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The RAILER System for Maintenance Management of U.S. Army Railroad Networks:

RAILER I Description and Use

by
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The U.S. Army Construction Engineering Research Laboratory (USA-CERL) is developing the RAILER system for managing the inspection, evaluation, and repair of Army railroad networks. This report describes RAILER I, an interim system whose capabilities support FORMAP-2, a multiyear rail rehabilitation program at U.S. Army Forces Command (FORSCOM) and National Guard installations.

RAILER I consists of a set of data collection procedures and a computer program which will help Directorates of Engineering and Housing (DEHs) locate and identify their installation's railroad assets, assess current network conditions, determine short- and long-term maintenance and repair (M&R) needs, and systematically plan and prioritize M&R work.

This report describes the structure of RAILER I, details the inspection and inventory procedures needed to collect the data used by the computer program, explains how the program's output can be used to support network and project level planning, and describes the testing and evaluation of the program. It also makes recommendations regarding the implementation and enhancement of the program and suggests some actions FORSCOM could take to encourage its use. Instructions for operating the program are provided in a companion manual, USA-CERL ADP Report M-88/16, *The RAILER System for Maintenance Management of U.S. Army Railroad Networks: RAILER I Computer User's Guide*.

Approved for public release; distribution is unlimited.

FOREWORD

This research was conducted for U.S. Army Forces Command (FORSCOM) under Army Funding Authorization Document 88-08837, dated 29 September 1987. The FORSCOM Technical Monitor was initially William Taylor (AFEN-TSF) and later Carole Jones (AFEN-TSF). The support of both individuals, as well as that of Donald Herby (AFEN-RMO), is very much appreciated.

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

The authors wish to acknowledge the contributions of the following persons. Debra Piland developed the RAILER I computer software which is essential to the RAILER system. Robert W. Pugh assisted in developing the related facilities inspection procedures and contributed to field work. Susan Wagers traveled extensively, worked on track segmenting, and reviewed the data. The track rank procedure described here was developed for this project by Allen Snyder, David Dorfman, and John Grier at the Military Traffic Management Command (MTMC), Newport News, VA. The Transportation Systems Center (TSC) collected field data for this project.

The authors also thank G. Prose, B. Sparks, R. Parham, M. Pearson, M. Britton, R. Harris, and M. Khan for their work.

COL Carl O. Magnell is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

Army engineers, technicians, and maintenance planners face many questions regarding the facilities for which they are responsible, including how to determine what needs to be done, how much it will cost, how work should be prioritized for planning and budgeting and what effects will result from deferring maintenance and repair (M&R). In many cases the answers to those questions come from local experience. Where the experience is lacking or time constraints limit the effort that can be devoted to the facility M&R planning process, decisions may be made without knowledge of their full impact. The consequences may be premature deterioration, accelerated costs, misallocation of resources, and mission impairment.

Although these problems arise for all facilities, they are particularly noticeable in the maintenance of installation railroad track networks. Many installations use their networks only rarely and therefore have little railroad expertise and limited M&R funding. The networks, in some cases, exist primarily for mobilization. These tracks frequently receive low priority for resources due to their relatively light use (or nonuse) in peacetime. Over time, however, the tracks continue to deteriorate until they cannot perform an imposed mission, and then major resources must be expended for rehabilitation. In many cases, such costly rehabilitation would not be necessary if proper, timely maintenance and spot repairs had been done throughout the network's history.

Existing methods of track inspection and evaluation, adopted from the commercial industry, often rely on the judgment of persons with considerable track maintenance experience. However, those responsible for maintaining trackage at military installations often lack this experience. Thus, they may be unable to evaluate track condition properly, diagnose track-related problems, or determine efficient procedures for the long-term maintenance of their track. The result has been inadequate inspection, evaluation, and maintenance of Army track networks.

These problems are being addressed through a U.S. Army Construction Engineering Research Laboratory (USA-CERL)-developed Engineered Management System (EMS) for railroads called RAILER. When the system is completed, installation Directorates of Engineering and Housing (DEHs) will be better able to understand and control the condition of their railroad tracks. The concept behind the RAILER system is to provide effective and efficient management of U.S. Army track networks through systematic procedures so that appropriate portions of the network are maintained in an optimal condition for the least possible cost consistent with their mission. As a decision support tool, RAILER will help the user:

- Locate and identify physical assets
- Assess current and future conditions
- Determine short- and long-term M&R needs

- Plan M&R work systematically.

To perform these functions, RAILER will include standardized procedures and methods based on sound civil, railroad, maintenance, and facilities engineering practices. These procedures will be supported by completely user-oriented microcomputer database management software for ease in reporting and analysis.

The RAILER system is being developed in phases to permit early deployment. RAILER I (version 1.0), sponsored by the U.S. Army Forces Command (FORSCOM), is an interim system which supports the FORMAP-2 rail rehabilitation program at FORSCOM and National Guard installations. RAILER I will help users perform the tasks listed above (except for predicting track condition), but in a somewhat simplified manner. RAILER version 2.0 and subsequent enhancements, sponsored by the Office of the Chief of Engineers (OCE), will use more sophisticated procedures and will completely fulfill the required tasks.

Originally, RAILER was being developed solely under OCE's sponsorship. However, before this system was complete, the need arose for an interim track inspection and evaluation system to support the FORMAP-2 program. This multiyear, multimillion-dollar track rehabilitation program began in FY87. The interim system, named RAILER I to distinguish it from a more comprehesive version still under development, will be used to plan rehabilitation work and post-rehabilitation M&R.

In conjunction with RAILER I, USA-CERL has developed the FORSCOM Prioritization Program (FORPROP), a computational procedure which enables FORSCOM to coordinate the FORMAP-2 railroad track major rehabilitation program. FORPROP is a decision support program for prioritizing funds to appropriate FORSCOM installation projects by maximizing overall benefit/cost ratios. This program is fully documented in a separate USA-CERL technical report[1] and computer user's guide.[2]

Objective

The RAILER I project had two objectives:

1. To develop track inspection and evaluation procedures that provide a quick determination of whether existing track conditions meet current standards[3]; such procedures should be usable without previous track maintenance experience.

2. To implement these procedures in a computer program which will store inventory, inspection, evaluation, and repair cost information.

[1] D. R. Uzarski, J. S. Liebman, C. S. Melching, and D. E. Plotkin, *FORSCOM Railroad Project Prioritization Program (FORPROP) for the RAILER System: Development and Testing*, Technical Report (TR) M-88/19 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], September 1988).

[2] S. Karls, D. A. Piland, and D. R. Uzarski, *FORSCOM Railroad Project Prioritization Program (FORPROP) for the RAILER System: Computer User's Guide*, Automated Data Processing (ADP) Report M-88/17 (USA-CERL, September 1988).

[3] *Interim U.S. Army Railroad Track Maintenance Standards* (Headquarters, Department of the Army, [HQDA], Office of the Assistant Chief of Engineers, October 1986).

The procedures and program were designed to facilitate work planning and other functions in conjunction with FORSCOM's FORMAP-2 railroad rehabilitation program.

Approach

RAILER I is designed to be fully compatible with later RAILER versions and enhancements so that a later field upgrade can be done easily. It uses a yes/no decision process designed to indicate which track segments are currently satisfactory and which require immediate M&R, or replacement of certain components, or other rehabilitation work.

RAILER I couples civil, railroad, and maintenance engineering with database management technology to facilitate decision support; in particular, it permits the easy formation of annual and long-range work plans.

Prior to beginning work on this project and in conjunction with the overall RAILER system development, an extensive literature search was conducted and many commercial railroads, both large and small, were contacted to determine the inventory and inspection methods currently used by the railroad industry.[4] Although various inventory systems are used in the commercial sector, none of those systems appear entirely applicable to U.S. Army trackage. Furthermore, the commercial sector must comply with the requirements of the Federal Railroad Administration (FRA) track safety standards, which do not apply to military networks.

The procedures that will be described were developed from the experience and expertise of military engineers, railroad engineers, facility managers, and others with railroad maintenance management experience from both military and civilian sectors. When practical, these procedures were designed to ensure compatibility with existing Army methods and terminology, including the Integrated Facility System (IFS) and the installation Transportation System Capability Studies (TSCS) done by the Military Traffic Management Command Transportation Engineering Agency (MTMCTEA). The procedures have been extensively field tested at several U.S. Army installations. In this report, the methods and illustrations reflect recommended procedures. Many of the figures, tables, and reports refer to a fictional Army installation called "Camp Example."

Scope

This report covers one part of the RAILER program--interim maintenance management procedures. (Identification and inventory of components were described elsewhere.[5]) More specifically this report:

- Describes the RAILER I system.

[4] S. C. Solverson, M. Y. Shahin, and D. R. Burns, *Development of a Railroad Track Maintenance System for Army Installations: Initial Decision Report*, TR M-85/04/ ADA149491 (USA-CERL, November 1984).

[5] D. R. Uzarski, D. E. Plotkin, and D. G. Brown, *Maintenance Management of U.S. Army Railroad Networks—The RAILER System: Component Identification and Inventory Procedures*, TR M-88/13 (USA-CERL, September 1988).

- Explains what inventory, inspection, and other data elements are needed and how they are obtained for RAILER I use.

- Introduces the RAILER I microcomputer operating environment.

- Describes system's function the in both network and project level railroad maintenance management.

- Provides guidelines for system implementation.

- Summarizes the results of field tests conducted as part of the research.

Future RAILER technical reports will describe detailed track inspection procedures, structural evaluation of U.S. Army track, the development and use of a Track Structure Condition Index (TSCI), the complete RAILER system, and long-range work planning procedures.

Mode of Technology Transfer

The procedures described in this report can be used in their present form for managing the track networks associated with the FORMAP-2 program. These procedures will be compatible with the overall RAILER Railroad Maintenance Management System currently being developed by USA-CERL. It is recommended that RAILER I be used at all FORMAP-2 installations and that upgrades be made when available.

The RAILER I technology should be transferred to the installations through outside assistance, such as a contract administered by the U.S. Army Engineering and Housing Support Center (USAEHSC), and through a training program conducted in association with USAEHSC and USA-CERL. A computer user's guide[6] is available.

[6] D. A. Piland and D. R. Uzarski, *The RAILER System for Maintenance Management of U.S. Army Railroad Networks, RAILER I Computer User's Guide*, ADP Report M-88/16 (USA-CERL, September 1988).

2 THE RAILER I SYSTEM AND DATABASE

RAILER I couples civil, railroad, and maintenance engineering with database management technology to facilitate decision support; in particular, it permits the easy formation of annual and long-range work plans.

Its use consists of three interrelated types of activities involving a database:

- Data collection in the field
- Data entry and other data management activities
- Use of the database for decision support.

To facilitate these activities, the RAILER I system consists of three elements:

- Database structure
- Procedures for data collection that are consistent with the database structure
- Computer software for database management and decision support applications.

The RAILER I database structure (Figure 1) is the heart of the system. Although the computer software is integral to the RAILER I concept, the database structure can be partially implemented manually (without a computer) at some installations with small, simple railroad networks.

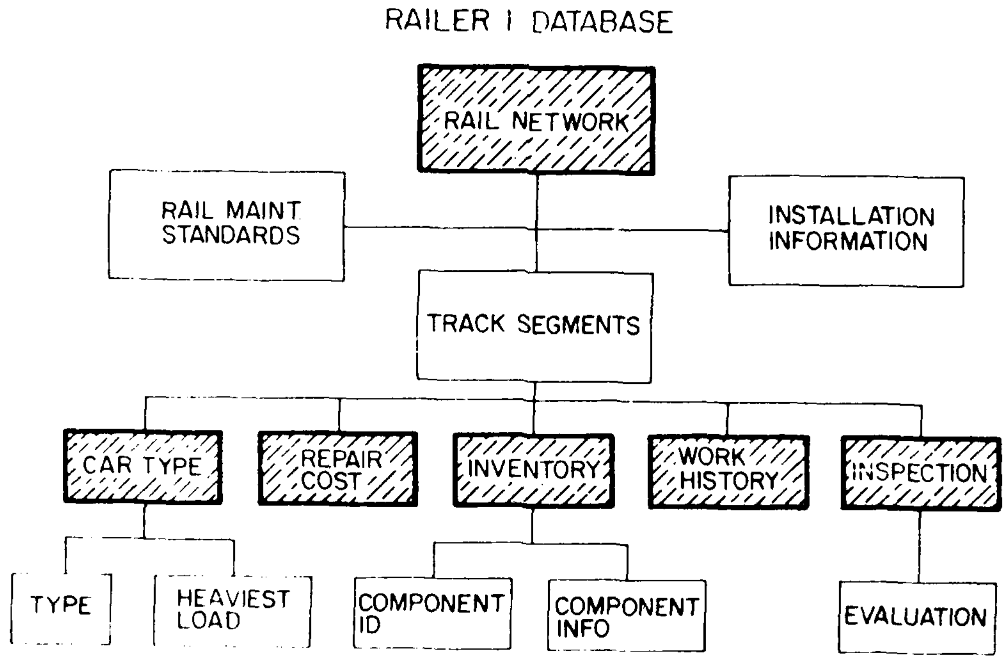

Figure 1. RAILER I database structure.

Database Structure

The database structure corresponds to a conceptual approach to subdividing an installation's track network. Each installation network consists of one or more tracks. For maintenance management purposes, each track is divided into one or more track segments. The RAILER I database for a network has three main sections: rail maintenance standards (which incorporate the Interim U.S. Army Railroad Track Maintenance Standards), installation information, and track segment data. As indicated in Figure 1, most of the database is organized around these track segments (middle box).

Installation information (upper right box, Figure 1) includes data elements which identify the installation, indicate the connecting commercial carrier, and summarize the network characteristics (the track numbers and length and number of segments of each track). Installation information is usually collected in conjunction with track segment inventory information. The data elements and collection procedures are described more fully in Chapter 3.

Rules and guidelines for track segmenting are discussed extensively in the RAILER inventory technical report.[7] If an installation's railroad network is viewed as a geometric arrangement of groups of three line segments which meet only at their end points, then the track segmenting process will usually identify each significant line segment as a separate track segment. This will generally result in track segments with homogeneous traffic loadings (and mission), allowing each track segment to be treated as a single unit for maintenance management purposes.

As indicated by the third row of boxes in Figure 1, several data sets are associated with each track segment. (Note: the order of the boxes in the figure does not indicate sequence or relationship.) Two of these, car type and inventory, include nonevaluative data which describe the segment and its use. The other three boxes, inspection, repair cost, and work history, contain data which are used in the routine M&R process.

In car type information, the "type" data element specifies the car types which are used on each track segment. This data is used to help indicate (along with other data elements) the relative importance of each segment with respect to the rest of the network. The heaviest load data within car type can be used for structural analysis of the track. This analysis is external to RAILER I but will be an internal facility in later versions. Car type information is discussed more fully in Chapter 5, where other uses of the data are also indicated.

Within track inventory, two track components in addition to track segments are assigned component identification numbers by RAILER; these are curves and turnouts. The assignment of these identification numbers is thoroughly documented in the RAILER Component Identification and Inventory Procedures technical report,[8] along with the inventory data structure. In Chapter 4 relevant parts of that report are summarized and minor differences between RAILER I and enhanced version segment inventory data elements and procedures are appropriately noted. In addition to these component IDs, the track inventory data provides a nonevaluative description of each track segment.

The track evaluation process that leads to M&R decisions is initiated by the collection of track inspection data. (The track inventory information discussed in the last

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[7] D. R. Uzarski, D. E. Plotkin, and D. G. Brown.
[8] D. R. Uzarski, D. E. Plotkin, and D. G. Brown.

paragraph provides the framework for the collection and manipulation of the inspection data.) Within RAILER I, inspection data is limited to five data groups: rail defects, turnouts, ties, vegetation, and track geometry; future inspection requirements will include other data groups such as road crossings and other track materials. The RAILER I track inspection data elements and collection procedures are described in Chapter 4.

After the inspection data are collected and entered into the database, the computer compares them to the Interim Track Maintenance Standards. These standards are represented by the upper left box in Figure 1. Discrepancies between the standards and inspection data constitute track defects.

The extent and type of these defects will largely determine the cost of repair. In RAILER I, the user enters an estimated repair cost along with other information for each track segment (later versions will generate these costs internally.) The repair cost data elements and related items are described more fully in Chapter 5. The use of these cost values within RAILER fosters cost effective maintenance management based on network logic. The collection and use of the cost data is discussed in Chapter 7.

Finally, whenever a track project is completed, a summary of the work performed on each segment is entered in the work history database. This feedback data allows the user to identify and analyze persistent problems. Work history data are discussed further in Chapter 5.

Related Facilities

Related Facility Information is another data set utilized in RAILER I. It is not depicted in Figure 1 because it is not directly connected to the main database structure. The Related Facility database is presented in Figure 2. As indicated there, Related Facility Information includes data elements on (connecting) commercial track, lighting, loading docks and ramps, and marshalling yard pavements. These elements have been separated from the main database at FORSCOM's request because of their indirect relationship with the installation track network. The collection and use of this data is discussed further in Chapter 5. These data elements will be more fully integrated into future RAILER versions.

FORPROP

In conjunction with RAILER I, USA-CERL has developed the Forces Command Railroad Project Prioritization Program (FORPROP), a computational procedure which enables FORSCOM to coordinate the FORMAP-2 railroad track major rehabilitation program. FORPROP is a decision support program for allocating funds to appropriate FORSCOM installation projects in an optimal fashion by maximizing overall benefit/cost ratios. This program is fully documented in a separate USA-CERL technical report and a computer operations guide. FORPROP implementation requires a selected set of RAILER I data elements from each installation; this includes installation information, car type, inventory, inspection, and related facility data elements. These elements and the RAILER I computer operations associated with sending them to FORSCOM are discussed in Chapter 6. The use of FORPROP for maintenance management is discussed in Chapter 7.

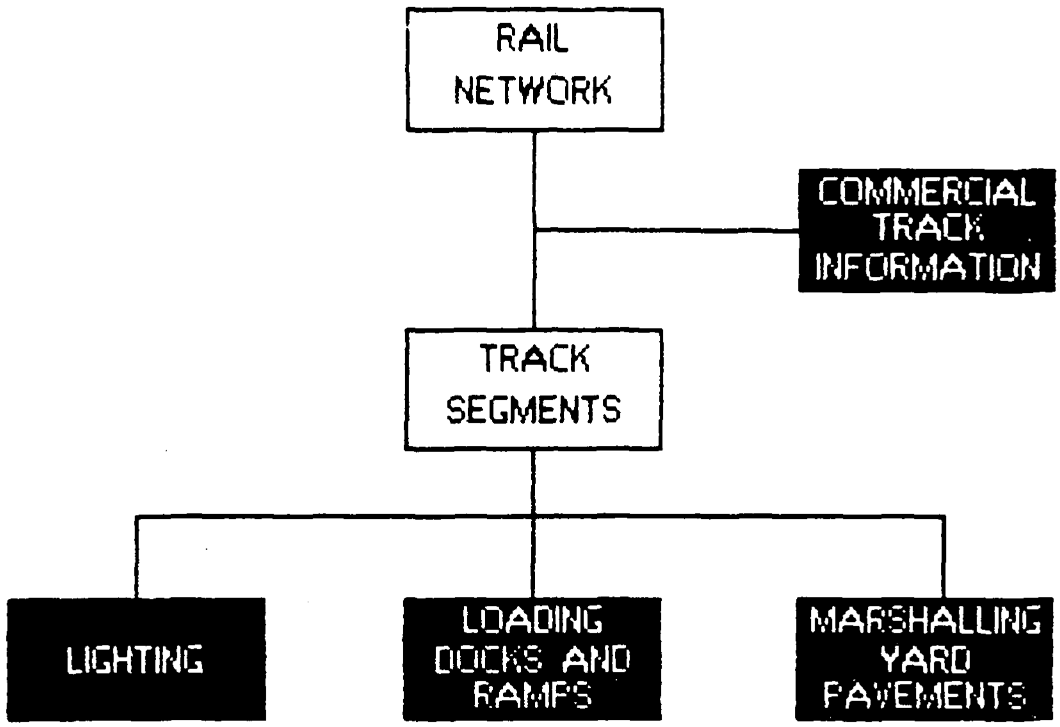

Figure 2. Related facilities database structure.

