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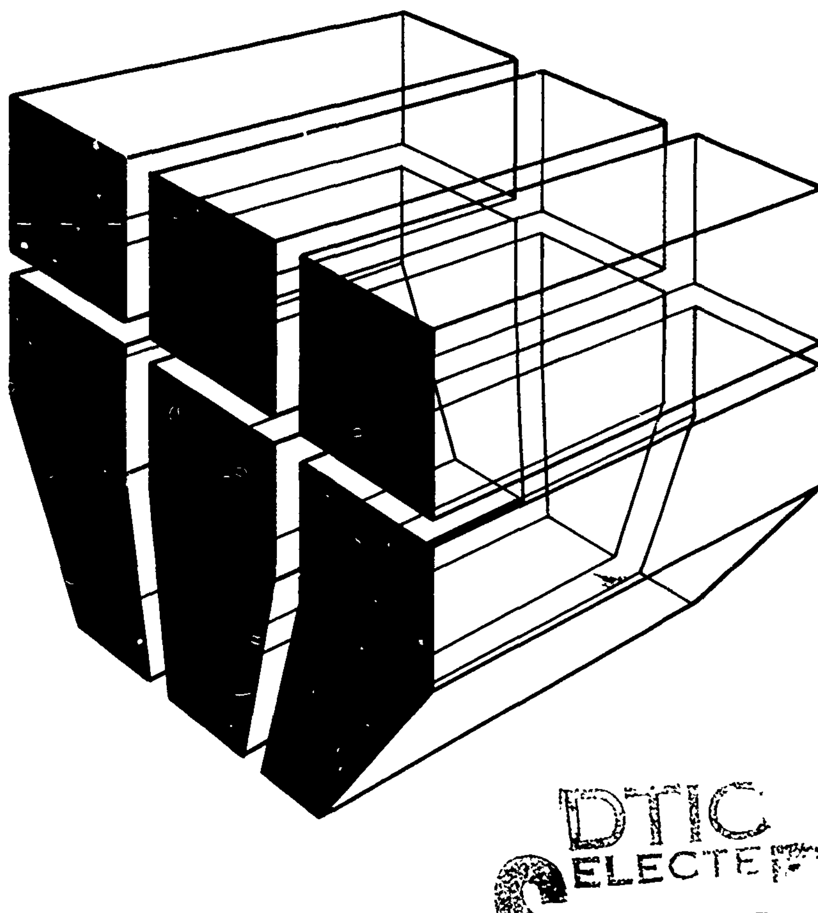
Railroad Maintenance Management System

DEVELOPMENT OF A RAILROAD TRACK MAINTENANCE MANAGEMENT SYSTEM FOR ARMY INSTALLATIONS: INITIAL DECISION REPORT



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This report assesses current Army railroad maintenance and repair (M&R) management practices, and suggests methods and procedures to solve problems created by lack of standardized track management practices.

Large and small American railroad companies were surveyed to determine if a complete maintenance management system already existed which the Army could adapt. ~~It was found that there is~~ no complete track maintenance management system which could be readily adapted to Army use. The most efficient way of

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providing a track maintenance management system is to design one specifically tailored to the Facility Engineer's system of operations. This report outlines such a complete track maintenance management system. The proposed

Based on a literature search, a survey of commercial railroad M&R maintenance management systems, and interviews with installation track maintenance personnel, a proposed track maintenance management system has been developed which would incorporate the following procedures:

1. Objective, uniform track inspection methods.

2. A standardized track condition rating and evaluation system;

3. A database for storing and retrieving track inventory information;

4. Guidelines and standards for determining the most viable M&R alternatives;

5. Procedures for performing life-cycle project cost analyses;

6. Budget planning and project prioritization procedures; and

7. Efficient work reporting methods.

FOREWORD

This study was done for the Assistant Chief of Engineers (ACE), under Project 4A762731AT41, "Military Facilities Engineering Technology"; Task C, "Operation and Maintenance Strategy"; Work Unit 042, "Railroad Maintenance Management System." The ACE Technical Monitor was Mr. R. Williams, DAEN-ZCF-B.

The work was performed by the Engineering and Materials (EM) Division of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). Dr. Robert Quattrone is Chief of USA-CERL-EM.

