover. (No decrease in functionality or safety when operating in backup mode). It is important to understand the difference between safety and reliability in this portion of the discussion. Some train detection systems use redundancy as a form of assuring safety. When used in this manner, the redundancy cannot be considered as providing additional reliability (availability). Since the second (or backup system) is used to achieve safety, the crossing can be considered as operating in a potentially unsafe mode when operating only on the backup channel.

- An external event recorder (independent of other systems) is provided.

- An independent crossing controller is provided for control of gates, lights, bells, etc. (may be either solid state or relays).

- Full Battery backup is provided (per FRA requirements) with 48 hours operating capability.

- The equipment is housed in a 6 ft x 6 ft bungalow.

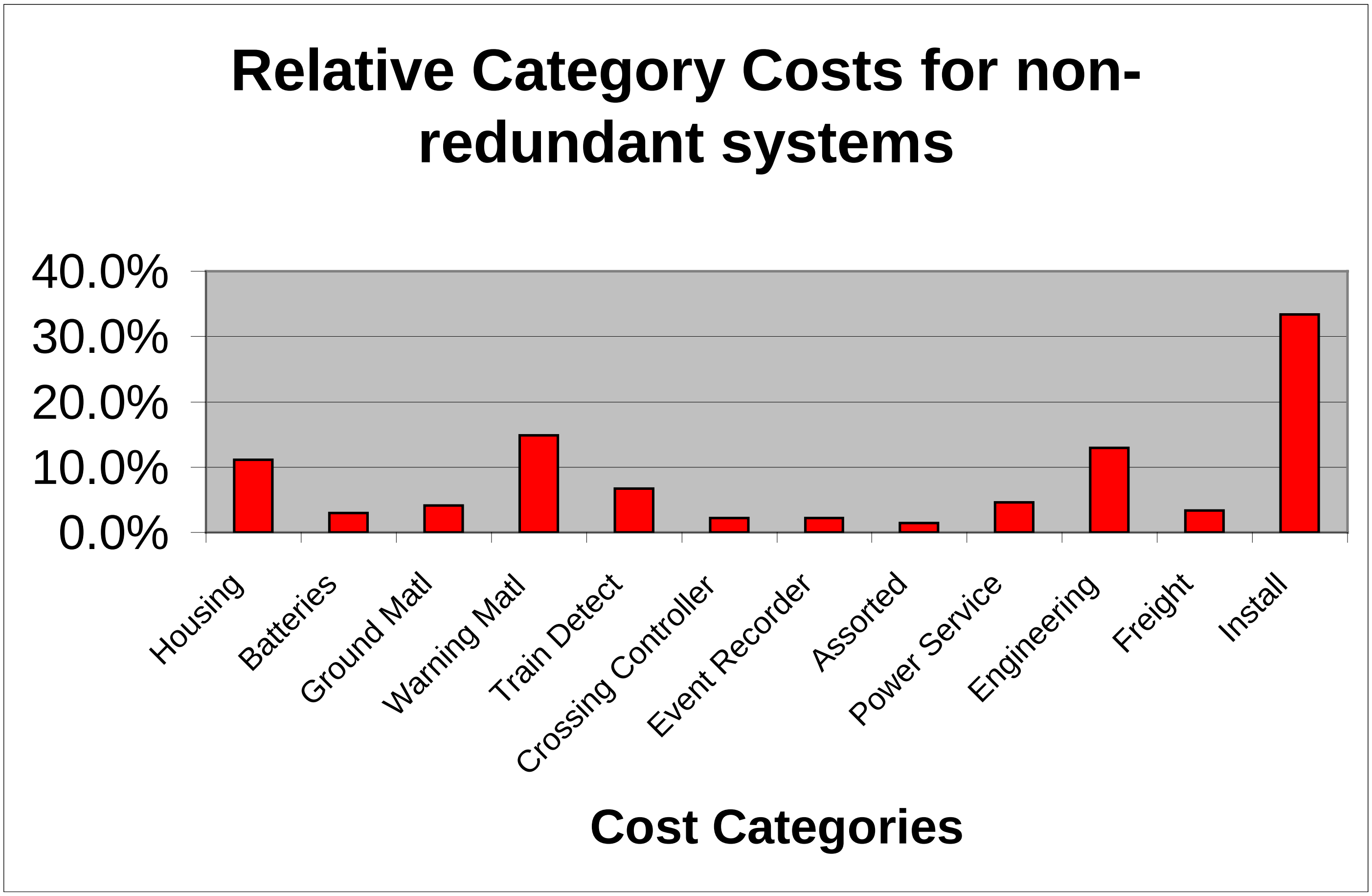
- The crossing has no extraordinary installation requirements.

- There are no adjacent crossings requiring DAX'ing (communication with an adjacent crossing where crossings are located closely together).

Next, we identified major categories for assigning costs. Because of the proprietary nature of the costs and the variation of costs depending on purchase volumes, costs were based on general agreement of the committee that these were reasonable costs for each category. In many cases, a range of typical values was required to describe the various category costs because of the wide variation of systems, even though this is a relatively simple system. The following table summarizes cost by each of the categories. The Percentages shown reflect the average portion of the total cost that each category contributes (separately for systems with non-redundant train detection and systems with redundant train detection). Percentages marked with a double asterisk (**) varied up to +/- 30% due to site-specific conditions. The bar graph following this table presents the information graphically for easier comparison.

Cost Category	**Equipment / Services Included**	**Cost % (non-redundant detection)**	**Cost % (redundant detection)**
Housing Material	Bungalow, equipment rack assemblies, various adjustment resistors, and wires.	11.1%	10.6%
Batteries and Chargers	Batteries and charging equipment	3.0%	2.8%
Ground Material	Foundations, ground rods, ducts, locks, cable, bondstrand and other external cabling	4.1%	3.9%
Warning Material	Gate mechanisms, brackets, counterweights, flashing lights, masts, and signs	14.8%	14.1%
Train Detection (non-redundant)	Single set of uniform time warning equipment and track shunts	6.7%	
Train Detection (redundant)	Fully redundant (with automatic switchover) uniform time warning equipment and track shunts.		11.3%
Crossing Controller	Crossing control equipment, either relay or solid-state	2.2%	2.1%
Event Recorder	External event recorder including required inputs and outputs	2.2%	2.1%
Assorted Electrical/Electronic Equipment	Surge protection panels and equipment, battery chokes, etc.	1.5%	1.4%
Power Service	Equipment necessary to interface to commercial power systems and local utility charges for installing system.	4.6%**	4.4%**
Engineering	Site surveys, logical crossing design, detailed wiring and equipment layout design, equipment assembly, wiring and factory testing	13.0%	12.3%
Freight	Cost of shipping the wired system to the physical field location	3.3%	3.2%
Installation	Cost of installing the equipment in the field, including final adjustments and	33.4%**	31.7%**

	field-testing.		



The obvious conclusion of this exercise is that there is no silver bullet for reducing the cost of highway-rail grade crossings. Most of the major cost drivers are not dependent on equipment or technology. Installation, Engineering, Freight and Power Service alone are responsible for more than 50% of the crossing costs. One of the most frequently targeted areas for cost reduction is train detection, although it can be seen that only about 7% of the total crossing costs can be attributed to train detection (up to 12 % of a fully redundant system). The baseline cost also doesn't address some of the more difficult to quantify life-cycle costs. It is generally expected that highway-rail grade crossings will operate safely and reliably for 20 to 30 years. New technology systems would be expected to have the same lifetime. For now, the most promising approach for cost reduction at highway-rail grade crossings is to continue the process of driving costs down in every category, using new technology where appropriate