This completes the overview of the RAILER I database structure. Data collection procedures are described in Chapters 3 through 5, in conjunction with more detailed descriptions of the individual data elements. Data entry, other computer operations, and the computer system are described in Chapter 6. Chapters 7 through 9 discuss creating and maintaining an installation database that facilitates decision support for railroad maintenance management.

3 COMPONENT IDENTIFICATION AND TRACK SEGMENT INVENTORY

The first step in using RAILER I is identifying and locating these track components:

- Track and track segments
- Turnouts and curves
- Location references, using standard surveyor's stationing.

After all tracks, track segments, turnouts, and curves are numbered, and tracks are stationed, inventory information about each track segment must be obtained. The sections below summarize the component identification procedures and outline information contained in the RAILER I track segment inventory. More detail may be found in the previously cited RAILER component identification and inventory procedures technical report[9]. Within the RAILER I system, certain inventory elements have been simplified as an interim measure.

Component Identification

Within the overall RAILER system, four major track components are assigned identification numbers. These are:

1. Track. A branch of the track network.

2. Track Segment. A portion of a track. Segments represent the basic unit for railroad maintenance management.

3. Turnout. A track component structure used to divert trains from one track to another.

4. Curve. Bends in the track designed to change the direction of travel.

Track Identification

Each track in a network needs to be labeled with a unique number. Where numbers have been previously assigned, they should be retained. In the RAILER system track numbers can have a maximum of five alpha-numeric digits. A consecutive numbering sequence based on the network layout is recommended. The track numbering sequence at Camp Example (a fictitious installation) is shown in Figure 3.

Track Segment Identification

Tracks are divided into management units called track segments. Each track must have at least one track segment. Two required and two optional criteria are used for dividing tracks into segments: train operations, track use, rail weight (optional), and bridges (optional); these criteria are discussed further below.

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[9] D. R. Uzarski, D. E. Plotkin, and D. G. Brown.

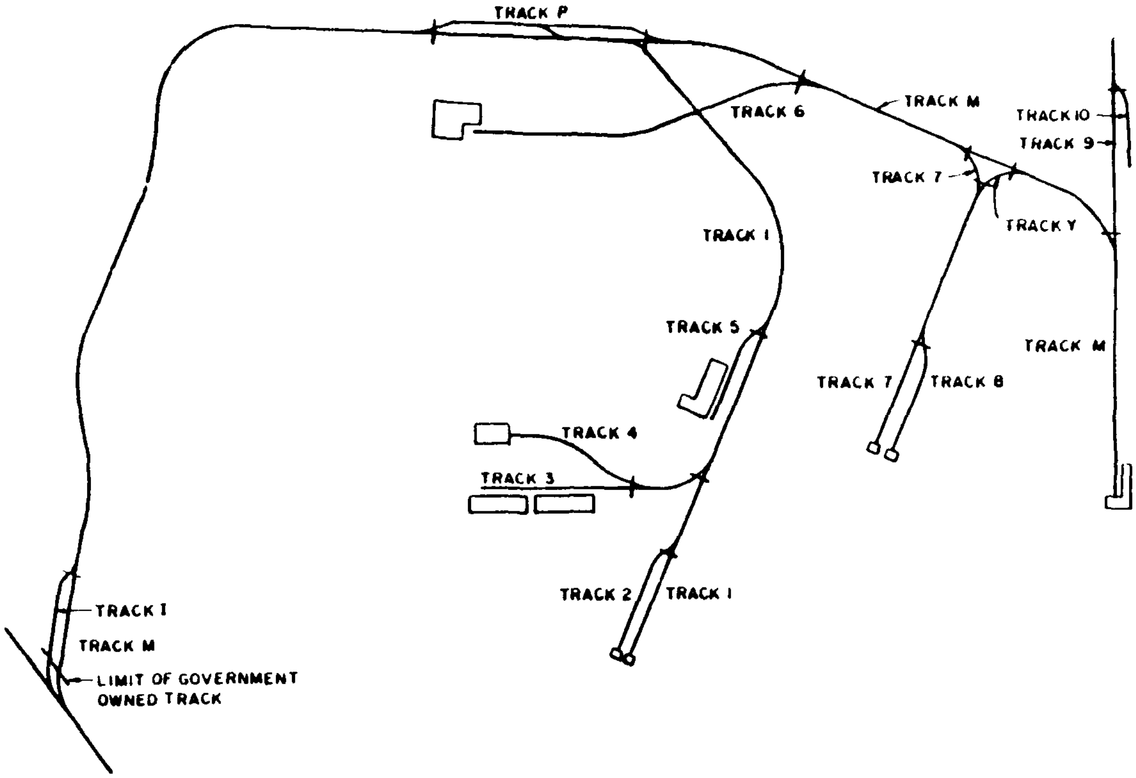

Figure 3. Track numbering sequence at Camp Example.

Once the tracks have been divided into appropriate track segments, they should be numbered for identification purposes. The track segment number is created by adding a 2-digit suffix to the track number.

Example: M03 (This indicates the third segment of track M)

Track segment numbers created in this fashion must not exceed seven alphanumeric digits. Numbers should be consecutive for all track segments of a given track. The track segment numbering sequence at Camp Example is shown in Figure 4.

Occasionally, it may be desirable to split a track segment into two or more smaller segments. In order to retain the consecutive numbering sequence without renumbering other segments, the "new" segments would retain the original 2-digit suffix plus an additional A, B, etc. for a total of a three digit suffix. Camp Example segments 901A and 901B (Figure 4) are the result of dividing the first segment of track 9 into two new track segments.

Train Operations. Track can also be divided into portions over which the type and density of operations are relatively uniform. These factors are partially determined by routing. Therefore, this segmenting criterion requires that segments begin or end at virtually every turnout, since a turnout allows a choice of routes. Each turnout is located within the single track segment that contains the switch points. The last switch tie defines the boundary of a turnout, and hence the beginning and ending points of segments which meet at the turnout. Figure 5 illustrates this segmenting process. The turnout aspect of the train operations criterion tends to dominate the segmenting process, as is evident in Figure 4.

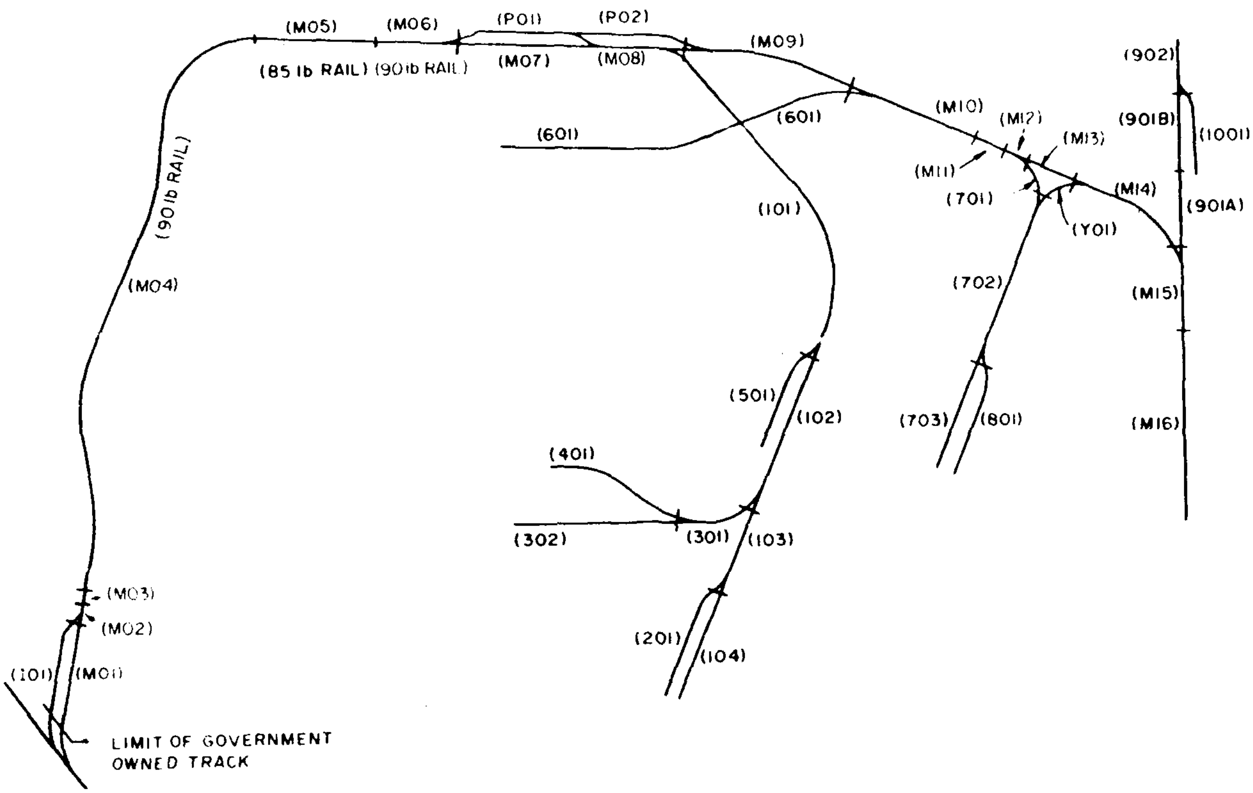

Figure 4. Track segment numbering sequence at Camp Exchange.

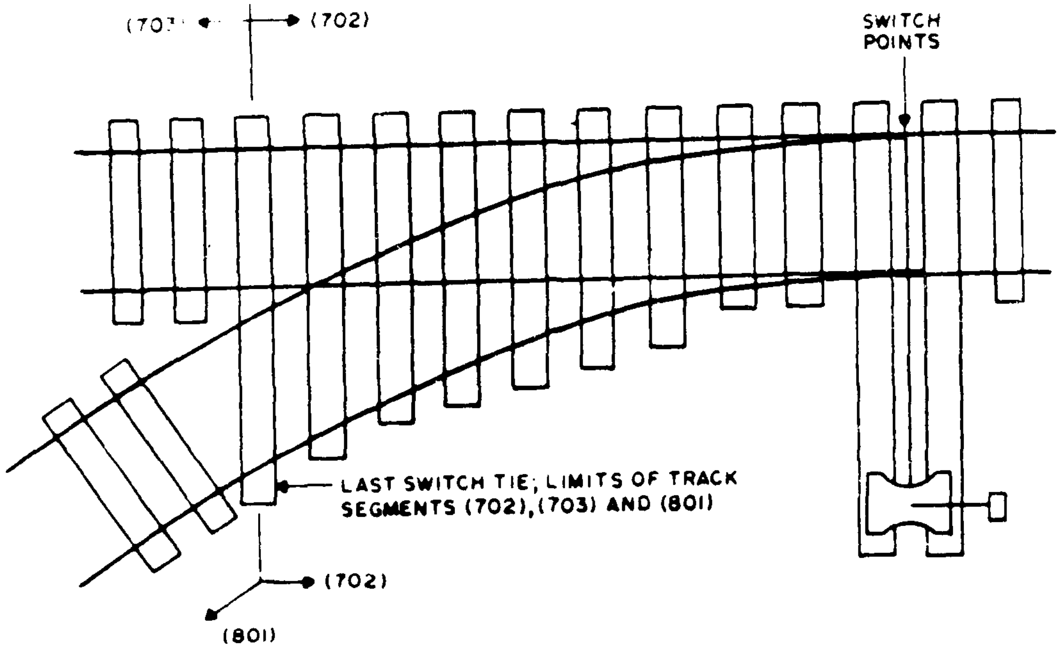

Figure 5. Track segmenting at a turnout (from Camp Example).

The rigid application of this segmenting "turnout rule" can sometimes result in track segments which are too small to be effective maintenance management units. Crossovers and back-to-back turnouts are two such situations addressed by the RAILER segmenting criteria. In a crossover connection (when there is less than 50 ft* of track between the last switch ties of the two crossover turnouts) each half of the crossover is included in the track segment containing the turnout. Similarly, if the distance between the last switch ties of back-to-back turnouts is less than 50 ft, half of this length is included in each of the two adjoining segments. See Figure 6 for illustrations of both situations (from Camp Example). In each case, if the track length between the last switch ties is more than 50 ft, it is treated as a separate track segment.

Some parts of a track may never have any trains on them. In such cases, the active and inactive portions of the track may be designated as separate segments. Segments 901A and 901B (Figure 4) are an example of this (segment 901A is active while 901B is not).

Track Use. While many specific track functions may exist within a network, five general categories are used for management purposes (the track uses at Camp Example are indicated in Figure 7):

1. Loading. Tracks used for loading and unloading mission-related equipment and supplies.

2. Storage. Tracks used for long- or short-term storage of freight cars, including classification yard tracks and interchange tracks.

3. Service. Tracks used for servicing either general installation operations or railroad equipment. Includes tracks leading to a power plant, waste treatment facility, commissary, engine house, or car shop.

4. Auxiliary. Tracks used to aid train operations, including sidings, wye tracks, and runaround tracks.

5. Access. Tracks which provide connections between the other five types of tracks, as well as those which link the installation and the commercial route(s).

Note that a given track, such as Camp Example Track M, can have different primary track uses along its length. The track use segmenting criterion accounts for the fact that these different track uses imply significantly different track maintenance activities and priorities, and hence should not be included in a single, homogeneous maintenance management unit.

As illustrated in Figure 7, the track use criterion tends to reinforce the train operations segmenting criterion. However, track use can indicate segmentation where train operations does not. For example, track use is the only distinction between Camp Example segments M15 and M16. (Segment M15 has Auxiliary track use in support of the wye operations which also require segments M10, M11, M12, M13, M14, 701, 702, and Y01.)

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*Metric conversion factors are available on p 116.

Rail Weight. It may be desirable to segment the track at rail weight change locations if the magnitude of the change and/or the associated track length are significant enough to warrant special management consideration. Camp Example segment M05 (Figure 4) reflects an application of this segmenting criterion.

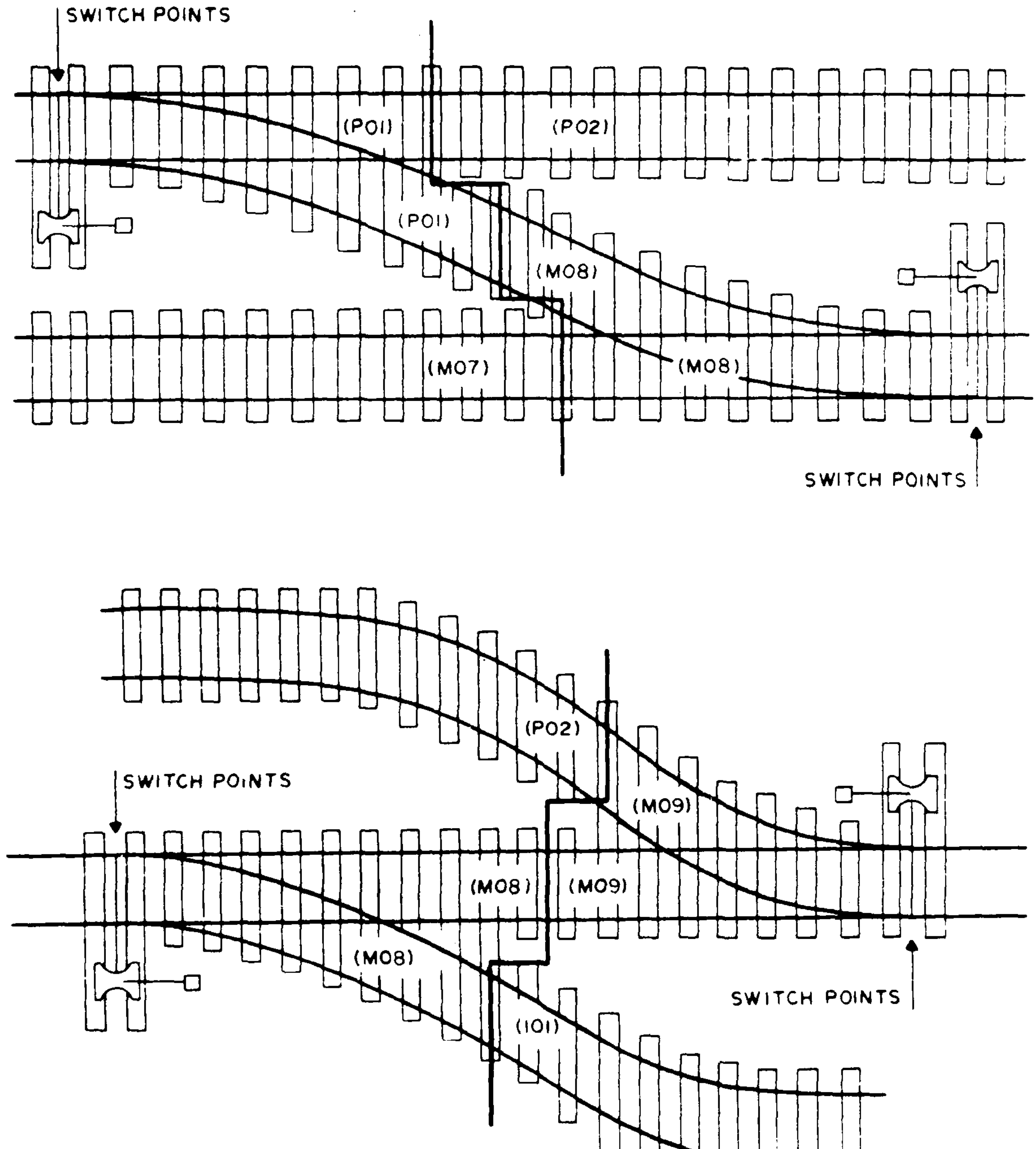

Figure 6. Track segmenting at crossovers and with back-to-back turnouts.