Special appreciation is extended to Mr. John M. Pitt and Mr. Gerald W. Chase of the Iowa State University Civil Engineering Department, to Mr. Arnold Gross of the U.S. Department of Transportation, Federal Railroad Administration, and to Dr. Alan Bing of A. D. Little, Inc. The authors would also like to express their appreciation for the comments received from and guidance provided by the following individuals: F. W. Taylor (FORSCOM), B. F. Flaherty (DARCOM), C. Williams, (TRADOC), J. F. Hovell (FESA), and R. D. Jackson (WES).

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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DEVELOPMENT OF A RAILROAD TRACK MAINTENANCE MANAGEMENT SYSTEM FOR ARMY INSTALLATIONS: INITIAL DECISION REPORT

1 INTRODUCTION

Background

The Directorate of Military Programs' Annual Summary of Operations Report[1] (Redbook) for 1980 indicates that the Army maintains 3048 miles (4904 km) of railroad track. This track is scattered in discrete sections at 81 installations throughout the Continental United States (CONUS). The length of track at individual installations is generally small, with the largest trackage being just over 200 miles (320 km). Much of the Army's track was built or rehabilitated during World War II; however, some dates to the early 1900s. By mainline railroad standards, daily traffic is generally very light; however, some installations have more intensive trackage requirements which support the time-sensitive outloading and receiving needs of rapidly mobilizing and deploying units.

In 1980, the U.S. Army Forces Command (FORSCOM) requested $16 million to upgrade rail facilities; FORSCOM has recently requested an additional $28 million to correct identified rail mobilization deficiencies. However, in many cases, track maintenance has been deferred to provide more funds for projects which directly affect a greater population of the installation users. If this trend continues, some of the track may deteriorate to a point where it could no longer support its mobilization mission. To maintain Army track effectively and economically and insure that it can support the installation's mission, the FE must have a practical way to identify cost-effective maintenance and repair (M&R) which will provide objective input into the decision-making process.

Purpose

The purpose of this study is to:

1. Define management problems related to M&R of railroads on Army installations.

2. Obtain agreement and commitment from users, early in the research and development (R&D) cycle, about which problems should be solved and what R&D products are required.

3. Assess current Army railroad maintenance management practices and investigate commercially available technology that can be implemented without further R&D, and provide a realistic baseline on which new R&D can be proposed.

[1] Annual Summary of Operations Report (Directorate of Military Programs, Office of the Chief of Engineers, 1980).

4. Recommend R&D, and project anticipated benefits to the Real Property Maintenance Activities (RPMA) mission.

Approach

MACOM engineers, Strategic Mobility personnel, and track maintenance personnel were interviewed to obtain input about Army track maintenance problems. Twenty-seven large operating railroad firms, 14 firms operating short-line railroad tracks, the Federal Railroad Administration (FRA), and private railroad consultants were surveyed to determine what system, if any, they used for managing their track maintenance operations.

Mode of Technology Transfer

It is recommended that the information provided in this report be used as background for recommending a plan for a railroad maintenance management system.

2 PROBLEM DEFINITION

The 3048 miles (4904 km) of railroad track maintained by the Army exist in units ranging from 0.5 to 212 miles (0.8 to 339 km) long, and are dispersed throughout CONUS on 81 Army installations. The FE, who is in charge of all installation maintenance, is responsible for maintaining the serviceability of the trackage. Because of the small amount of trackage at each installation, the FEs and their staffs generally do not have specialized railroad engineering skills or experience.

In recent years, a great deal of track maintenance has been deferred, mainly because the needs of a railroad track network are not as obvious as those of other installation items, such as failed pavements or leaking roofs; thus, it does not compete well for maintenance funding. Also, over the past 40 years, railroads have played a declining role in the overall transportation picture of the nation; as a result, fewer people have experience in determining track condition and recommending maintenance projects. At present, there is no standard way to educate personnel in identifying track distresses and in planning and recommending track maintenance procedures. In addition, there is no standard method for gathering track inventory and condition data and no unified way of determining a track's condition. Thus, the FE does not have the information to decide what maintenance is required to correct specific, identifiable track problems and how much funding these operations will require. This has been a problem in the railroad industry for many years, and has prompted the need for track measurement and management systems.

3 STATE-OF-THE-ART MAINTENANCE PROGRAMS, SYSTEMS, AND TECHNOLOGY

To determine what railroad maintenance management systems were available, a literature search was performed and commercial railroads and firms operating and maintaining track were contacted. The following sections summarize how maintenance operations are generally conducted by commercial railroads, how this work is planned, and what systems are available for providing required management information.

Typical Track Maintenance

The kinds of maintenance programs used by American railroad companies depend mostly on the railroad's size. Large railroads have two types of maintenance programs: basic or section gang, and production.

Basic or Section Gang

The section gang's main job is to keep the tracks clear so the trains can run. Therefore, much of its work tends to be of an unplanned, "fire fighting" or emergency nature.

Basic track maintenance has two main characteristics:

1. It is very labor-intensive, relying much more on people than on machines and material.

2. The work is highly variable, including such things as bolt tightening, snow shoveling, brush cutting, repairing road crossings, spot aligning and leveling, changing one tie, replacing one rail, and cleaning up after accidents or derailments.

On any given day, the local maintenance supervisors, called gang foremen, decide what jobs the basic track force will perform. In addition, on most American railroads, they will be given other jobs by the division engineer, track supervisor, or roadmaster. Both railroad and FRA personnel inspect the railroad tracks regularly. The section gangs are responsible for correcting any safety standard violations found.

Section gang members are normally full-time employees of the railroad's maintenance department. The number of gangs in each division is based on track-mile characteristics and track "equivalencies." For example, one switch is judged to need the same maintenance support as about 0.25 track miles (.4 km), and one road crossing is estimated to need maintenance support equivalent to about 0.15 track miles (.24 km). By computing the number of actual and equivalent track miles in a division, and relating that to the number of miles one person can maintain, the maintenance personnel required and associated budget levels can be determined.

The work of the section gang is manually planned and controlled by the section gang foreman and the foreman's immediate supervisor. Only occasional control is exercised at the division or headquarters level. Usually only 60 percent of the workforce is assumed available for routine maintenance because of the unpredictable "fire fighting" nature of its work. Only the Chessie System Railroads use sophisticated computer-oriented tools to plan and control section gang work; i.e., jobs are scheduled over a 14-day period, rather than daily.

Production Gangs

Large railroads have another type of maintenance, called production of medium term. Instead of "fighting fires" and keeping track open, production maintenance crews improve the overall physical condition of the property. Production work, which is done by highly mechanized gangs of from 10 to 70 people, has the following characteristics:

1. Wide-ranging. It includes jobs like replacing continuous lengths of rail (usually for several miles), replacing at least 400 ties per mile, unloading ballast, and surfacing many miles of track.

2. Interdependent. For example, ties are replaced before rail is relaid; however, the lining and surfacing are put down after the rail is relaid, while road crossings are usually repaired at the same time it is relaid.

3. Varied but regular. It can be planned, scheduled, and controlled better than section gang work.

4. Comprehensive. It draws on many resources, including materials, equipment, and personnel, and requires a large financial commitment.

5. Often changed. Because it requires a large financial commitment, production work is often revised according to the prevailing economic conditions.

Unlike section gang planning, money and materials for production work are not allocated uniformly according to mileage. The process of allocating production funds usually begins about 1 year before the work will be done; all locations which need this type of work are defined through visual inspection by either the division or headquarters staff.

Information needed to define the jobs includes:

1. Counts of the number of bad ties per mile

2. Reports on the number of ultrasonically detected rail defects per mile and rail defect history

3. Annual tonnage figures

4. Track geometry car information such as the number and severity of defects, the degradation history of the line and surface, and (possibly) an index of the overall geometric condition of the track.

After a production job is proposed, the chief engineer or a designee reviews the job list and discusses it with the appropriate staff and division people. The chief engineer may also make another visual inspection of the proposed work site.

After the job list is reviewed and evaluated (usually in the fall of the year), each job is assigned a priority. When the budget is set, the jobs are scheduled in order of priority. Once the work season begins, the actual progress of each production work gang is charted daily and compared with the planned schedule.

The planning/information collection/scheduling process for production work covers (1) work definition, (2) review and priority ranking, (3) budgeting, (4) scheduling, (5) reporting, and (6) schedule control. This process is similar among most large railroads. However, the degree of sophistication used to carry out the process varies greatly. Extremes range from a nearly comprehensive computerized system to only partially complete manual records.