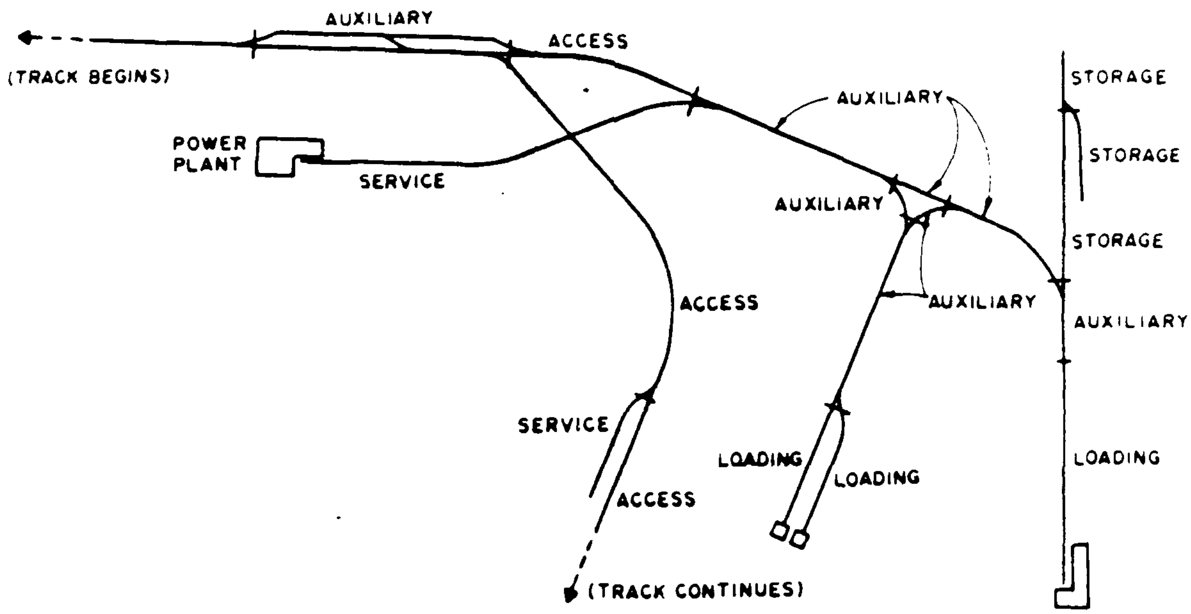

Figure 7. Track uses for a portion of the Camp Example network.

Bridges. Because of the unique maintenance requirements for trackage over a bridge, this length of track can be designated as a separate segment. The limits of a track segment at a bridge are illustrated in Figure 8. Camp Example segments M03 and M11 (Figure 4) are both bridge track segments.

Other Factors. Ideally, the track in any segment should have uniform traffic and physical characteristics over its entire length. Where significant changes in these characteristics occur, new segments should be created. Other than the four criteria discussed, segments may also be created based on ballast type, subgrade soil type, tie spacing, overall track condition, etc.

Turnout Identification

Turnouts are numbered individually within the track network. Where a numbering system has already been established, it should be retained. Otherwise, all turnouts are numbered as follows:

(Integer) T (Diverging Track Number)

This three-part number is established as follows.

1. Integer. "1" is reserved for the turnout where the diverging track begins. The point-of-switch location for the diverging track is usually station 0+00. All other turnouts leading to the same track are designated consecutively, (2,3,..), in an order corresponding to increasing station location.

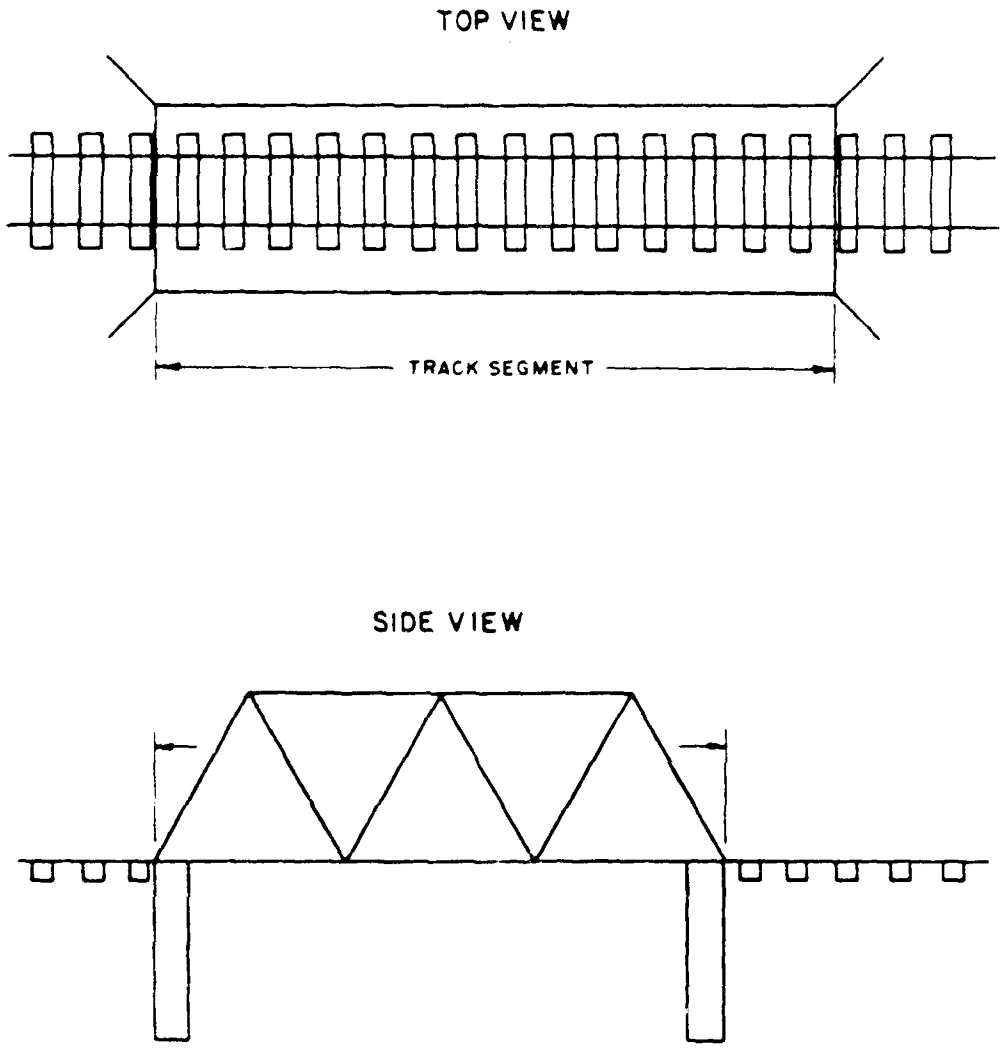

Figure 8. A bridge track segment.

2. T. Used to indicate that a turnout (rather than a track, track segment, or curve) is being identified.

3. Diverging Track Number. The track which the turnout diverges into or leads into.

Example: 1T26 (This indicates the first turnout leading into track 26).

The turnout numbering for a portion of Camp Example is depicted in Figure 9.

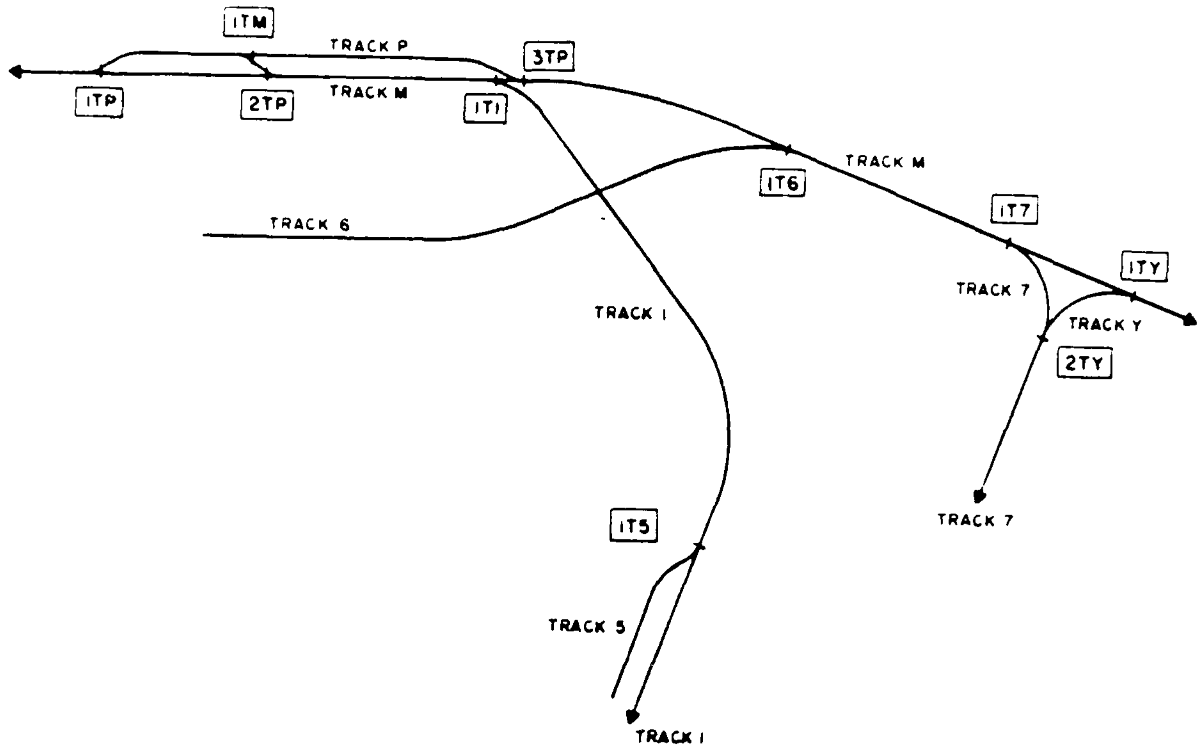

Figure 9. Turnout numbering for a portion of the Camp Example network.

Curve Identification

Unlike a turnout, a curve may be part of more than one track segment. However, a curve will always lie entirely with one track and thus will have only one identification number.

All curves should be numbered as follows:

(Integer) C (Track Number)

This three-part number is established as follows.

1. Integer. The curves in each track are numbered beginning with "1" for the first curve encountered and continuing consecutively to the end of the track.

2. C. Used to indicate that a curve (rather than a track, track segment, or turnout) is being identified.

3. Track Number. The track which contains the curve.

Example: 6C4A (This indicates the sixth curve in track 4A.)

The curve numbering for a portion of Camp Example is depicted in Figure 10.

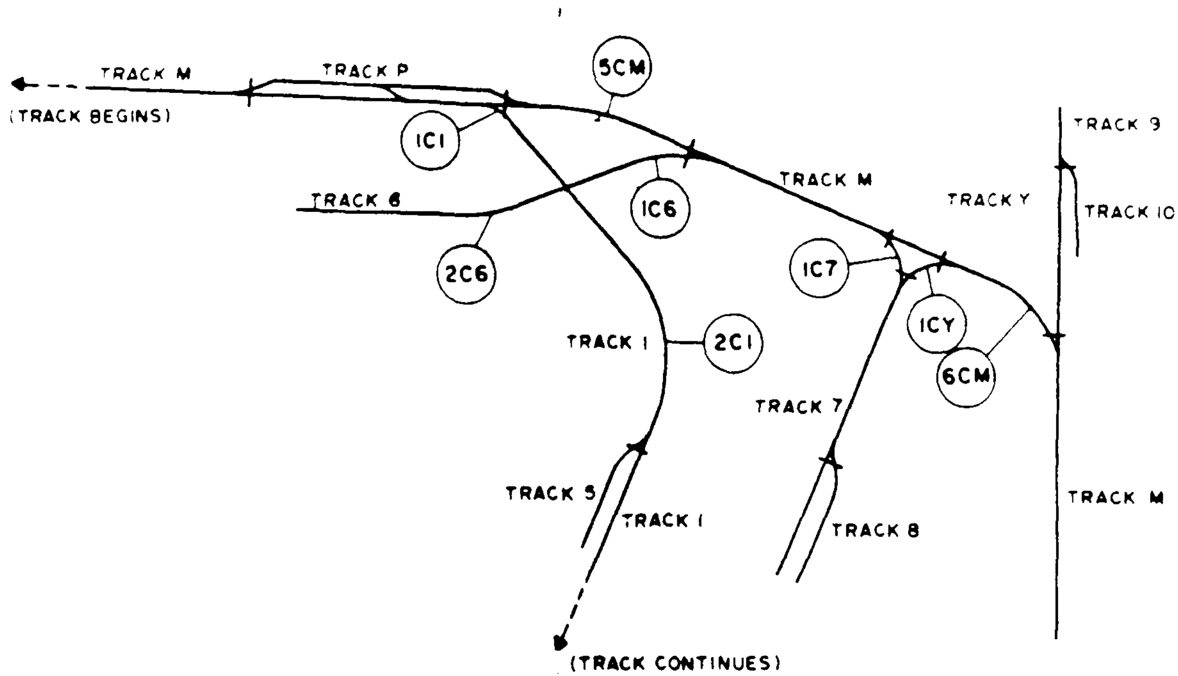

Figure 10. Curve numbering sequence for a portion of the Camp Example network.

Short connecting curves (those which allow a track to run parallel to its originating track) are usually not designated as separate curves, and are not included in the curve numbering sequence or curve inventory. When the distance between parallel tracks (centerline to centerline) is greater than 25 ft, the connecting curve should be separately identified (see Figure 11).

Location Referencing

Once tracks have been identified, a location reference system (track stationing) should be established to assist in locating inventory items and track deficiencies. The basic units are hundred-foot lengths (or stations) followed by a "+" and then the extra feet (less than 100) to the right of the "+". Thus, station 18+46 is 1,846 ft from the origin.

As defined in this report, a track originates at the point-of-switch of the turnout leading to the track. Figure 12 illustrates the origin of track 8 at a turnout. This point of origin, by definition, is station 0+00. An exception to this stationing procedure is the point on a track where Government maintenance responsibility begins. This point should be designated as station 0+00 for that track. (However, if that point is uncertain or unknown, this track should also be stationed from the point-of-switch.) Figure 13 illustrates this stationing sequence for Camp Example.

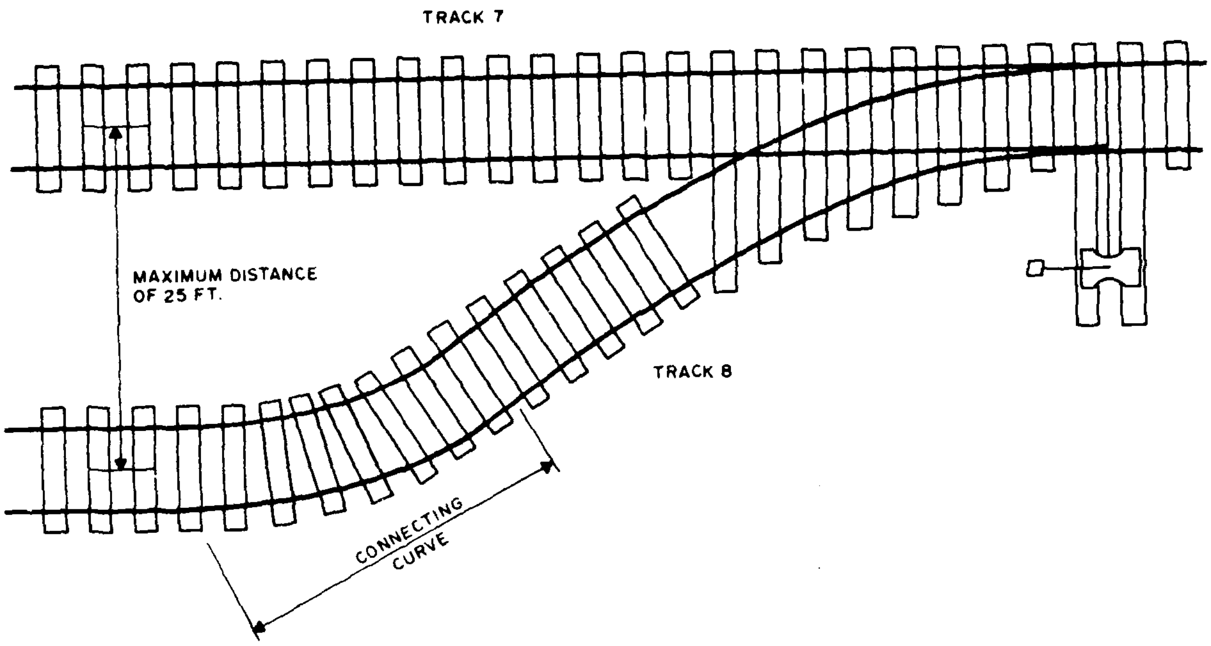

Figure 11. Illustration of connecting curve (from Camp Example).

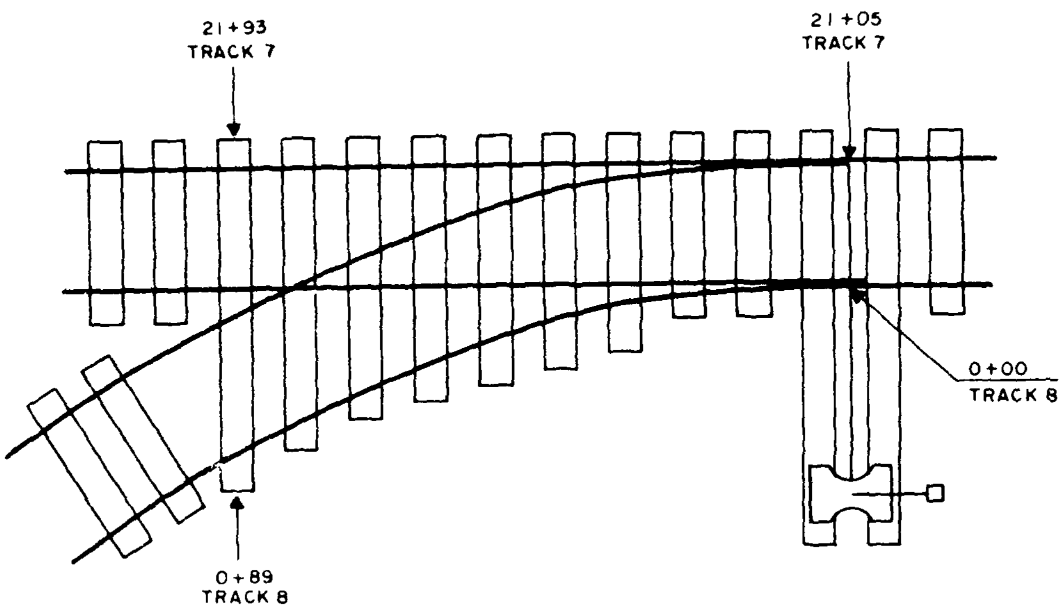

Figure 12. Track point of origin at point-of-switch (from Camp Example).

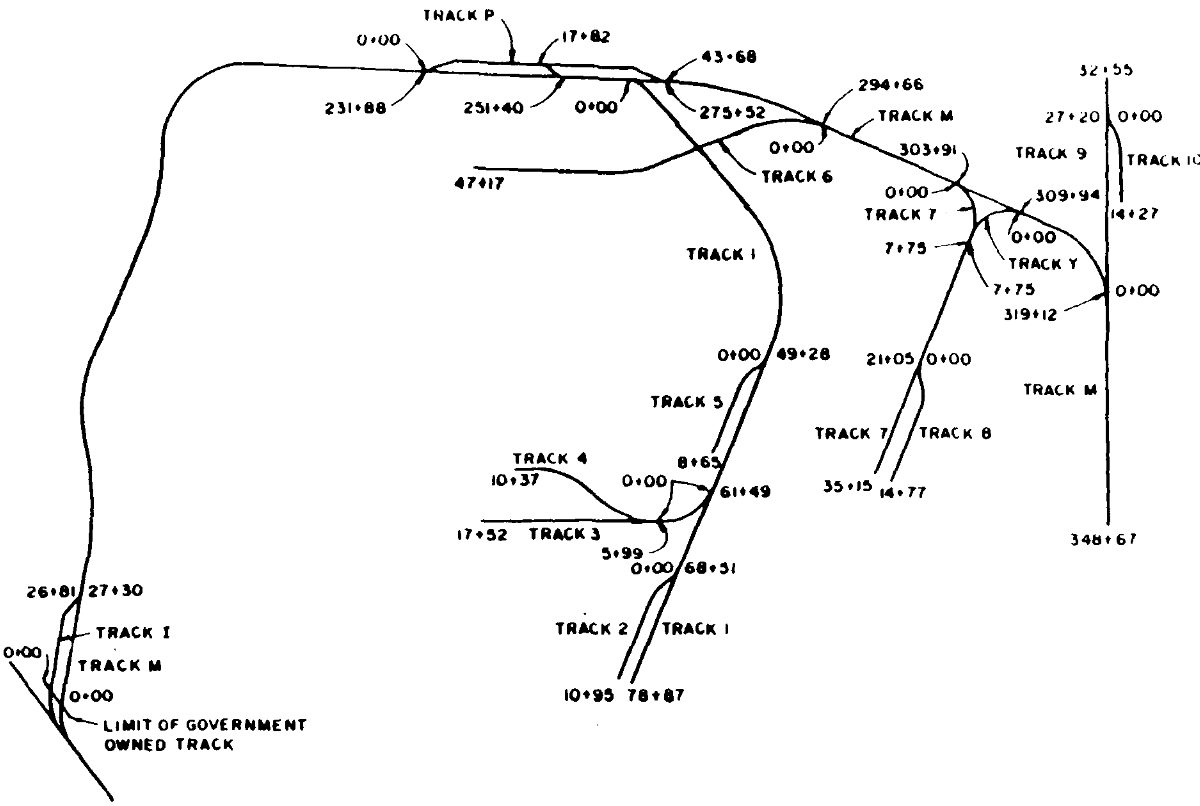

Figure 13. Track stationing sequence at Camp Example.

It is recommended that stamped metal plates (2 in. by 2 in.) be affixed to the ties every 200 ft, and trackside markers visible from a locomotive should be affixed every 1000 ft, where practical. Figure 14 shows a station plate affixed to a tie.

The referencing system should be accurate to the nearest foot. The use of a simple measuring wheel, either manually or mounted on a track cart, provides measurements to the required level of accuracy. These stationing techniques are discussed further in Chapter 10.

After an installation's track network has been stationed and all components (track segments, turnouts, and curves) have been identified, installation information and track segment inventory data can be collected.

Installation Information

The installation information data elements identify the installation, indicate the connecting commercial carrier, and summarize the network characteristics. These data elements are presented in Table 1. Detailed description of the elements can be found in the RAILER Component Identification and Inventory Procedures technical report. The first column of elements in Table 1 can generally be obtained from office records, subject to field verification when necessary; the items in the second column are collected

D. R. Uzarski, D. E. Plotkin, and D. G. Brown.

for each track on the installation. These latter elements summarize the network characteristics. Figure 15 shows a completed installation information form for Camp Example. A blank form is included in Appendix A.

Track Segment Inventory

Table 2 lists the RAILER I track segment inventory data elements which are organized into ten groups. Figure 16 shows a completed track segment inventory form; a blank form is included in Appendix A. These elements are only a subset of the overall RAILER system track segment inventory data elements presented in the RAILER component identification and inventory procedures technical report,[11] along with detailed element descriptions and data collection procedures. Only one of these data element definitions is different for RAILER I; as indicated in Figure 16, the tie plate data element is restricted to a "yes" or "no" response. This difference and the smaller set of inventory data elements reflect the interim nature of RAILER I.

Two of the inventory elements require some interpretation; the first is Beginning Location. Recall that track segments often begin and end at the last switch tie, but the 0+00 point of most tracks is located at the point-of-switch. As a consequence, the Beginning Location (data element 1, Table 2) of the first track segment of a track will usually be a station value greater than 0+00. This is illustrated by comparing Figures 5 and 12, which show, respectively, the segmentation and stationing at Camp Example turnout 1T8.

Figure 14. Illustration of a station plate affixed to a tie.

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[11] D. R. Uzarski, D. E. Plotkin, and D. G. Brown.

The second inventory element needing explanation is Track Rank (data element 5, Table 2). This element is a number ranging from zero to one that shows the relative importance of the track segment. By definition, the single most important functional track segment will have a value of 1.0, and all access and inactive track segments will have a value of 0.0. Track rank can be derived subjectively or through a calculation procedure presented in Appendix B. This procedure was developed specifically for FORSCOM type installations, and is thus recommended for use with RAILER I. Track rank is a key data element used in prioritizing segments and/or work accomplishment (discussed in Chapter 7).

Table 1

Installation Information Data Elements

Installation	Installation Trackage
1. Installation Number	6. Track Number
2. Relation Code	7. Track Length
3. Installation Name	8. Number of Segments
4. State Code	
5. Serving Railroad Company Name	

RAILER I
INSTALLATION INFORMATION

DATE: 7/1/87

INSTALLATION INFORMATION				
Installation Number	Relation Code	Installation Name	State Code	Serving Railroad Company Name
EX111	EX111	Camp Example	OR	Union Pacific RR

INSTALLATION TRACKAGE								
Track Number	Track Length	# of Segments	Track Number	Track Length	# of Segments	Track Number	Track Length	# of Segments
1	7887	4						
2	1095	1						
3	1752	2						
4	1037	1						
5	865	1						
6	4517	1						
7	3565	3						
8	1477	1						
9	3255	3						
10	1427	1						
I	2681	1						
M	34867	16						
P	4368	2						
Y	775	1						

12/15/86

Figure 15. Completed network information form for Camp Example.

Table 2

Track Segment Inventory Data Elements

SEGMENT IDENTIFICATION
1. Beginning Location
2. End Location
3. Track Category
4. Track Use
5. Track Rank
6. Preceding Segment Number
7. Comments

BALLAST
8. Ballast Depth
9. Comments

BRIDGES
10. Facility Number
11. Construction Type
12. Deck Type
13. Comments

CULVERTS
14. Centerline Location
15. Comments

CURVES
16. Curve Identification Number
17. Curvature
18. Maximum Desired Speed
19. Comments

PLATES/FASTENINGS
20. Tie Plates
21. Rail Anchors
22. Gage Rods
23. Comments

RAIL
24. Weight
25. Section
26. Begin Location
27. Comments

RAIL CROSSINGS
28. Centerline Location
29. Crossing Segment Number
30. Rail Weight
31. Frog Type
32. Crossing Angle
33. Comments

ROAD CROSSINGS
34. Road Name
35. Centerline Location
36. Crossing Length
37. Crossing Type
38. Bolted Joints
39. Comments

TURNOUTS
40. Turnout Identification Number
41. Switch Point Location
42. Direction
43. Point Length
44. Rail Weight
45. Frog Type
46. Frog Size
47. Guard Rail Length
48. Comments

TRACK SEGMENT #: 101 RAILER I DATE: 5/29/87

INSTALLATION NAME: Camp Example TRACK SEGMENT INVENTORY INFORMATION

SEGMENT IDENTIFICATION						BALLAST
Begin Location (station)	End Location (station)	Track Category	Track Use	Track Rank	Preceding Track Segment Number (s)	Depth (inches)
1+11	50+16	(A) B	(Acc) Aux L So St	0.0	M08	14
Comments:						Comments:

BRIDGES			CULVERTS	CURVES										
Facility Number	Construction Type	Deck Type	Centerline Location (Station)	Curve ID Number	Curvature (Degrees) 1	2	3	4	5	6	7	8	Avg	Max Desired Speed (m.p.h.)
		Open Ballast	47+41	1C1									8	15
		Open Ballast		2C1									4.5	20
Comments:			Comments: Bridger Creek	Comments:										

PLATES/FASTENINGS			RAIL			RAIL CROSSINGS				
Tie Plates	Rail Anchors (#/200 TF)	Gage Rods	Weight (lbs/yd)	Section	Begin Location (Station)	Centerline Location (Station)	Crossing Segment Number	Rail Weight (lbs/yd)	Frog Type	Crossing Angle (degree)
N (Y)	80	(N) Y	90	AS	1+11	12+29	601	90	(B) RI SM	60
N Y		N Y							B RI SM	
N Y		N Y							B RI SM	
N Y		N Y							B RI SM	
Comments:			Comments:			Comments:				

ROAD CROSSINGS				
Road Name	Centerline Location (Station)	Crossing Length (feet)	Crossing Type	Bolted Joints
Bradley Blvd.	36+48	24	Timber/Asphalt	N (Y)
				N Y
				N Y
Comments:				

TURNOUTS							
Turnout ID Number	Switch Point Location (Station)	Direction	Point Length (LF)	Rail Weight (lbs/yd)	Frog Type	Frog Size	Guard Rail Length (LF)
1TS	49+28	LH EQ (RH)	13	90	(B) SG RBM SP	7	11
		LH EQ RH			B SG RBM SP		
Comments:							

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Figure 16. Completed Track Segment Inventory Form for Camp Example Segment 101.

4 TRACK INSPECTION

Inspection consists primarily of visual observation of the track and roadway, along with some measurements of track geometry. When needed, automated track geometry measuring and internal rail defect testing may be added to the process. As with inventory, inspection information is obtained and recorded for each track segment in the railroad network.

RAILER I inspection covers the following:

- Ties
- Turnouts
- Vegetation
- Automated track geometry
- Rail defect testing.

Recommended data collection forms have been created to help the inspector gather the required information and to assist with entry of the information into the computer database. Blank copies of the inspection forms may be found in Appendix A. All track inspection follows criteria established by the Interim U.S. Army Railroad Track Maintenance Standards.

Once the inspection information has been entered into the computer database, the RAILER I program can compare the inspection information to the Army track standards and print the results of the comparison in varying levels of detail. In addition, the actual inspection information may be printed in a variety of forms, ranging from single pieces of information to a complete inspection record. These comparison and other inspection report formats are discussed in detail and illustrated with examples in Chapters 7 and 8.

The inspection procedures discussed below are sometimes inappropriate when a track segment is extremely deteriorated. The time and effort required to implement these procedures is often roughly proportional to the density of track defects. For network level management, the primary purpose of track inspection is assessing track condition; however, with severely deteriorated track segments, track condition can usually be easily determined by a very cursory examination. A complete RAILER I inspection of these segments is therefore often unwarranted. Instead, the RAILER I user can indicate with the RAILER I computer procedures that the track segment is extremely deteriorated and hence does not need a complete RAILER I inspection (at this time).

In the RAILER I system, inspection forms often use "number of occurrences" for reporting observations. An "occurrence" will have one of two interpretations. For ties, single, specific, "countable" observations (such as a defective tie) are recorded each time that observation is noted. For vegetation inspection, this definition is difficult to apply. In this case, there may be long, continuous conditions that need to be noted. In such cases, an "occurrence" is any observation of the condition within a 200-ft length. If the condition extends past a 200-ft mark, then a second "occurrence" is usually recorded. (Note: in implementing RAILER, it is recommended that 200-ft station markers be installed on the track or roadway).

The following sections include a discussion of the required inspection along with sample completed inspection forms.

Ties

Tie inspection involves determining which ties are defective, and then noting both the total number of defective ties in each segment and the number of times certain arrangements of defective ties occur. Ties significantly shifted from their required normal position are also noted during the inspection. Tie renewal generally dominates track maintenance management at most installations; the following detailed discussion reflects the corresponding importance of tie inspection.

In RAILER and the U.S. Army track maintenance standards, the term "defective tie" is reserved for ties which can no longer adequately perform their function in the track structure, usually because of deterioration. Each defective or missing tie is a tie defect; occurrences of consecutive defective or missing ties (in groups of 2, 3, 4, and 5 or more) are also tie defects. However, not all tie defect types are specifically concerned with defective ties. Some tie defect types, such as skewed ties, concern the position of the tie with respect to the rest of the track structure.

Four track segments can be inspected with a single tie inspection form. Figure 17 shows a completed form for three Camp Example track segments and EXMPL01, another hypothetical track segment. The data for segment EXMPL01 is based on the diagram of tie defects in Figure 18; this figure represents all significant aspects of RAILER I tie inspection. The following discussion refers to segment EXMPL01.

As diagrammed in Figure 18, track segment EXMPL01 is 99 ft long (three 33-ft rails on the north side) and includes 55 ties. The defective ties are counted on the diagram; this number, 32, is entered in the last column of the form (bottom of Figure 17). It is suggested that a hand-held counter be used to keep track of the total defective tie count.

Each occurrence of consecutive defective ties is also noted on the tie inspection form with tally marks which are then totaled at the bottom of each column. (There is also space for tally marks for "Total Defective Ties" in case a hand-held counter is not available.) For example, there are two occurrences of three defective ties in a row in segment EXMPL01 (centered around ties number 13 and 44, respectively). Each multiple of five consecutive defective ties is counted as a separate occurrence with any remainder forming an appropriate cluster; for example, 18 consecutive defective ties count as three occurrences of "5 or more" and one occurrence of "3." With track segment EXMPL01, the seven consecutive ties centered around tie number 36 count as a single occurrence of "5 or more" and one occurrence of "2."

The Interim U.S. Army Track Maintenance Standards require all rail joints to "be supported by at least one nondefective crosstie whose centerline is within 18 in. of the rail ends." For inspection purposes, all ties within 18 in. of the rail ends are termed "joint ties." Occurrences of the tie defect type "All Joint Ties Defective" are associated with individual rail joints. There are two such occurrences in track segment EXMPL01 (located at stations 5+33 and 5+66). Often only one of two joint ties is defective, such as at stations 5+17 and 5+83 in segment EXMPL01; these are not occurrences of this tie defect type.

RAILER I INSPECTION
TIES

DATE: 7/2/87
INSPECTOR: Dave Brow

DEFECTIVE TIE CONDITIONS

TRACK SEGMENT #	CONSECUTIVE DEFECTIVE TIES 2	3	4	5 or more	ALL JOINT TIES DEFECTIVE	AVERAGE SPACING PER RAIL LENGTH > 22 in.	SKEWED TIES	MISSING/ BUNCHED/BADLY SKEWED TIES (tie spacing along either Rail > 48 in.)	TOTAL DEFECTIVE TIES
101 TOTAL	67	15	0	0	0	0	0	0	455
COMMENTS:									
102 TOTAL	15	7	1	0	1	0	0	0	123
COMMENTS:									
103 TOTAL	15	0	3	0	0	0	1	0	30
COMMENTS:									
EXMPL01 TOTAL	7	2	0	1	2	1	6	5	32
COMMENTS:									

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Figure 17. Completed tie inspection form for three Camp Example track segments and Segment EXMPL01.

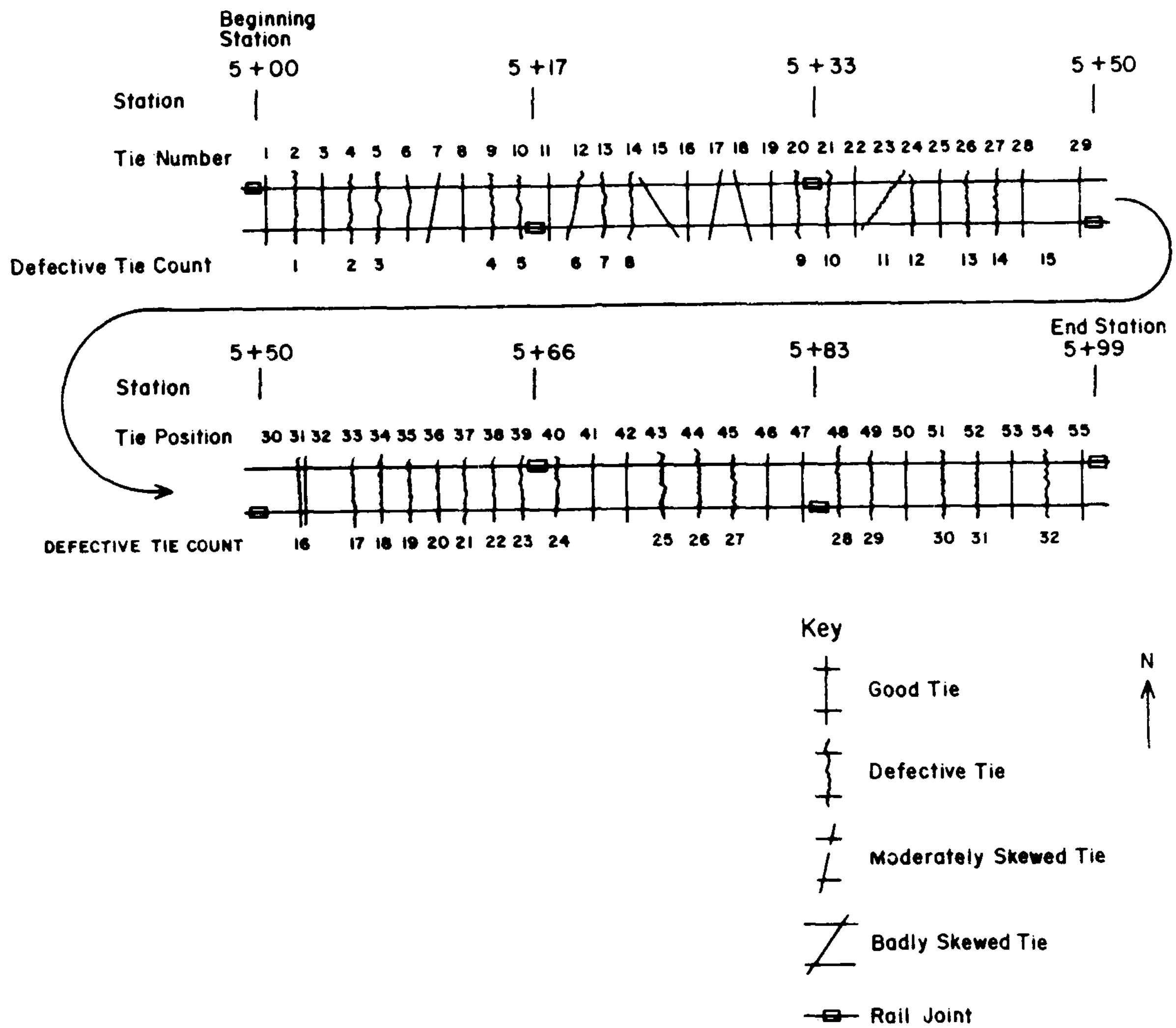

Figure 18. Tie defects track diagram of Segment EXMPL01.

An average tie spacing of 22 in. or less is required by the Interim U.S. Army Track Maintenance Standards. As indicated on the tie inspection form, a larger average tie spacing along a rail length counts as a tie defect occurrence. With the 33-ft rail lengths of track segment EXMPL01, a 22-in. average tie spacing is equivalent to 18 ties per rail length. Along the first two rail lengths on the north rail of that segment, there are 20 ties per rail length; however, along the last rail length there are 16 ties, hence the single occurrence of this defect type.

Ties that are skewed to any significant degree are undesirable and should be noted during track inspection. There are six skewed ties in track segment EXMPL01. When defective ties are also skewed, they do not count as skewed tie defect occurrences. Sometimes because of severe skewing or other reasons, the center-to-center distance between two ties along one or both rails is greater than 48 in. This is a separate tie defect type of which there are five occurrences in segment EXMPL01. Two of these occurrences are due to severely skewed ties; the other three are respectively due to: the combined effect of two moderately skewed ties (ties 17 and 18), a missing tie (between ties 28 and 29), and a bunched tie (tie number 32).