Track maintenance for smaller railroads is not a scaled-down version of the work done by large railroads. Section gangs are used similarly on large and small railroads, but small railroads approach long-term planning and production work very differently. Small railroads are not organized by divisions, and production work is done less often. It also usually involves less mechanized equipment and rarely involves rail renewal. On most small railroads, the rail itself may last up to 100 years, with deterioration caused only by environmental factors. On small railroads, production work is done by two or more section gangs working on a special project, sometimes with a few more persons assigned to help. Scheduling tends to be less rigorous because there is no pressure to move equipment from one division to another. Equipment capacity often far exceeds the railroad's requirements. Reporting is also less formal, since the headquarters is usually near the worksite, making it relatively easy to supervise and control the work closely.

Both large and small railroads have written or published specifications and records to help them plan and manage their maintenance work. This is discussed in detail in the following sections.

Track Maintenance Management Systems

USA-CERL surveyed single small railroads and companies which owned several small railroads to find whether management information systems were used and if they were available to the Army (see Appendix A). Most of these railroads had track maintenance files, but none had any formal system.

Unlike the smaller railroads, many large railroads have track maintenance information systems in varying degrees of completeness and levels of sophistication. The fundamentals of these systems are described below.

Physical Inventories

Physical track information is available at most North American railroad headquarters. It is listed by milepost, using mainly manual information systems, although some railroads support these systems with computers. Physical information is usually condensed onto track maps called profiles. These profiles typically include:

1. Track data: vertical elevation, horizontal alignment, switch locations, siding, grade crossings, and structures like bridges and signal towers.

2. Bridge data: size, type, date of construction, and capacity.

3. Grade crossing data: traffic lanes, type of construction, and protection methods.

4. Railroad crossing data: dimensions and ownership.

5. Rail data: type, weight, whether jointed or welded, and date installed.

6. Ballast data: type, nominal depth, last date cleaned, and date of last application of new ballast.

7. Surfacing data: date of last surfacing and often the type of surfacing machine used.

8. Joint facility data: ownership description plus data listed in 1 through 7 above.

9. Boundary data: limits of railroad land ownership.

How much of these data are available depends on how the railroad stores and maintains information. However, no railroad had a ready-made maintenance information system that could be adapted entirely to Army needs.

Condition Inventory

On most railroads, condition data are limited to rail defects, tie condition, and bridge inspections. However, some of the larger railroads, particularly those with computerized information systems, keep data on rail wear and ballast conditions. One railroad, the Canadian Pacific, has a formal condition inventory system, in which it stores data on the number of bad ties and on rail defects, such as end batter or wheel burns. No railroad surveyed had a systematic way of evaluating track condition based on the condition inventory. Most rely on the experience and judgment of their roadmasters or division engineers, who subjectively rate track condition based on the track inspector's report.

Maintenance Standards

Most railroads allow their operating departments to set the maximum train speed allowed on a given track, based on traffic density and characteristics and marketing considerations. In turn, train speed determines the FRA safety class to which the track must be maintained. Maintenance policy and standards are based on required track class; many railroads base their standards on FRA track safety criteria. Several of the larger railroads have a more restrictive set of standards, but these are usually considered proprietary. However, most large railroads do publish standards on how to perform most of their typical maintenance operations.

Individual railroads usually base their design criteria on American Railroad Engineering Association (AREA) standards, but it is common for large railroads to vary or modify these standards somewhat. Design criteria and M&R criteria should not be considered to be the same.

Condition Analysis and Budget Appropriations

Railroad maintenance work is chosen, scheduled, and ranked based on available physical and condition inventory data and maintenance standards. An experienced engineer interprets these data and then assigns and ranks maintenance work.

To interpret the need for surfacing, several railroads use a Track Quality Geometry index, which is based on a track geometry car analysis.* This type of index is limited in application and is at a relatively early stage of development.

It is possible to take the data from a condition inventory report, translate it into a Track Quality Index, and then rate it against a specified required Track Quality Index. The greater the deviation, the higher the priority for the maintenance expenditure. However, this method has two significant problems:

1. At present, the Track Quality Indices are used only in conjunction with a track geometry car and relate only to line and surface. Many factors could cause poor alignment, including poor tie condition, fouled ballast, worn rail, etc. The track geometry car does not collect data on any of those factors and cannot differentiate among the causes of geometrical changes.

2. A commercial firm** is developing a line and surface Track Quality Index as a maintenance prediction tool; however, their research is at least 2 years from completion, and when finished, will predict only the need for surfacing. This index is being developed for tracks carrying more than 10 million gross tons per year, considerably higher than the heaviest Army track density. Also, their analysis method assumes that the track is in good condition.

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*Committee No. 32 (Systems Engineering) of the AREA has surveyed the use of the track geometry car as a management planning tool and associated management information systems among major railroads. Appendix B explains the principle of the track geometry car, and Appendix C lists the railroads included in AREA's survey.

**The A. D. Little Company under contract to the FRA Office of Research and Development.

4 TECHNOLOGICAL OPPORTUNITIES: FUNDAMENTALS OF A TRACK MAINTENANCE MANAGEMENT SYSTEM FOR USE AT ARMY INSTALLATIONS

Based on input from potential users, a track maintenance management system, similar to the PAVER Pavement Maintenance Management system,[2] has been proposed to provide the FE with the information needed to budget and plan track maintenance. Such a system must be designed to address situations unique to Army track and fit into the FE's present operations.

A system to support Army track maintenance should include a standard method of gathering track inventory and condition data, a method of storing and manipulating these data, and a reporting system that will provide the FE with the information needed. Specifically, the system should include:

1. A method of inspection that is objective and uniform and that will not place unrealistic demands on the installation's resources.

2. A repeatable, standardized condition evaluating and indexing system that will help the FE select and set priorities for maintenance projects.

3. A database for storing and retrieving related track inventory information.

4. Guidelines and standards for determining the most viable M&R procedures from among the various alternatives.

5. Procedures for performing life-cycle project cost analysis of M&R projects.

6. Budget planning and project prioritization procedures which will generate summary reports for the FE's use at the network management level.

7. Work reporting procedures which will allow update of the database and storage of actual cost data.

Figure 1 is a flowchart of the logic of the proposed track maintenance management system. The following paragraphs discuss each part of the system and analyze its potential for being accomplished by existing technology.

Inspection

The condition of the track at an installation can be determined only by inspection. Generally, maintenance inspections are subjective, and are therefore neither uniform in application nor repeatable. Because data obtained from inspection is the primary basis for determining M&R requirements and priorities, the inspection procedure must provide reliable, objective information. This can be done by using simple mechanical measurements of the track

[2] M. Y. Shahin and S. D. Kohn, Pavement Maintenance Management for Roads and Parking Lots, Technical Report M-294/ADA10296 (U.S. Army Construction Engineering Research Laboratory, 1981).