When tie inspection for a track segment is completed, the number of occurrences of each defect type are totaled. These totals will then be entered into the RAILER I database.

Turnouts

Turnout inspection involves examining the condition of the individual parts, determining whether the parts are properly applied and fastened, and making measurements to check for proper position and adjustment.

The RAILER I turnout inspection form is arranged to guide the inspector through the inspection process. A sample completed turnout inspection form is shown in Figure 19. Defects are simply checked (or their number noted) on the form and measurements are entered where requested. In addition, diagrams have been provided on the back of the form (Figure 20) to illustrate the required measurements and certain switch point and frog defects.

The condition of most turnout parts is recorded in the middle section of the form (Components). In this section, observations have been grouped into five categories, with the following general interpretations:

1. No Defects. There is nothing wrong with that component.

2. Improper size/type/position. The component is either the wrong type or improperly positioned, but is fully secured and does provide at least part of its intended function.

3. Loose. The correct part is in place but not properly secured.

4. Chipped/worn/bent/cracked/broken/corroded/altered. Physical defects significant enough to prevent the component from functioning properly. The component is considered defective and should be replaced.

5. Missing. Component part is not there.

Vegetation

Vegetation inspection involves observing when significant amounts of vegetation are present in the roadbed or within 3 ft of the track centerline. In the RAILER I system, observations are recorded for each 200-ft stretch of track (the length used to indicate an "occurrence") for locations to left and right sides of the track, as well as on the track itself. Thus, if a segment begins at station 4+00 and ends at 20+00, then there can be at most eight occurrences of each vegetation defect for each location.

RAILER I INSPECTION
TURNOUTS

TRACK SEGMENT #: M12
TURNOUT ID #: 1T7

DATE: 7/2/87
INSPECTOR: HARRIS

GENERAL		TIES	
Rail Weight changes within Turnout limits	N (Y)	# of Defective Ties in a row (worst case)	2
Reversing Tangent Past Frog Less than 50 Feet	(N) Y	# of Occurrences where Joint Ties are Defective	1
Switch Difficult to Operate	N (Y)	# of Occurrences where Tie Spacing > 22 in.	0
		# of Skewed Ties	3
Line & Surface	Good Fair (Poor)	# of Missing/Bunched/Badly Skewed Ties (Tie spacing along either rail > 48 in.)	c
		TOTAL # of Defective Ties	7

	COMPONENTS	NO DEFECTS	IMPROPER SIZE/ TYPE/POSITION (Y or #)	LOOSE (Y or #)	CHIPPED/WORN/BENT/ CRACKED/BROKEN/ CORRODED/ALTERED (Y or #)	MISSING (Y or #)
SWITCH & STAND	Switch Stand		Y	Y	(Y)	Y
	Point Lock/Lever Latch		Y	Y	Y	(Y)
	Connecting Rod		Y	Y	(Y)	Y
	Switch Point - Left		Y *	Y	(Y)	Y
	Switch Point - Right		Y *	Y	(Y)	Y
	Switch Rods				2	
	Clip Bolts		4			
	Slide Plates			2		
	Braces			2		3
	Heel Filler & Bolts					2
	Cotter Keys			4		
FROG	Point & Top Surface		Y	Y	(Y)	Y
	Bolts			4		
GUARD RAILS	Guard Rails	✓				
	Filler & Bolts	✓				

	MEASUREMENTS (inches)	STRAIGHT SIDE	TURNOUT SIDE
FROG +	Gage at Point	56.1	57.2
	Guard Check Gage	54.4	55.6
	Guard Face Gage	52.8	54.0
	Flangeway Width	1.6	1.6
	Flangeway Depth	1.6	1.6
GUARD RAILS +	Flangeway Width	1.6	1.6
OTHER	Gage at Switch Points	57.2	
	Gage at Joints in Curved Closure Rails	56.1	

COMMENTS:

* See reverse for illustrations of wear and improper positions
+ See reverse for illustrations of measurements

Figure 19. Completed turnout inspection form for Camp Example.

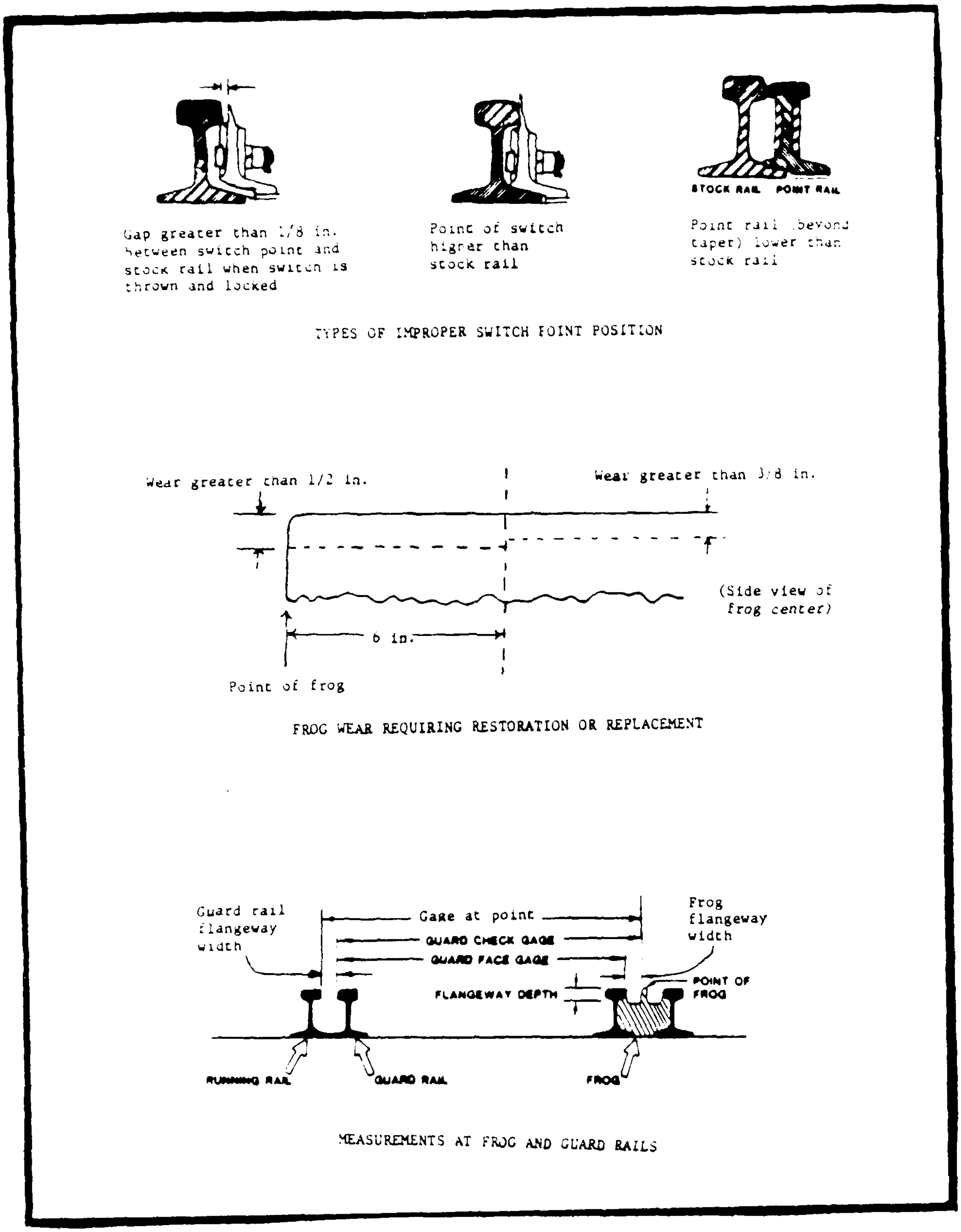

Figure 20. Back of turnout inspection form.

Segments do not normally begin or end at even 200 ft stations. If the distance from the beginning (or end) of the segment to the nearest 200 ft station in the segment is 100 ft or more, then this length of track is treated like a separate 200 ft track length and can have vegetation defect occurrences. If the distance is less than 100 ft, then this portion of track is combined with the adjacent 200 ft section for purposes of vegetation defect occurrences. For example, consider a track segment which begins at 0+80 and ends at 50+70. Here the track from 0+80 to 2+00 can have separate defect occurrences; however, the portion from 50+00 to 50+70 cannot, but is combined with the 48+00 to 50+00 portion for vegetation inspection.

Like the tie inspection form, four track segments can be inspected with a single vegetation inspection form. Figure 21 shows a completed form. A diagram on back of the vegetation inspection form (Figure 22) shows the limits for left, center, and right locations.

At any point along the track, a vegetation defect might occur in one, two, or all three of the locations listed (left, center, right). Several different types of defects may be marked for each 200 ft; however, any single defect type may be marked only once.

When defects do not apply to a location, the location column shows a dash. For example, the defect of "Growing In Ballast" can only apply to the roadbed, or "Center" location.

When vegetation inspection is complete, the occurrences are totaled and entered into the RAILER I database.

Automated Track Geometry Measurements

The RAILER I system is set up to handle input of track geometry information directly from a computer disk produced by automated track geometry measuring equipment. Since the information is obtained directly from a computer disk, there is no track geometry inspection form. For the information to be read into the RAILER I database properly, it must be collected and formatted appropriately. Each observation includes the seven data elements described in Table 3. The data must be collected in an ASCII file with one line per observation; the seven data elements in each line are separated by single blank spaces. This format requirement is illustrated in Table 4. As indicated in Table 3, RAILER I is capable of handling gage, crosslevel, and warp information.

Rail Defects

Most rail defects are internal and show outward effects only in their later stages. Thus, inspection for rail defects usually requires the services of a contractor who has special rail defect detection equipment. Information on obtaining these services and writing contract specifications may be obtained from the U.S. Army Corps of Engineers Waterways Experiment Station.*

*David Coleman, Waterways Experiment Station, ATTN: WESGP-1P, 3909 Halls Ferry Road, P.O. Box 631, Vicksburg, MS 39180; telephone (commercial) (601) 634-2223.

RAILER I INSPECTION
VEGETATION

DATE: 7/3/87
INSPECTOR: R. Harris

TRACK SEGMENT	DEFECTS	LOCATION* Left Occurrences	Left Total	Center Occurrences	Center Total	Right Occurrences	Right Total
101	No Defects	卌 卌 |	11	卌 ||||	9	卌 卌	10
	Insufficient, where needed	卌	5		-	||	2
	Growing in Ballast		-	卌 卌 卌 ||	15		-
	Prevents Track Inspection	|	1		2	||	2
	Interferes with Walking	|	1		0	||	2
	Interferes with Visibility of Signs	||	2		-	卌	5
	Brushes Sides of Rolling Stock	||||	4	|	1	卌 |	6
	Interferes with Trains or Track Vehicles	|	1		0		0
	Presents a Fire Hazard	|	1	|	1	|	1
	COMMENTS:						
102	No Defects	卌 |	6		0	|||	3
	Insufficient, where needed		0		-		0
	Growing in Ballast		-	卌 |	6		-
	Prevents Track Inspection		0	||	2		0
	Interferes with Walking		0		0		0
	Interferes with Visibility of Signs		0		-	|	1
	Brushes Sides of Rolling Stock		0		0	||	2
	Interferes with Trains or Track Vehicles		0		0		0
	Presents a Fire Hazard		0	|	1		0
	COMMENTS:						
103	No Defects		0	||	2	|	1
	Insufficient, where needed	|	1		-		0
	Growing in Ballast		-	||	2		-
	Prevents Track Inspection		0		0		0
	Interferes with Walking	|	1		0		0
	Interferes with Visibility of Signs	||	2		-	|	1
	Brushes Sides of Rolling Stock	|	1		0	|	1
	Interferes with Trains or Track Vehicles	|	1		0		0
	Presents a Fire Hazard		0		0	|	1
	COMMENTS:						
104	No Defects	|	1		0	||	2
	Insufficient, where needed		0		-		0
	Growing in Ballast		-	||||	4		-
	Prevents Track Inspection		0		0		0
	Interferes with Walking	|	1	|	1		0
	Interferes with Visibility of Signs	|	1		-	|	1
	Brushes Sides of Rolling Stock	||	2	|	1	||	2
	Interferes with Trains or Track Vehicles		0		0		0
	Presents a Fire Hazard		0		0		0
	COMMENTS:						

* See reverse for illustrations of location

1/29/

Figure 21. Completed vegetation inspection form for Camp Example.

The RAILER I system can handle rail defect information obtained from detection equipment output or based on visual inspection. Figure 23 is a completed rail inspection form for Camp Example. When detection equipment is used, the information may be entered into the database directly from the continuous report, or the information may be transferred onto the form and then entered.

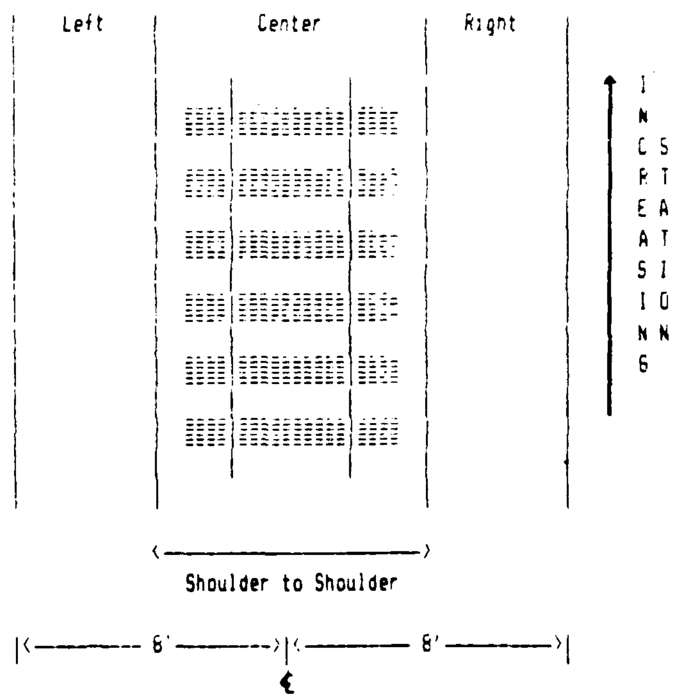

Figure 22. Diagram on back of vegetation inspection form.

Table 3

Track Geometry Data Elements

1. Track Segment Number
2. Station Location
3. Gage Measurement
4. Crosslevel Measurement
5. Warp Measurement
6. Curve ID Number

   This data element is one of the following:

   a) A Curve Identification Number (data element number 16, Table 2) if measurement is made in a curve.

   b) A pound sign (#), indicating that the location of the measurement is not in a curve.

   c) A capital s (S), indicating that the data (set of seven elements) comes from the spiral (transition) portion of the curve.

7. Turnout ID Number

   This data element is one of the following:

   a) A Turnout Identification Number (data element number 40, Table 2) if measurement is made within limits of a turnout.

   b) A pound sign (#), indicating that the location of the measurement is not in a turnout.

Table 4

Samples of Track Geometry Data from Camp Example Track 1

Data Element Numbers (See Table 3)

1	2	3	4	5	6	7
101	7+44	57.1	+0.4	+1.3	#	#
101	7+45	57.1	+0.4	+1.4	#	#
101	7+46	57.0	+0.4	+2.2	S	#
101	7+47	56.9	+0.3	+1.9	S	#

1	2	3	4	5	6	7
101	9+98	56.6	+0.2	+0.6	#	#
101	9+99	56.6	+0.0	+1.0	#	#
101	10+00	56.6	-0.0	+1.2	#	#
101	10+01	56.6	-0.1	+1.3	#	#
101	10+02	56.6	-0.1	+1.3	#	#
101	10+03	56.7	-0.2	+1.1	#	#
101	10+04	56.7	-0.1	+0.6	#	#
101	10+05	56.7	-0.1	-0.2	#	#
101	10+06	56.7	-0.2	-0.6	#	#

1	2	3	4	5	6	7
101	24+47	56.6	+0.1	+0.1	#	#
101	24+48	56.6	+0.1	+0.1	#	#
101	24+49	56.6	+0.0	-0.0	2C1	#
101	24+50	56.7	-0.0	-0.1	2C1	#

1	2	3	4	5	6	7
101	49+26	57.0	-1.5	+2.6	#	#
101	49+27	56.8	-1.5	+2.6	#	#
101	49+28	56.7	-1.4	+2.6	#	1T5
101	49+29	56.7	-1.5	+2.6	#	1T5

1	2	3	4	5	6	7
101	50+14	56.4	-1.7	+0.8	#	1T5
101	50+15	56.3	-1.8	+0.7	#	1T5
102	50+16	56.4	-1.8	+0.7	#	#
102	50+17	56.4	-1.8	+0.6	#	#

INSTALLATION NAME: Camp Example

RAILER I
RAIL INSPECTION

TRACK SEGMENT NUMBER	DATE	LOCATION (STATION)	RAIL (LEFT OR RIGHT)	DEFECT TYPE	COMMENTS
401	5/20/?7	10+23	L	17	
501	"	—	—	26	
701	"	3+83	L	18	
901A	"	—	—	26	
901B	"	18+86	R	4	
M04	"	168+48	R	11	
M04	"	78+45	R	13	
I01	"	3+08	L	19	

RAIL DEFECT TYPES

1 = Bolt Hole Crack
2 = Broken Base
3 = Corroded Base
4 = Complete Break
5 = Crushed Head
6 = Defective Weld
7 = End Batter (>1/4")
8 = Fissure - Compound
9 = Fissure - Transverse
10 = Fracture - Detail
11 = Fracture - Engine Burn
12 = Head/Web Separation
13 = Piped Rail
14 = Split Head - Horizontal
15 = Split Head - Vertical
16 = Split Web
17 = Torch Cut
18 = Wear - Side (>1/2")
19 = Wear - Vertical (>1/2")
20 = Overflow
21 = Shelling
22 = Corrugation
23 = Chip/Dent in Head
24 = Engine Burn
25 = Flaking
26 = Rail Weight Insufficient for Mission

Figure 23. Completed rail inspection form for Camp Example.

5 OTHER DATA GROUPS

In the two preceding chapters, three data groups (installation, inventory, and inspection information) were discussed. In this chapter, the remaining data groups--car type, repair cost, and work history--are similarly discussed. This includes descriptions of data elements, data collection procedures, and the role of the data in railroad maintenance management.

Car Type Information

For each track segment, car type information characterizes the car types (including locomotives) and their individual maximum loadings that can be expected during normal operations and/or mission-related special activities (such as mobilization). A completed car type data collection form for Camp Example is presented in Figure 24; Appendix A includes a blank car type form. As indicated in the form, "Car Type" is limited to five car types and three locomotive types. For cars, the "Heaviest Load" is the maximum expected net-loading of the given car type when operated on the given track segment; a locomotive's heaviest load is its total weight (gross tons).

Car type data is collected in the field only for functional (loading, service, storage and auxiliary) track segments. This data is generally obtained from the Installation Transportation Office (ITO). While this data can be (and usually is) based on historical records, planned changes in railroad operations and installation mission should be accounted for. After this field-collected data is entered into the computer, the RAILER I software automatically updates car type information for both access and functional track segments. This update procedure is based on the network structure; the preceding track segment data element provides the necessary information.

Regular installation train operations often include auxiliary track use which is unrelated to succeeding functional tracks. The car type data entry and update process allows the user to properly account for these train movements. In particular, car types can be directly assigned to auxiliary tracks, such as wyes, which are in addition to those car types which must use the auxiliary track for access to succeeding functional (or other auxiliary) tracks.