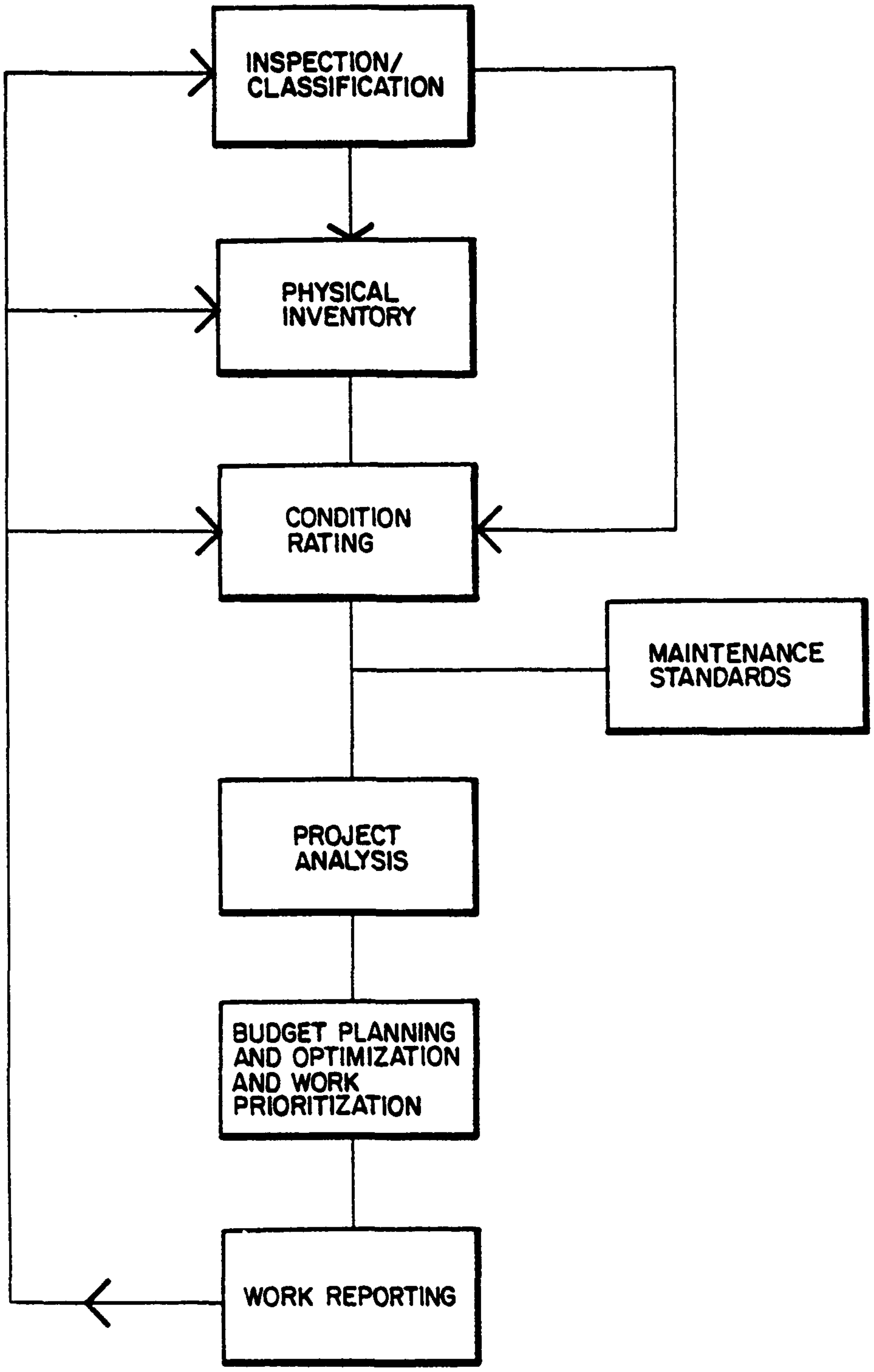

Figure 1. Track maintenance management process flowchart.

condition, and by creating a standardized visual inspection procedure which defines the types and severities of common track distress types. A manual which defines the distress types and establishes inspection procedures can be developed to provide standard condition inspections. This manual, along with operator training in the standardized inspection procedure, will provide uniform visual inspection information.

The railroad industry relies on experienced employees to perform maintenance inspections. Such trained personnel are becoming increasingly hard to find and generally remain employed by the railroad companies. Thus, a systematic maintenance inspection method which can be used by people with little or no track repair experience will prove more valuable over time.

Condition Rating

A repeatable uniform track condition rating procedure can be developed which would quantify the track condition inspection results into a communicable Track Condition Index (TCI). Based on a scale of 0 to 100, the TCI would rate the track's structural integrity and operational condition. If the TCI is developed to agree with the collective judgment of experienced track maintenance engineers, it would provide a uniform means of rating the condition of Army tracks.

Project prioritization is an expected immediate payoff of using a uniform condition rating procedure, such as the TCI. Because each unit of track is rated on the same uniform objective scale, the unit with the lowest rating will be in the poorest condition. The FE can use this list of ranked track sections to set priorities for repair projects.

There are currently no comprehensive track indices that could be readily adapted to the Army's needs. The work of commercial railroad companies in this area has been geared toward heavily used mainline track which handles more than 10 million gross tons per year, and has been directed toward assessing the need for line and surface work.

Track Data Storage and Retrieval

A database for track information can be created to store and retrieve track-related data. Development of the database and selection of the data elements should be based on the experience of track maintenance engineers and planners. The database system should be operable both manually or on an automated basis, so that both large and small installations can use it efficiently. An automated system could generate reports which would supply useful management information concisely and clearly.

There are three problems with adapting existing information systems, whether manual or computer-based, to Army use:

1. Almost all railroad systems describe track location in terms of line number and milepost. Army track is generally not described in this way.

2. There is no common industry standard which mandates the kind of track information kept in existing systems.

3. Each railroad stores the information it feels is most important, and no two are the same. However, commercial railroads are concerned with large volumes of traffic, while the Army is not. Thus, the content of commercial systems is not uniform, and the type of information they store is different from what the FE needs.