Both car type information data elements (Type and Heaviest Load) are among those sent to FORSCOM for use within FORPROP (see Chapters 2 and 6). They are also quite useful for installation maintenance management. Car Type often indicates, in conjunction with Track Use (inventory data element 4, Table 2), the role of the track segment with respect to installation activities; this data element can be used with other information to indicate the relative importance of track segments. As discussed in Chapter 8, Heaviest Load provides important information for track structural analysis. As mentioned in Chapter 9, Car Type is also useful for MTMCTEA installation transportation system capability studies (TSCS).

INSTALLATION NAME: Camp Example

RAILER I
CAR TYPE INFORMATION

DATE: 5/20/87

Complete Car Type Information for LOADING, SERVICE, and STORAGE Tracks only.
Car Type options are FLAT, HEAVY FLAT, BOX, HOPPER, GONDOLA, 6 AXLE LOCOMOTIVE, 4 AXLE LOCOMOTIVE, and 2 AXLE LOCOMOTIVE.
List all Car Types that are appropriate for each Track Segment.
For cars, "Heaviest Load" is the heaviest loading (net tons) placed on the car; for locomotives, "Heaviest Load" is the total weight (gross tons) of the locomotive.

Track Segment #	Car Type	Heaviest Load (Tons)	Track Segment #	Car Type	Heaviest Load (Tons)
104	Flat	80	703	Flat	40
104	Heavy Flat	140	703	6 Ax Loco	190
104	4 Ax. Loco	110	703	4 Ax Loco	110
201	Flat	80	801	Flat	40
201	Heavy Flat	140	801	6 Ax. Loco	190
201	4 Ax Loco	110	801	4 Ax. Loco	110
302	Box	55	M16	Flat	80
302	Gondola	98	M16	Gondola	98
302	4 Ax Loco	110	M16	6 Ax. Loco	190
			M16	4 Ax Loco	110
401	Gondola	98			
401	4 Ax Loco	110	I01	Flat	Ø
			I01	Heavy Flat	Ø
501	Box	55	I01	Box	55
501	4 Ax. Locoo	110	I01	Hopper	100
			I01	Gondola	98
601	Gondola	Ø	I01	6 Ax. Loco	190
601	6 Ax Loco	190	I01	4 Ax Loco	110
601	4 Ax Loco	110			
601	Flat	Ø			
601	Heavy Flat	Ø			
601	Hopper	100			

4/1/87

Figure 24. Completed car type form for Camp Example.

Repair Cost Information

The repair cost information data elements are track segment number, date, estimated cost and comments. The comments field should include a description of the work associated with the cost. In addition to eliminating track defects, the work may include track improvements. The cost data element is the estimated cost (direct cost plus overhead, profits, etc.) of all repairs and improvements on a given track segment, including those of related facilities.

Within the maintenance management cycle, cost information is generally collected twice; after the annual track inspection when costs are estimated with sufficient accuracy for network level management, and during the detailed planning stage when more detailed cost estimates are prepared to support project level management. Cost estimating procedures to support network and project level management are discussed in Chapters 7 and 8, respectively.

Repair cost information facilitates cost-effective maintenance management. Because this information is collected separately for each segment, network logic can be applied. This is discussed further in Chapter 8. The repair cost is also one of the data elements sent to FORSCOM for FORPROP implementation (see Chapters 2 and 6).

Work History Information

The work history information data elements are track segment number, year work was completed, and a description of the work done. Track work reporting and feedback is the last step in the maintenance management cycle. Whenever a track project is completed, the work history information should be updated for each track segment in the project. Unlike most other data groups, when work history is updated, previous entries for the same track segment are left alone. Over time, the work history of a given segment can accrue several entries. Work history information is thus an archival database. When RAILER I is first implemented at an installation, it is recommended that previous work be summarized and entered into the work history database, to the extent that records and institutional memory exist.

Work history information allows the user to identify and analyze persistent problems, compare maintenance methods with results, and establish per segment expenditure trends. The application of work history information in maintenance management is also discussed in Chapters 7 and 8.

Related Facilities

An installation's railroad track network is not used in isolation from the installation's other facilities and resources and the connecting commercial track. The role of railroad track in an installation's mission is especially intertwined with some related facilities such as ramps and docks. This interrelationship is such that the track cannot be evaluated independently from the related facilities, with respect to its mission. For example, it makes no sense to separate the evaluation and associated maintenance management of a circus loading track from that of the track's end loading ramp; each depends on the other. The FORMAP-2 program has recognized this relationship by including work on related facilities; the prioritization of such work is included in FORPROP.

To facilitate a more complete track evaluation, RAILER I also considers facilities that are auxiliary to the track and track structure. These "related facilities" include ramps and docks, lighting equipment, marshalling yards, and the connecting commercial track. They all play an important role in the mobilization mission of FORSCOM installations. However, these facilities have been separated from the main RAILER I database at FORSCOM's request because they are not part of the track structure.

Associated with each facility type are several data elements. The commercial track data elements are track segment number and FRA class. A completed related facilities form for Camp Example (Figures 25 and 26) shows data elements associated with each of the other facility types; Appendix A includes a blank related facilities form. Note that both inventory and inspection information are collected with this form.

The facility number data element may be of the related facility itself or of some more aggregate structure. For example, a ramp is usually not a part of any other structure, so it will probably have its own facility number; a dock, on the other hand, is usually attached to a warehouse and will probably have the same facility number as the warehouse. The condition code data element may be obtained by direct field inspection or through existing inspection records. The C1, C2, C3 coding is consistent with U.S. Army facility inspection procedures[13] (see Figures 25 and 26).

In RAILER, related facility information is used in calculating the related facility condition rating (see Appendix C) and is useful in calculating track rank (see Appendix B). The related facility condition rating of each segment and the connecting commercial track identification number are among the data elements sent to FORSCOM for use in FORPROP (see Chapters 2 and 6).

---

[13] *RPMA Component Inspection Handbook* (Facilities Engineering Support Agency [FESA], Fort Belvoir, VA, May 1979).

Camp Example

RAILROAD SYSTEM RELATED FACILITIES INSPECTION

LOADING DOCKS, RAMPS, AND MARSHALLING YARDS 7/3/87
Date

STRUCTURAL

LOADING DOCKS AND RAMPS

Track Segment Number	Facility Number	Deck: Material Type	Deck: Condition Code	Support Structure: Material Type	Support Structure: Condition Code	Overall Condition Code	Comments:
104	RMPR11	A	C2	B	C2	C2	
201	RMPR21	A	C1	B	C2	C2	
703	RMPR71	D	C2	D	C3	C3	[illegible] Ramp
801	RMPR81	D	C2	D	C2	C2	[illegible] Ramp
M16	RMPRM1	E	C2	C	C2	C2	
302	DOKR31	C	C2	A	C1	C1	
302	DOKR32	C	C1	A	C2	C2	
501	DOKR51	A	C1	D	C1	C1	
501	DOKR52	A	C2	D	C1	C2	

Material Type	CONDITION CODING: C1 = EXCELLENT/GOOD C2 = FAIR C3 = POOR/FAILED
A = Concrete/ Asphalt	C1 = Few or no defects, scattered surface cracking C2 = Medium severity cracking and deterioration C3 = High severity cracking and deterioration
B = Masonry	C1 = Few or no defects; Scattered surface cracking C2 = Medium severity cracking of stone and/or mortar joints C3 = High severity cracking of stone and/or mortar joints
C = Wood	C1 = Few or no defects. Peeling of paint, delamination, or splintering C2 = Loose connections, splitting; Holes in wood, pieces missing C3 = Mold/fungus growth; Decay/rot; Rodent/insect infestation
D = Metal	C1 = Few or no defects; Low severity corrosion C2 = Medium severity corrosion; Some broken welds or connections C3 = High severity corrosion; Several broken welds/connections; Members fractured
E = Earth/ Gravel	C1 = Few or no defects; Scattered small holes; High fill level C2 = Nominally high fill level; Medium severity potholes and ruts C3 = Low fill level; Large potholes; Severe erosion and rutting

MARSHALLING YARD PAVEMENTS

Track Segment Number	Facility Number	Pavement Type	Condition Code	Comments:
104	—	B	C1	
201	—	B	C1	
703	—	A	C2	
801	—	A	C2	
M16	—	A	C3	

	CONDITION CODING: C1 = EXCELLENT/GOOD C2 = FAIR C3 = POOR/FAILED
A = UNPAVED/ GRAVEL	C1 = Few or no defects; Low severity corrugations, potholes, rutting; Good drainage C2 = Medium severity corrugations, potholes, rutting; Fair drainage C3 = High severity corrugations, potholes, rutting
B = CONCRETE/ ASPHALT	C1 = Low severity cracking and deterioration. Paver PCI > 70 C2 = Medium severity cracking and deterioration; Paver PCI > 30 but < 70 C3 = High severity cracking and deterioration; Paver PCI < 30

Figure 25. Front of completed related facilities form for Camp Example.

RAILROAD SYSTEM RELATED FACILITIES INSPECTION

LOADING DOCKS, RAMPS, AND MARSHALLING YARDS

[illegible]
Date

LIGHTING

Track Segment Number	Facility Number (Note A)	Lighting Area	Condition Code (Note B)	Comments:
104	LXR11	A	C1	
104	LXMW1	B	C1	
103	LXR31	A	C1	
103	LXMW1	B	C1	
703	LXR71	A	C3	Portable Lights
703	LXME1	B	C2	Portable Lights
[illegible]	LXR?1	A	C3	Portable Lights
501	LXME1	B	C2	Portable Lights
M16	—	A	C3	No Lighting
M16	—	B	C3	No Lighting
302	BLWH1	A	C2	Warehouse 1
302	BLWH2	A	C1	Warehouse 2
501	BLCOMØ	A	C2	Commissary

Lighting Area	CONDITION CODING: C1 = EXCELLENT/GOOD C2 = FAIR C3 = POOR/FAILED
A – LOADING DOCKS, RAMPS, AND ADJACENT TRACKAGE (NOTE C)	C1 = AVERAGE LIGHTMETER READING OF 5 OR GREATER C2 = AVERAGE LIGHTMETER READING > 3.5 BUT < 5 C3 = AVERAGE LIGHTMETER READING < 3.5; NO LIGHTING AVAILABLE
B – MARSHALLING YARDS	C1 = AVERAGE LIGHTMETER READING OF 2 OR GREATER C2 = AVERAGE LIGHTMETER READING > 1 BUT < 2 C3 = AVERAGE LIGHTMETER READING < 1; NO LIGHTING AVAILABLE

A. IF LIGHTING HAS ITS OWN FACILITY NUMBER, THEN THIS NUMBER SHALL BE USED.
B. READINGS TAKEN AT 40 FOOT INTERVALS.
C. READINGS SHOULD BE TAKEN ALONG THE ADJACENT LENGTH OF TRACK GENERALLY USED DURING LOADING OPERATIONS.

Figure 26. Back of completed related facilities form for Camp Example.

6 COMPUTER OPERATIONS

After it is collected, RAILER I data can be manipulated in a variety of ways using the computer to facilitate decision support. This chapter presents a relatively brief overview of these operations. The Railer I Computer Users Guide[14] describes the computer operations in complete detail.

This chapter presents enough detail to give the reader a general understanding of data entry options; internal data organization, manipulation, and calculations; and report generation options for decision support.

Software and Hardware

RAILER I computer programs are built on the R:base 5000 relational database management system.[15] This permits a very flexible approach to data entry and, more importantly, report generation. The presence of R:base 5000 is hidden from the RAILER I user through the use of menu-driven screens; thus, no knowledge of R:base is needed to operate the RAILER I programs. The hardware requirements for RAILER I include an IBM-XT, AT, or 100 percent IBM-compatible microcomputer; a 20 megabyte hard disk; 640K RAM; and a dot matrix 80-column printer (with IBM standard character set).

Menu Structure

RAILER I computer operations are menu driven, and the menu hierarchy is designed around the database structure. Because (as discussed in Chapters 2 and 5) related facilities information is separated from the main database, RAILER I includes two separate programs, the main program and a related facilities program.

Figure 27 illustrates the basic decision tree/menu structure available to the computer operator in creating, altering, manipulating, and reporting the main database; this database was illustrated in Figure 1 (p 15). The information type and report type options in Figure 27 include the six information data groups discussed in Chapter 2 and represented by the dark boxes in Figure 1. As indicated in Figure 28, the Related Facilities menu structure is similar to the main program's; the related facilities database was illustrated in Figure 2 (p 18). The four related facilities information types referred to in Figure 28 correspond to the dark boxes in Figure 2.

Main Program

Figure 29 shows the opening menu of the main RAILER I program; Table 5 describes the options. In addition to the three primary options indicated in Figure 27, the opening menu includes help and exit options. These two additional options are included in almost all RAILER I menus. With other menus, the "exit" option returns the user to the previous menu. Each of the three primary options shown are discussed below.

---

[14]D. A. Piland and D. R. Uzarski.

[15]R:base 5000 is a copyrighted software system developed by Microrim, Inc.

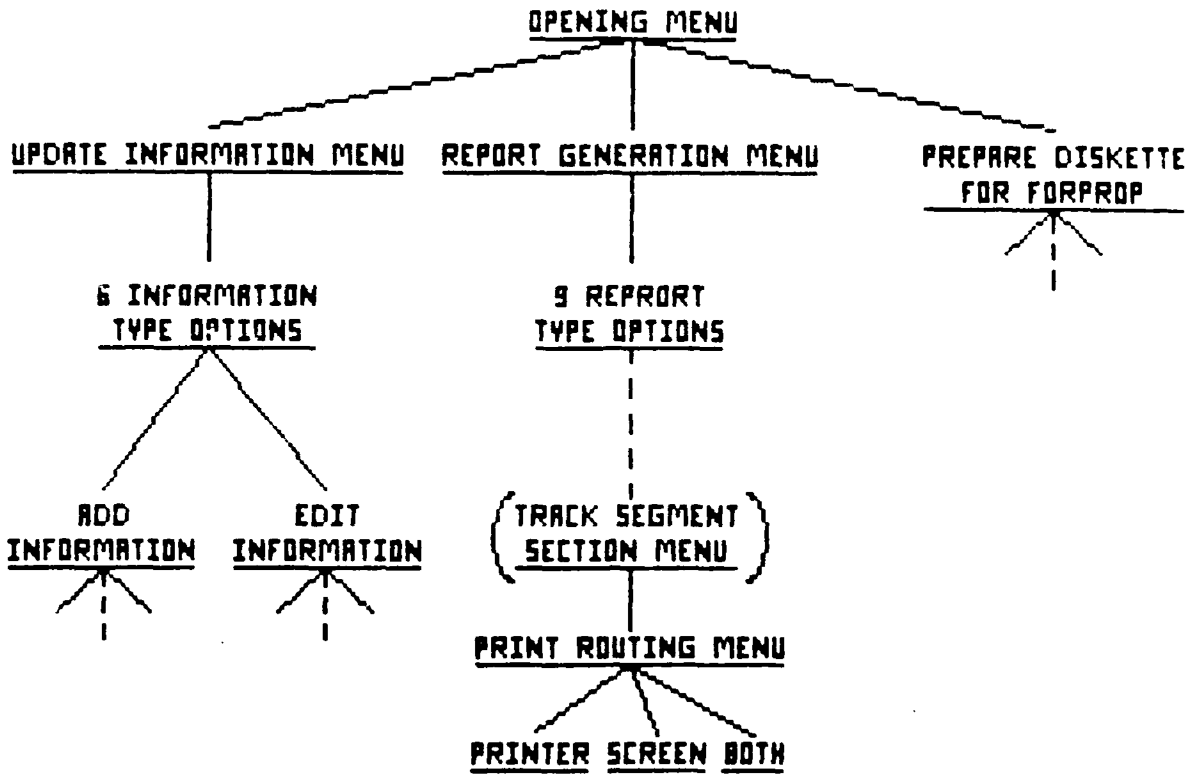

Figure 27. Brief decision tree/menu outline for main program.

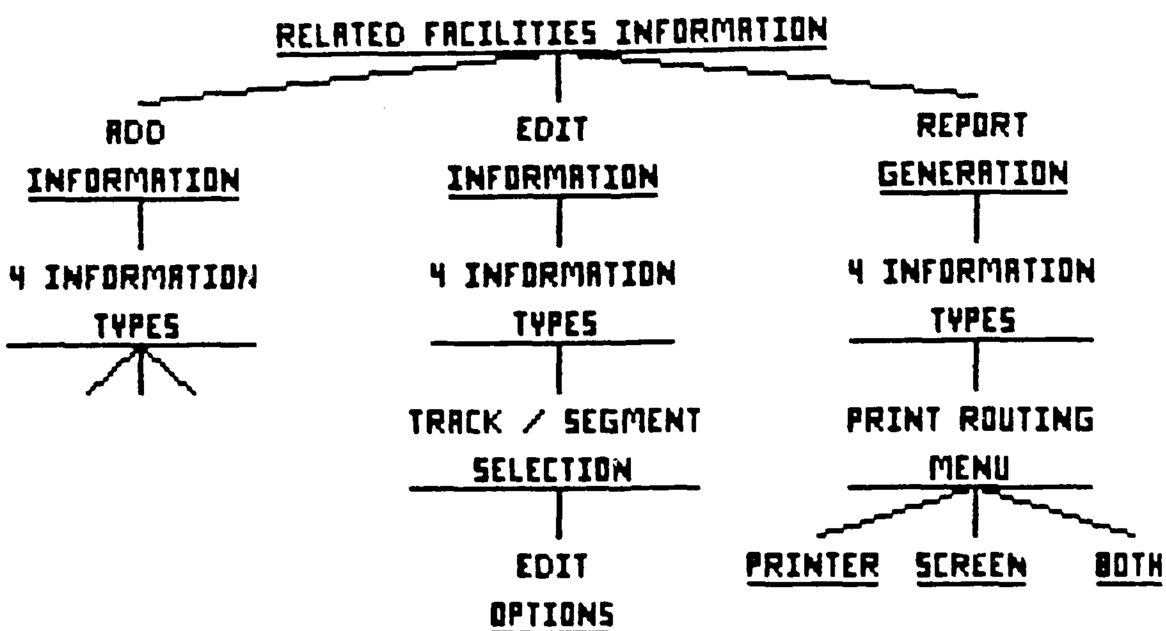

Figure 28. Brief decision tree/menu outline for related facilities program.

```
-----------------------OPENING MENU-----------------------
  (1)  Update Information
  (2)  Report Generation                    F[10] HELP
  (3)  Prepare Diskette for FORPROP         [ESC] TO EXIT
```

Figure 29. Opening menu.

Table 5

Opening Menu Option Descriptions

OPTIONS:

(1)	UPDATE INFORMATION - This option takes you another menu screen which gives you the choice to update Installation Information, Track Segment Inventory Information, Track Segment Inspection Information, Car Type Information, Repair Cost Information, and Work History Information.
(2)	REPORT GENERATION - This option takes you to another menu screen for generating various reports.
(3)	PREPARE DISKETTE FOR FORPROP - This option copies information from your database onto a diskette to be sent to U.S. Army Forces Command to be used in the operation of FORPROP.
F[10]	This option displays a help screen.
[ESC]	This option exits from the RAILER I system.

Update Information

The "Update Information" menu is presented in Figure 30, with option descriptions in Table 6. The six information types on this menu correspond to the six dark boxes in Figure 1. With four of these information types, the user has the option of either adding new information or editing old information. The exceptions are Car Type Information and Repair Cost Information; for these information types the "update" function is not divided into separate add and edit procedures. With Track Segment Inspection Information, a third option (in addition to "add" and "edit") allows the user to indicate uninspected deteriorated track segments as discussed in Chapter 4.

```
——————————UPDATE INFORMATION——————————
(1)  Installation Information
(2)  Track Segment Inventory Information
(3)  Track Segment Inspection Information
(4)  Car Type Information
(5)  Repair Cost Information              F[10] HELP
(6)  Work History Information             [ESC] TO EXIT
```

Figure 30. Update information menu.

Table 6

Update Information Menu Option Descriptions

OPTIONS:

(1) INSTALLATION INFORMATION - This option takes you to another menu screen which gives you the choice to ADD or EDIT Installation Information.

(2) TRACK SEGMENT INVENTORY INFORMATION - This option takes you to another menu screen which gives you the choice to ADD or EDIT the Track Segment Inventory Information.

(3) TRACK SEGMENT INSPECTION INFORMATION - This option takes you to another menu screen which gives you the choice to ADD or EDIT Track Segment Inspection Information and to Indicate Uninspected Deteriorated Track.

(4) CAR TYPE INFORMATION - This option allows you to UPDATE Rail Car Type Information for Auxiliary, Loading, Service, and Storage Tracks. The computer then automatically generates the Car Type Information for the rest of the tracks on the installation.

(5) REPAIR COST INFORMATION - This option allows you to UPDATE Repair Cost Information for each Track Segment.

(6) WORK HISTORY INFORMATION - This option allows you to ADD or EDIT Work History Information for each Track Segment.

F[10] This option displays a help screen.

[ESC] This option returns to the previous OPENING MENU.

The individual information types also have customized updating options. These options, which increase flexibility, include the ability to choose between data element groups and data elements. Options for entry format are also included; in the case of Track Inventory, new data may be entered by entire track segment or by individual data element. These various options are indicated by the unlabeled branching at the bottom of the Update Information option tree in Figure 27.

With four of the six information types, only current information is kept; for these four, the information update procedures simply write over (replace) any preexisting data element values. With the other two information types, Work History and Track Segment Inspection, noncurrent data can (and should) be kept for archival purposes. For these two, the "edit" option should only be used for correcting an erroneous entry; the "add" option should be used if the new information supplants previously correct but outdated information. For both Work History and Track Segment Inspection, the date (or year) data element is used to distinguish different entries in the two archives.

The computer automatically manipulates some of the raw data, either as it is entered or just afterwards. The vegetation inspection occurrence data collected by 200-ft stations (discussed in Chapter 4) is converted in the computer to percentages for each track segment. As discussed in Chapter 2, all appropriate track inspection data are compared to the Interim U.S. Army Railroad Track Maintenance Standards as the data is entered.

RAILER I automatically calculates superelevation: the intended increase in elevation of the outer rail above the inner in a curve. The amount of superelevation is specified in the Interim Track Maintenance Standards as a function of curvature degree and maximum operating speed. Within RAILER I, this value is a curve inventory data element which is automatically calculated as a function of data elements 17 and 18 from Table 2. The track standards prohibit a superelevation of more than 4 in. The superelevation calculated by RAILER I may be greater than this limit. If the maximum curve operating speed (data element 18) and curvature degree (data element 17) entered by the RAILER I user imply a superelevation greater than 4 in., the installation should lower the maximum curve operating speed to a value which is consistent with the given curvature degree and a 4-in. superelevation.

All the defects of each track segment are examined automatically to determine the worst defect. Based on this worst defect, a track segment is assigned a maintenance standard condition which indicates what operating restriction (if any) is placed on the track segment. This maintenance standard condition and the track use (see Chapter 3) together determine the IFS condition[16]; the relationships between these two condition ratings and track use are indicated in Figure 31. The maintenance standard condition rating is discrete (as is also the IFS condition rating) and based on only the worst defect in a segment. A more refined, almost-continuous track segment condition rating, based on all defects, is calculated for each segment when data is generated for FORPROP. This analytical procedure is described in Appendix D, including a discussion of its relationship to the maintenance standard condition rating.

The last major automatic data manipulation involves car type information. Once this information has been entered for all functional track segments (loading, storage, service, and auxiliary), the computer automatically updates all track segments. This update activity is based on the preceding segment number (data element 6, Table 2), and primarily affects access and auxiliary track segments.

---

[16] *Integrated Facility System User's Manual* (FESA, Fort Belvoir, VA, January 1987).

OPERATING RESTRICTION	TRACK USE				
	ACCESS	LOADING	AUXILIARY	SERVICE	STORAGE
NO DEFECTS	C1	C1	C1	C1	C1
NO RESTRIC.	C1	C1	C1	C1	C1
10 MPH	C2	C2	C2	C2	C1
5 MPH	C3	C3	C2	C2	C2
OUT OF SERVICE	C3	C3	C3	C3	C3

C1 = SATISFACTORY C2 = MARGINAL C3 = UNSATISFACTORY

Figure 31. IFS condition ratings as determined by maintenance standard condition ratings and track use.

Report Generation

After the data has been entered and automatically manipulated by the computer, it is available through reports for decision support applications. The strength of RAILER I as a decision support tool is largely a function of the flexibility and ease with which reports are generated.

As indicated in Figure 27, report generation is one option of the RAILER I opening menu. The "Report Generation" menu is presented in Figure 32, with option descriptions in Table 7. The first six report generation options are the same information types just discussed with respect to the "Update Information" menu (see also Figure 30). The Parameter and Comparison reports (options 7 and 9) are particularly useful decision support tools in network and project management. The use, structure, and flexibility of these two report options are described in Chapters 7 and 8.

The missing information report (option 8) is a useful database management tool which allows the operator to verify the completeness of the data. If any piece of data is missing from the installation, track segment inventory, or track segment inspection information report (options 1, 2, or 3), the entire report will be included in the missing information report. Most of the missing information report for Camp Example is presented in Figure 33; the rest of the report consists of inspection reports for turnouts 1T4 and 1T8 like that for turnout 1T2 included in Figure 33. In this case, the "missing information" includes inventory and inspection data for turnout guard rails associated with self-guarded frogs, and rail defect data. Judgment is required to determine if more data must be gathered. In this case, all of this data simply does not exist; for example, there are usually no guard rails when the frog is self-guarded. The Camp Example database is thus essentially complete.

```
------------------REPORT GENERATION-------------------
(1) Installation Information
(2) Track Segment Inventory Information
(3) Track Segment Inspection Information
(4) Car Type Information
(5) Repair Cost Information
(6) Work History Information
(7) Information by Setting Parameters
(8) Missing Information
(9) Condition Comparison To Maintenance Standards
                                        F[10] HELP
                                        [ESC] TO EXIT
```

Figure 32. Report generation menu.

Table 7

Report Generation Menu Option Descriptions

OPTIONS:

(1) INSTALLATION INFORMATION - Prints all the information concerning the Installation Network.

(2) TRACK SEGMENT INVENTORY INFORMATION - Prints all the Inventory Information for all segments, one segment, up to ten segments of your choice, or all the segments within a certain track.

(3) TRACK SEGMENT INSPECTION INFORMATION - Prints all the Inspection Information or Uninspected Deteriorated Track Segments for all segments, one segment, up to ten segments, or all the segments within a certain track. Inspection Information includes: Rail Inspection, Tie Inspection, Track Deflection Information, Track Geometry Inspection, Turnout Inspection, and Vegetation Inspection.

(4) CAR TYPE INFORMATION - Prints Car Type and Heaviest Load Information in Track Segment order, for all segments, one segment, or up to ten segments of your choice.

(5) REPAIR COST INFORMATION - Prints Repair Cost Information in Track Segment order, for all segments, one segment, or up to ten segments of your choice.

(6) WORK HISTORY INFORMATION - Prints Work History Information in Track Segment order, for all segments, one segment, or up to ten segments of your choice.

Table 7 (Cont'd)

(7) INFORMATION BY SETTING PARAMETERS - Prints information by special parameters set by you for the following items.

INVENTORY:

SEGMENT IDENTIFICATION	PLATES/FASTENINGS
BALLAST	RAIL
BRIDGES	RAIL CROSSINGS
CULVERTS	ROAD CROSSINGS
CURVES	TURNOUTS

INSPECTION:

RAIL INSPECTION	TRACK GEOMETRY
TIE INSPECTION	TURNOUT INSPECTION
TRACK DEFLECTION	VEGETATION INSPECTION

CAR TYPE:

TRACK SEGMENT #	CAR TYPE
HEAVIEST LOAD	

REPAIR COST:

TRACK SEGMENT #	REPAIR COST

WORK HISTORY:

TRACK SEGMENT #	COST
YEAR	WORK DESCRIPTION

(8) MISSING INFORMATION - Prints items with missing elements. This also prints a list of the track segments where Inspection Information, Car Type Information, and Repair Cost Information, are missing.

(9) CONDITION COMPARISON TO MAINTENANCE STANDARDS - This option compares the inspection results with the maintenance standards and prints three different reports showing where the track does not meet the maintenance standards. This information may be printed out for all segments, one segment, up to ten segments of your choice, or all the segments within a certain track.

F[10] This option displays a help screen.

[ESC] This option returns to the previous OPENING MENU.

EX111 — RAILER I TRACK SEGMENT INVENTORY — Page 1
CAMP EXAMPLE
TURNOUTS
11/18/87

TRACK SEGMENT# TURNOUT #	SWITCH POINT LOCATION	FROG SIZE	DIR	RAIL WEIGHT	POINT LENGTH	FROG TYPE	GUARD RAIL LENGTH
103 1T2	68+51	6	RH	90 lbs/yd	16.0 LF	SELF GUARDED	-0 LF
301 1T4	5+99	7	RH	80 lbs/yd	13.0 LF	SELF GUARDED	-0 LF
702 1T8	21+05	8	LH	80 lbs/yd	16.0 LF	SELF GUARDED	-0 LF

EX111 — RAILER I INSPECTION — Page: 1
CAMP EXAMPLE
RAIL INSPECTION
11/18/87

TRACK SEGMENT # /DATE	LOCATION	RAIL	DEFECT TYPE	DEFECT DESCRIPTION
501 03/26/87	-0- -0-	BOTH	26	RAIL WEIGHT INSUFFICIENT FOR MISSION
901A 03/26/87	-0- -0-	BOTH	26	RAIL WEIGHT INSUFFICIENT FOR MISSION

MISSING Turnout Component Information for the following Turnouts

EX111 — RAILER I INSPECTION — Page: 1
CAMP EXAMPLE
TURNOUT INSPECTION
12/02/87

Track Segment # 103 — Date 03/12/87
Turnout ID # 1T2

General

Rail Weight changes within Turnout limits: Y
Reversing Tangent Past Frog less than 50 Feet: N
Switch Difficult to Operate: Y

Line & Surface POOR

Ties

# of Defective Ties in a row (worst case): 4
# of Occurences where Joint Ties are Defective: 0
# of Occurences where Tie Spacing > 42 in.: 0
# of Skewed Ties: 2
# of Missing/Bunched/Badly Skewed Ties: 0

TOTAL # of Defective Ties: 8

Components	No Defects	Improper Size	Loose	Chipped/ Worn/Bent	Missing
Switch Stand	X	-	-	-	-
Point Lock/Lever Latch	-	-	Y	-	-
Connecting Rod	-	-	-	Y	-
Switch Point - Left	X	-	-	-	-
Switch Point - Right	X	-	-	-	-
Switch Rods	-	0	0	1	0
Clip Bolts	X	0	0	0	0
Slide Plates	X	0	0	0	0
Braces	-	0	4	0	0
Heel Filler & Bolts	X	0	0	0	0
Cotter Keys	-	0	0	0	2
Point & Top Surface	X	-	-	-	-
Bolts	-	0	2	0	2
Guard Rails	-	0	0	1	0
Filler & Bolts	-	0	0	0	2

-- Frog Measurements --	Straight Side	Turnout Side
Gage at Point	67.60	57 60
Guard Check Gage	64.00	54 00
Guard Face Gage	63.10	63 10
Flangeway Width	1.80	1 60
Flangeway Depth	1.80	1 40
-- Guard Rail Measurement --		
Flangeway Width	-0-	-0-

-- Other Measurements --
Gage at Switch Points 56 50
Gage at Joints in Curved Closure Rails: 56.60 -0-

Comments
-0-

Figure 33. Most of the Camp Example missing information report.

An example of the installation report is presented in Chapter 9. Multiple examples of all the other seven report options are presented in the chapters where their use in network and project level management is discussed.

The report generation process always ends with the print routing menu (see Figure 27) where the report output device(s) are chosen. For all appropriate report type options, the print routing menu is preceded by a menu for selecting the track segments to be reported; the exceptions are the Installation Information Missing Information and Condition Comparison Reports, report options 1, 8, and 9. Examples of these two menus are presented in Figures 34 and 35, respectively.

Prepare Diskette for FORPROP

The third main option of the opening menu (see Figures 27 and 29) allows the user to copy information from the installation RAILER I database onto a diskette to be sent to Headquarters, FORSCOM (HQ FORSCOM) for use in FORPROP.

The information is placed in three computer files. The first file includes installation identification information, specifically the installation identification number, the installation name, and the state code. The second file includes the commercial connecting track's identification number and FRA class.

The third file includes nine data elements for each installation track segment:

1. Track segment number
2. Preceding track segment number
3. Track condition
4. Track rank
5. Repair cost per segment
6. Car type
7. Heaviest load
8. Related facility condition
9. Repair cost per 100 ft.

For each track segment, only the most important car type and the maximum heaviest load are included. These may not match; for example, with a given track segment, the most important car type may be a flat car, but the maximum heaviest load may be associated with gondolas, a different car type. The most important car type is based on a car type ranking which FORSCOM gave USA-CERL.[17] RAILER I uses beginning and end station locations to calculate segment length and from that derives repair cost per 100 ft.

[17]Letter from FORSCOM, AFLG-TRT(G), dated 22 August 1986.

```
Press ESC when done with this data.

- Enter up to 10
    - Track Segment #'s to print specific Track Segments (e.g.) M01
      or NE01
                              and/or
   - Track #'s followed by an asterisk (*) to print all the Track
     Segments within that Track (e.g.) M* or NE*
                              or
- Enter ALL in the #1. location to print All the Track Segments.

                         1.  M01
                         2.
                         3.
                         4.
                         5.
                         6.
                         7.
                         8.
                         9.
                        10.
```

Figure 34. Track segment selection menu.

```
                     SELECT PRINT ROUTING
   Printer    Screen    Both      Exit
```

Figure 35. Print routing menu.

The Track and Related Facility conditions summarize defect information and are calculated within RAILER I; their respective calculations are described in Appendices D and C. These condition ratings range from 0.0 to 1.0, with 1.0 indicating no defects. The maintenance standard condition rating (discussed under *Update Information*) only indicates the worst track defect on the segment; the track condition rating does this and also accounts for all other track defects.

Before these three files of information are copied onto the diskette, two checks are performed. The first check makes sure that all condition ratings less than 1.0 are associated with nonzero repair costs. Defects with zero repair costs are incompatible with the FORPROP methodology. The second check verifies that all active track segments have at least one car type and heaviest load assigned to it. If either of these two checks turn up data inconsistencies or omissions, then the information is not copied onto the diskette, a message to that effect is displayed, and the user is returned to the opening menu (Figure 29).

Note that this third option of the main RAILER I program uses data from the Related Facilities database (i.e., commercial track data and related facility condition data). The Related Facilities program facilitates the database management of this information; that program is discussed next.

Related Facilities Program

The Related Facilities program is a database management program auxiliary to RAILER I. As indicated in Figure 28, it includes three main options for managing four information types. These information types are:

1. Commercial Track Information

2. Lighting Information

3. Loading Docks and Ramps Information

4. Marshalling Yard Pavement Information (see Figure 2).

The opening Related Facilities menu is presented in Figure 36, with option descriptions in Table 8. (The third option, "Examine or Print...", performs the same functions as the Report Generation option of the main program.) As indicated in Figure 28, after choosing one of the first three options, the user must choose one of the four information types. After an information type is chosen, the user is presented with different options depending on which mode (add, edit, or report) is being used. If the user is adding information, the options are customized to the four information types; this is indicated by the unlabeled branching in Figure 28. In the edit mode, after choosing an information type, the user is presented with a standardized set of edit options. For three of the information types, these edit options are preceded by options for choosing track or track segment numbers; the exception is commercial track information. The report option of the opening Related Facilities menu always ends with the same print routing menu used above for the main RAILER I program (see Figure 35).

```
-RELATED FACILITIES INFORMATION-
(1)  Add New Information
(2)  Edit Existing Information (change or delete) F[10] HELP
(3)  Examine or Print Related Facilities Information [ESC] TO EXIT
```

Figure 36. Related facilities opening menu.

Table 8

Related Facilities Menu Option Descriptions

OPTIONS:

(1) ADD NEW INFORMATION - This option allows you to add Commercial Track Information, Lighting Information, Loading Docks and Ramps Information, and Marshalling Yard Pavement Information into the database. It cannot be used to edit existing information.

(2) EDIT INFORMATION - This option allows you to change or delete existing information already stored in the database.

(3) EXAMINE OR PRINT RELATED FACILITIES REPORT - This option takes you to another menu screen which allows you to print information concerning the Related Facilities.

F[10] This option displays a help screen.

[ESC] This option exits out of the program to the system.

7 NETWORK LEVEL MANAGEMENT

Network level management consists of those activities associated with the network as a whole. Primarily this consists of the development of the annual and long-range (5 year) work plans. Work plan development activities include inspection, condition evaluation, work planning, work prioritization, and budgeting.

Timeframe

Network level maintenance management is performed annually. The Interim U.S. Army Railroad Track Maintenance Standards and Army Regulation (AR) 420-72[18] require that active track segments be visually inspected at least once a year. This inspection is intended to be the prime input to the development or updating of the annual and long-range work plans. As discussed in Chapter 4, the visual inspection should be supplemented with periodic track geometry and internal rail flaw testing on a less frequent basis. Also, as indicated in the standards, there are times when additional inspections may be necessary.

Steps for Developing a Work Plan

The following steps should be taken when using RAILER I in developing annual and long-range work plans for railroad track networks. The various reports that are used are obtained from the report generation menu, Figure 32. An introduction to report generation was provided in Chapter 6. Detailed information on report generation can be found in the computer user's guide.

1. Review Existing Plan

The engineer or technician reviews the existing plan. This provides information on those track segments scheduled for major M&R, for maintenance and minor repair, and on those not scheduled for any type of work. In the last case, work may not be needed, or it may be unfunded.

RAILER I stores and reports existing work plan information. This is obtained by choosing the Repair Cost Information (Repair Cost Report) option from the report generation menu. The first page of this report for the entire Camp Example network is presented in Figure 37. Briefly described in the report is the work that needs to be done, the cost, and planned year.

If the work plan information has not been stored in the RAILER I database, this information will have to be located in the office files.

If a plan does not exist, the development will begin with step 2.

---

[18] Army Regulation (AR) 420-72, *Surfaced Areas, Railroads, and Associated Structures* (Department of the Army, 24 March 1976).