Maintenance and Repair Guidelines

Guidelines can be developed for helping the FE determine the most viable M&R procedure for various distress types. The guidelines can be designed to consider various characteristics, such as state of deterioration, load capacity, age of components, and previous maintenance. Prediction models could also be developed that would help determine the consequences of repairing or of deferring maintenance. Such models would help the FE achieve maximum use of limited resources. The standard procedural manuals for track M&R published by commercial railroads and the experience of Army track maintenance managers could form the basis for developing M&R guidelines.

There are currently no prediction models for industrial track. If developed, they would expand the FE's ability to plan and budget expenditures for track maintenance.

Life-Cycle Cost Analysis

Procedures for performing life-cycle cost analysis will help the FE select the most cost-effective M&R procedure when faced with several alternatives. Factors to be included would be initial cost, future expected M&R costs, interest and inflation rates, analysis period, and salvage value. Economic analysis could then be performed automatically. The procedures for performing economic analysis developed for PAVER can readily be adapted for use in railroad track project analysis.

Budget Planning and Project Prioritization

To develop the long-range budget plans required to obtain M&R funding, the FE needs a methodology for predicting budget requirements 5 to 10 years in the future. A budget planning procedure can be developed that will estimate the rehabilitation dollars required over a 10-year period for a given level of condition. This report would be based on the user's input of minimum acceptable condition and on unit repair costs for various deficencies. Thus, the increased cost of differing rehabilitation can be anticipated.

To help the FE set project priorities, a procedure can be developed, based on the user's input, which lists sectors of track that are in the poorest relative condition. This information could be used, along with required standards and repair policy, to decide which projects will be given budget priority.

Several railroads use long-range budget planning for mainline track M&R, but budget planning for industrial track is an untried technique. It may be possible to adapt the budget planning tools already developed by commercial railroads for this purpose.

Work Reporting

Most large railroads have a daily reporting system for their production gangs. Gang foremen wire information daily to division headquarters where it is aggregated by either hand or computer. This information allows planners on future jobs to compare the time, labor, and materials estimated for the job with what was actually required to complete the work. Thus, a better planning and estimating job can be done on similar jobs in the future if factual historical data is recorded.

Work reporting has three important functions:

1. By reporting actual progress, it is easy to tell how well the project is meeting cost and schedule requirements. This lets personnel away from the jobsite assess their productivity and readjust work priorities if funding allocations change during the fiscal year.

2. Accurate reporting provides timely data that can be used to update the physical inventory. This is especially relevant when evaluating maintenance requirements for subsequent years.

3. Work reporting generates cost data for use in future budgeting.

It is very difficult for the Army to adopt an existing railroad work reporting system for the following reasons:

1. There is no standard method of work reporting used across the railroad industry. Each railroad's reporting system is designed to meet the specific needs of its engineering department and fit into the department's overall system.

2. The computerized systems that have been developed are designed to operate with specific hardware/software systems, and are not readily transferrable.

5 CONCLUSIONS AND RECOMMENDATIONS

This investigation noted several major problems related to management of railroad M&R at Army installations:

1. Installations do not have enough personnel who are trained or experienced in railroad track maintenance.

2. Lack of funding has caused railroad track maintenance to be deferred.

3. The FE lacks information for identifying track deficiencies and setting priorities for their repair.

4. There are no standards for educating personnel in identifying track distresses, gathering track inventory and condition data, and determining a repeatable track's condition.

Input from potential Army users defined the following needs which a railroad maintenance management system should fulfill:

1. An objective, uniform, and inexpensive track inspection procedure.

2. A repeatable, standardized condition evaluating and indexing system.

3. A systematic database fr storing and retrieving track inventory information.

4. Guidelines and standards for determining the most viable M&R procedures.

5. Procedures for performing life-cycle project cost analysis of M&R projects.

6. Budget planning and project prioritization procedures.

7. Work reporting procedures which will allow updating of the database and storage of cost data.

A review of current Army railroad maintenance management practices revealed that many of these needs could be met with the following R&D:

1. Development of a uniform inspection method to define track distress types and training of personnel in standardized inspection procedures

2. Development of a Track Condition Index to provide a uniform method of rating track condition

3. Development of M&R guidelines using input from experienced Army track maintenance managers and information from commercial railroad procedural manuals

4. Adaptation of procedures for performing life-cycle cost analysis from the PAVER pavement maintenance management system

5. Development of procedures for planning budgets and setting project priorities

6. Development of work reporting procedures.

No complete track maintenance management system that would be readily adaptable to use by FEs was found in the survey of railroad companies in the United States. The most straightforward, cost-effective way to provide a track maintenance management system for the Army is to design a system specifically geared toward the FE's needs and incorporating the methods and procedures listed above.

Therefore, it is recommended that this type of system be developed, because upon implementation, it will provide the FE with the following benefits to the RPMA mission: a means for inspection and condition rating, track inventory and data storage, budget planning, job prioritization, and work reporting. These tools will help him to plan, budget for, and manage track M&R.

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APPENDIX A:

FIRMS SURVEYED FOR TRACK MAINTENANCE MANAGEMENT SYSTEM ON SMALL RAILROADS

Alcoa Railroads

Kyle Railways, Inc.

National Railway Utilization Corporation

Potlach Roads and St. Mary's River Railroad

S. M. Pinsley Co.

Bessemer and Lake Erie Railroad (U.S. Steel Roads)

Tuscola and Saginaw Bay Railroad

Texas and Southern (Weyerhouser)

Pittsburgh and Lake Erie

American Short Line Railroad Association

Philadelphia, Bethlehem, and N. E. Railroad

Keokuk Junction Railway

Elgin, Joliet, and Eastern Railway

Trona Railway

APPENDIX B:

THE TRACK GEOMETRY CAR

Track geometry cars have been used for several decades by some large railroads, mostly to help plan short-term maintenance. Today's cars are more sophisticated, but are still basically used for finding geometric defects by comparing measurements with either maintenance or safety standards. Because each car costs about $400,000, they are used mainly on the principal service routes.

Most of the cars can detect geometric defects very effectively, but not the actual condition of the ties or ballast. For example, if a gauge defect is found, it might have been caused by a bad tie condition, missing tie plates or spikes, the rail being installed improperly, or some other factor. Each possible cause would require different remedial action.

By their very nature, the cars do not take external constraints like tonnage into consideration. A light-density line with poor ties and ballast might well have fewer defects than a higher density line with better tie and ballast conditions.

Some railroads, including the Santa Fe and Chessie, make additional use of the defect data by saving the inspection data and comparing them so that degradation trends and, hence, longer term maintenance planning needs can be analyzed and, in some cases, predicted.

Another way geometry cars help in quantitative maintenance planning is by providing a Track Quality (Geometry) Index. Index technology is still relatively new in the United States; the method of calculation is usually very subjective, and not verified mathematically. For example, the following is a partial list of how indices are calculated:

1. Integrated area

2. Standard deviation

3. Weighted integration

4. Variance.

At this writing, only the Southern Railway has related a Track Quality (Geometry) Index to avoidable costs as a planning tool. Currently, there are no recommended formulas for track or parameter indices.

Fully automated track geometry cars cost about $2000 a day to rent and operate. It would cost about $20 per mile to move a rail-based car between installations. Smaller, hi-rail vehicles are available, but have daily operating costs of about $1000. The FRA has two hi-rail vehicles the Army may be able to use occasionally, but only one installation could be inspected per day. If that installation had only a short track line, the cost per mile would be very high.

APPENDIX C:

LARGE RAILROADS SURVEYED REGARDING TRACK MAINTENANCE MANAGEMENT SYSTEMS AND FOR USE OF A TRACK QUALITY INDEX

Amtrak
Atchison, Topeka, and Santa Fe Railway
Bessemer and Lake Erie Railroad
Boston and Maine Corp.
Burlington Northern Railroad
Canadian Pacific Limited
Chessie System Railroads
Chicago, Milwaukee, St. Paul and Pacific Railroad
Consolidated Rail Corporation
DeLeuw Cather/Metro (Washington, D.C.)
Denver and Rio Grande Western Railroad
Duluth, Mesabi, and Iron Range Railroad
Elgin, Joliet, and Eastern Railway
Seaboard Coastline Railroad
Louisville and Nashville Railroad
Fort Worth and Denver Railroad
Grand Trunk Western Railroad
Houston Belt and Terminal Railroad
Maine Central Railroad
Minnesota, Northfield and Southern Railway
Missouri Pacific Railroad
Norfolk and Western Railway
Ontario Northland Railway
Richmond, Fredericksburg and Potomac Railroad
Southern Railway
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