EXIII CAMP EXAMPLE

RAILER I
REPAIR COST INFORMATION
11/23/87

Page 1

TRACK SEGMENT #	DATE	COST/SEGMENT	COST/100 TF	COMMENTS
1001	03/31/87	$0.00	$0.00	(Category B Track Sement)
101	03/31/87	$31,334.00	$638.82	Fix Turnout 1T5 - 1987, Tie renewal and vegetation eradication - 1988
102	03/31/87	$14,076.00	$1,152.83	Fix Turnout 1T3, tie renewal and veg. eradication - 1988
103	03/31/87	$9,862.00	$1,404.84	Fix Turnout 1T2 - 1987, ties and vegetaion - 1988
104	03/31/87	$5,860.00	$618.15	(INCLUDES COST TO REPAIR RAMP) Tie renewal and ramp repair - 1988
201	03/31/87	$5,020.00	$499.01	(INCLUDES COST TO REPAIR RAMP) Tie renewal and ramp repair - 1988
301	03/31/87	$9,659.00	$1,620.64	Tie renewal and vegetation eradication - 1988, fix Turnout 1T4 - 1989
302	03/31/87	$6,960.00	$652.30	(INCLUDES COST TO REPAIR DOCK AND UPGRADE LIGHTING - 1989) Ties - 1987
401	03/31/87	$5,890.00	$620.00	Tie renewal - 1988
501	03/31/87	$29,540.00	$3,806.70	(INCLUDES COST TO REPAIR DOCK AND UPGRADE LIGHTING - 1992) Ties - 1989
601	03/31/87	$24,340.00	$552.43	Tie renewal - 1987, Vegetaion eradication - 1988
701	03/31/87	$3,620.00	$605.35	Tie renewal - 1988
702	03/31/87	$22,956.00	$1,524.30	Tie renewal - 1987, Vegetaion eradication - 1989
703	03/31/87	$8,430.00	$637.67	(INCLUDES COST TO REPAIR RAMP, MARSHALLING AREA AND UPGRADE LIGHTING - 1988)

Figure 37. First page of repair cost report for entire Camp Example network.

2. Inspect Each Track Segment

Tracks are inspected annually using the RAILER I inspection discussed in Chapter 4. In practice, there are circumstances when the usually required annual inspection is not necessary, i.e., track segments that are "out of service" based on the last inspection and that require major M&R. Inspecting those track segments again is unnecessary since it would yield little if any additional useful information for work planning purposes. Also, if the track segment was previously not out of service, but has deteriorated so much that it is obviously inoperable, this can be indicated directly; this low-effort alternative to the complete RAILER I inspection procedure is discussed further in Chapter 4.

Although these annual inspections are intended to be used for work plan development, under certain circumstances they may also satisfy the project level inspection needed later in the management cycle. Project level inspections will be discussed in the next chapter.

3. Evaluate Each Inspected Track Segment

The track segments are evaluated based on the current inspection needed to determine their condition, classify the work needed (major M&R maintenance and minor repair), and roughly estimate its cost.

The Condition Comparison to Maintenance Standards (Comparison Report) option from the report generation menu is used for the condition evaluation. The Condition Summary option of the Comparison Report (Figure 38) provides a quick, segment by segment overview of the network condition. The track segment condition criteria are based on the Interim U.S. Army Railroad Track Maintenance Standards and the U.S. Army IFS system. The relationship between these two condition criteria was shown in Figure 31.

The other Comparison Report options, a comparison by inspection type and a detailed comparison, Figures 39 and 40, respectively, provide additional information on the nature and number of defects. The overall condition of each track segment as well as the type and number of defects present will indicate whether major M&R or maintenance and minor repair is needed.

It is important to recognize that all of the defects involve current needs, not future needs. RAILER I has no condition forecasting capabilities. Thus, when planning work for future years, it must be realized that the work needs will change and the categories (major M&R or maintenance and minor repair) may change.

The Work History Information (Work History Report) option from the report generation menu is another report that is useful in the evaluation process. This can help planners focus on an applicable work strategy based on what has been done before. An example of this report is shown as Figure 41.

4. Estimate the Cost to Complete the Work

Costs are estimated outside RAILER I. The network level management decision on which track segments should be maintained or repaired in which years is based, in part, on the available funds for track work. Accordingly, estimating work costs is an important step. Quick and rough scoping "desk" estimating procedures are appropriate for work planning; estimating for work accomplishment is a project level management activity and will be discussed in the next chapter.

EX111
CAMP EXAMPLE

RAILER I
CONDITION SUMMARY
11/18/87

Page 1

TRACK SEGMENT#	MAINTENANCE STANDARD CONDITION	IFS CONDITION
1001	5 MPH LIMIT	C2 - MARGINAL
101	OUT OF SERVICE	C3 - UNSATISFACTORY
102	5 MPH LIMIT	C3 - UNSATISFACTORY
103	OUT OF SERVICE	C3 - UNSATISFACTORY
104	5 MPH LIMIT	C3 - UNSATISFACTORY
201	5 MPH LIMIT	C3 - UNSATISFACTORY
301	5 MPH LIMIT	C3 - UNSATISFACTORY
302	OUT OF SERVICE	C3 - UNSATISFACTORY
401	5 MPH LIMIT	C2 - MARGINAL
501	5 MPH LIMIT	C2 - MARGINAL
601	OUT OF SERVICE	C3 UNSATISFACTORY
701	5 MPH LIMIT	C2 - MARGINAL
702	OUT OF SERVICE	C3 - UNSATISFACTORY
703	5 MPH LIMIT	C3 - UNSATISFACTORY
801	5 MPH LIMIT	C3 - UNSATISFACTORY
901A	5 MPH LIMIT	C2 - MARGINAL
901B	OUT OF SERVICE	C3 - UNSATISFACTORY
902	10 MPH LIMIT	C1 - SATISFACTORY
T01	OUT OF SERVICE	C3 - UNSATISFACTORY
M01	OUT OF SERVICE	C3 - UNSATISFACTORY
M02	5 MPH LIMIT	C3 - UNSATISFACTORY
M03	NO DEFECTS	C1 - SATISFACTORY
M04	OUT OF SERVICE	C3 - UNSATISFACTORY
M05	OUT OF SERVICE	C3 - UNSATISFACTORY
M06	OUT OF SERVICE	C3 - UNSATISFACTORY
M07	5 MPH LIMIT	C3 - UNSATISFACTORY

EX111
CAMP EXAMPLE

RAILER I
CONDITION SUMMARY
11/18/87

Page 2

TRACK SEGMENT#	MAINTENANCE STANDARD CONDITION	IFS CONDITION
M08	OUT OF SERVICE	C3 - UNSATISFACTORY
M09	OUT OF SERVICE	C3 - UNSATISFACTORY
M10	5 MPH LIMIT	C2 - MARGINAL
M11	5 MPH LIMIT	C2 - MARGINAL
M12	10 MPH LIMIT	C2 - MARGINAL
M13	NO RESTRICTIONS	C1 - SATISFACTORY
M14	OUT OF SERVICE	C3 - UNSATISFACTORY
M15	5 MPH LIMIT	C2 - MARGINAL
M18	OUT OF SERVICE	C3 - UNSATISFACTORY
P01	5 MPH LIMIT	C2 - MARGINAL
P02	5 MPH LIMIT	C2 - MARGINAL
Y01	10 MPH LIMIT	C2 - MARGINAL

Figure 38. Comparison report—condition summary for entire Camp Example network.

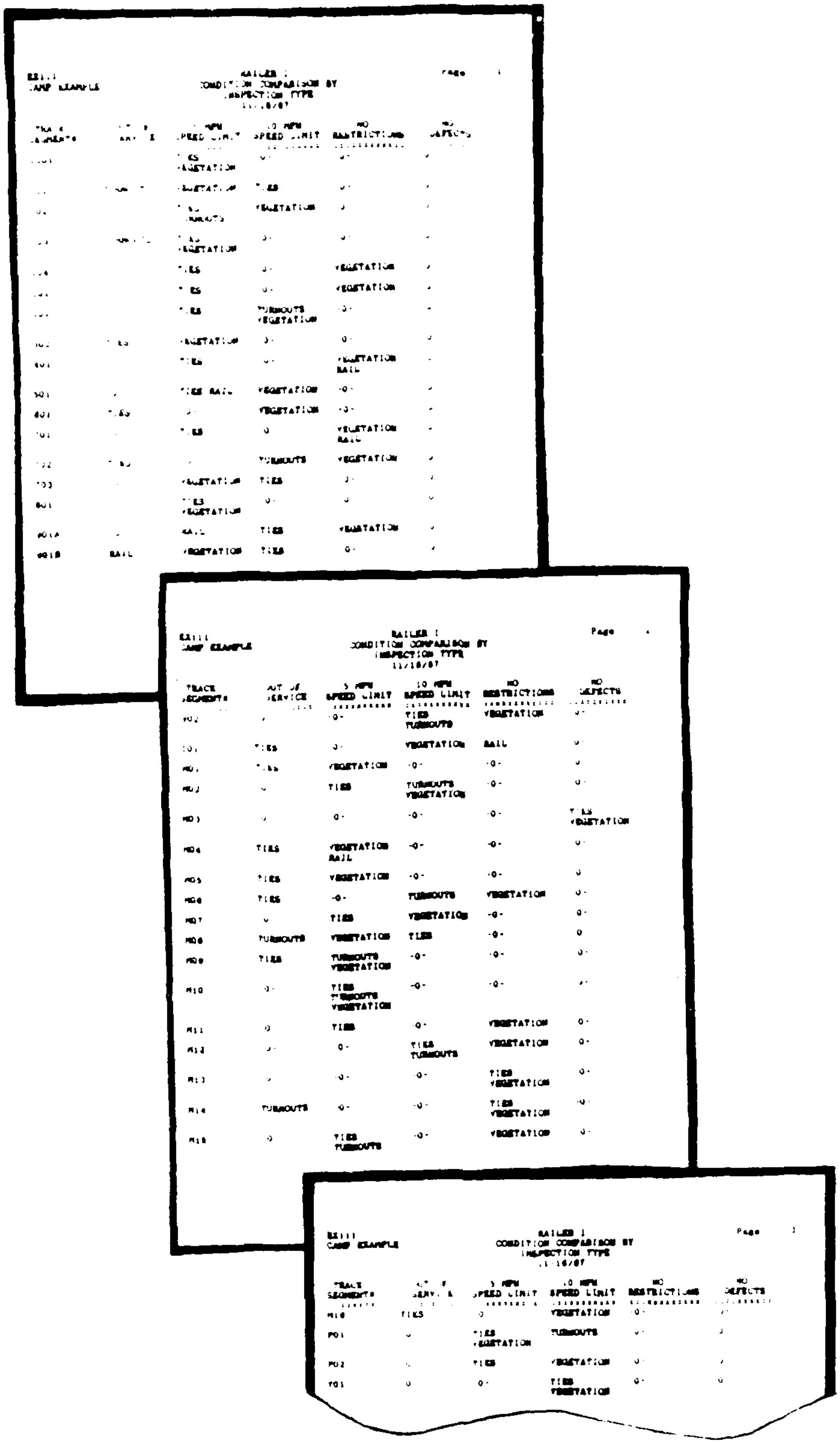

Figure 39. Comparison report—by Inspection Type for entire Camp Example network.

EX111 — RAILER I — Page: 1

CAMP EXAMPLE — DETAILED COMPARISON

11/18/87

TRACK SEGMENT #	MAINTENANCE STANDARD CONDITION	QUANTITY
M12		
	*** 10 MPH SPEED LIMIT ***	
	TIES - 3 CONSECUTIVE DEFECTIVE TIES	2
	TIES - ALL JOINT TIES DEFECTIVE	1
	TURNOUT - LINE & SURFACE	POOR
	TURNOUT - JOINT TIES DEFECTIVE	1
	TURNOUT - POINT LOCK/LEVER LATCH MISSING	Y
	TURNOUT - FROG POINT & TOP SURFACE CHIPPED, WORN OR CRACKED	Y
	*** NO RESTRICTIONS ***	
	TIES - 2 CONSECUTIVE DEFECTIVE TIES	1
	TIES - PERCENTAGE OF TOTAL DEFECTIVE TIES	17%
	TIES - TOTAL DEFECTIVE TIES	19
	VEGETATION - CENTER - GROWING IN BALLAST	100%
	VEGETATION - RIGHT - BRUSHES SIDES OF ROLLING STOCK	100%
	TURNOUT - RAIL WEIGHT CHANGES WITHIN TURNOUT LIMITS	Y
	TURNOUT - SWITCH DIFFICULT TO OPERATE	Y
	TURNOUT - DEFECTIVE TIES IN A ROW	2
	TURNOUT - MISSING, BUNCHED OR BADLY SKEWED TIES	3
	TURNOUT - SWITCH STAND BENT, CRACKED OR BROKEN	Y
	TURNOUT - CONNECTING ROD BENT, BROKEN OR ALTERED	Y
	TURNOUT - LEFT SWITCH POINT CHIPPED, WORN, BENT, BROKEN OR ALTERED	Y
	TURNOUT - RIGHT SWITCH POINT CHIPPED, WORN, BENT OR BROKEN	Y
	TURNOUT - SWITCH RODS BENT, CRACKED, BROKEN, CORRODED OR ALTERED	2
	TURNOUT - CLIP BOLTS IMPROPER SIZE OR TYPE	4
	TURNOUT - SLIDE PLATES LOOSE	2
	TURNOUT - BRACES LOOSE	2
	TURNOUT - BRACES MISSING	3
	TURNOUT - HEEL FILLER & BOLTS MISSING	2
	TURNOUT - COTTER KEYS LOOSE	4
	TURNOUT - FROG BOLTS LOOSE	4
	TURNOUT - FROG GAGE AT POINTS (STRAIGHT SIDE)	56.10''
	TURNOUT - FROG GAGE AT POINTS (TURNOUT SIDE)	57.20''
	TURNOUT - GAGE AT SWITCH POINTS	57.20''
	TURNOUT - GAGE AT JOINTS IN CURVED CLOSURE RAILS	56.10''
	TURNOUT - FROG GUARD CHECK GAGE (STRAIGHT SIDE)	54.40''
	TURNOUT - FROG GUARD CHECK GAGE (TURNOUT SIDE)	55 60''
	TURNOUT - FROG GUARD FACE GAGE (TURNOUT SIDE)	54.00''
	TURNOUT - FROG FLANGEWAY WIDTH (STRAIGHT SIDE)	1.60''
	TURNOUT - FROG FLANGEWAY WIDTH (TURNOUT SIDE)	1.60''
	TURNOUT - FROG FLANGEWAY DEPTH (STRAIGHT SIDE)	1.60''
	TURNOUT - FROG FLANGEWAY DEPTH (TURNOUT SIDE)	1.60''
	TURNOUT - GUARD RAILS FLANGEWAY WIDTH (STRAIGHT SIDE)	1.60''
	TURNOUT - GUARD RAILS FLANGEWAY WIDTH (TURNOUT SIDE)	1.60''

Figure 40. Comparison report—detailed comparison for Camp Example Track Segment M12.

EX111 RAILER I Page. 1
CAMP EXAMPLE WORK HISTORY INFORMATION
11/18/87

TRACK SEGMENT #	YEAR	COST	WORK DESCRIPTION
1001	1978	$0.00	SEGMENT REDUCED TO CATEGORY B (INACTIVE TRACK).
101	1977	$17,000.00	REPLACE 450 TIES AND 50 SWITCH TIES.
601	1977	$39,200.00	REPLACE 350 TIES, REBUILD TRACK CROSSING, CLEAN DITCHES.
601	1978	$19,000.00	BALLAST AND SURFACE.
901B	1978	$0.00	SEGMENT CREATED OUT OF OLD SEGMENT 901 AND REDUCED TO CATEGORY B (INACTIVE TRACK).
902	1978	$0.00	SEGMENT REDUCED TO CATEGORY B (INACTIVE TRACK).
I01	1980	$28,000.00	500 TIES REPLACED, BALLAST ADDED, AND RAIL AND TIES RAISED.
M01	1980	$26,250.00	550 TIES REPLACED, BRUCHCUTTING, DITCHES CLEANED, BOLTS TIGHTENED/REPLACED.
M02	1980	$18,900.00	REPAIR FLOOD DAMAGE, 100 TIES REPLACED, BALLAST AND SURFACE, BOLTS TIGHTENED/REPLACED.
M03	1980	$12,500.00	REPAIR FLOOD DAMAGE TO BRIDGE, CLEAR DEBRIS FROM BRIDGE PIERS.
M04	1984	$30,600.00	REPLACE 630 TIES, CLEAN DITCHES AND CULVERTS.
M04	1980	$27,600.00	SOUTH END: REPAIR FLOOD DAMAGE, REPLACE 400 TIES, BALLAST AND SURFACE 1,000 FEET, TIGHTEN/REPLACE BOLTS.
M08	1984	$7,200.00	REPLACE 150 TIES AND 2 BROKEN RAILS.

Figure 41. Work history report for entire Camp Example network.

One particular method of estimating that provides reasonable results is establishing unit price approximations for typical tasks based on work type, e.g., reconstruction with or without new rail, tie replacement, surfacing, vegetation eradication, etc. These unit prices can then be combined with the inspection results for a cost estimate. The best source for obtaining specific required tasks to use in these calculations is the detailed option of the Comparison Report (see Figure 40). Specific component details may also be useful. These are available through either the Track Segment Inventory Information (Inventory Report) or the Information by Setting Parameters (Parameter Report) options of the report generation menu. Where appropriate, the estimate should include direct labor, equipment, overhead, profit, and other administrative costs that must be considered as part of the project cost. The estimator must also consider whether the work will be done by a contractor or by installation personnel.

5. *Work or Track Segment Prioritization*

Once the work to be performed for each track segment has been identified and the costs estimated, the total cost must be compared to the expected funding level. If the needed work exceeds the available funds for the annual work plan, some of the work must be deferred to later years. Accordingly, a prioritization procedure must be used. Through proper prioritization, a long range (5 year) work plan can be developed that assigns work to given years based on the projected funding ceiling. Prioritization is discussed in more detail later in this chapter.

6. *Finalize the Plan*

After the work has been prioritized, the annual and long range work plan is nearly complete. Any changes, adjustments, deletions, or additions need to be made. These may result from networking considerations, funding target changes, emergencies, "political" actions, mission changes, or other factors. Networking considerations are discussed in the section on prioritization.

7. *Repeat Next Year*

Railroad maintenance management is a dynamic process. Track conditions worsen over time, missions change, funding levels vary, and a multitude of factors affect planning. For those reasons, a long-range, multiyear work plan is only valid for one year--the first one. It must be updated annually with current information and decision criteria.

Prioritization

The concept of prioritization is simple. When available funds are less than what is needed to do all of the required work, prioritization establishes which work gets done and which gets deferred. Traditionally, this decision is made subjectively. RAILER I permits much more structured work prioritization.

To properly prioritize maintenance work, it must first be divided into two categories: (1) work funded through a Major Command (MACOM) (e.g., FORMAP-2) and (2) work funded by the installation. This division is necessary because currently HQ FORSCOM is prioritizing major M&R work, while installation DEHs are prioritizing maintenance and minor repair. The prioritization methods for MACOM level and for installation level decision making are different.

MACOM-Administered Work

Work that FORSCOM is prioritizing is funded through the FORMAP-2 program. FORMAP-2 is a multiyear program designed to rehabilitate track at several installations. Since the funding spans several years and many of the installations need the work done immediately, a method is needed for FORSCOM to allocate the funds among those installations. Accordingly, USA-CERL has developed a prioritization program called FORPROP (FORces command railroad PROject Prioritization). This program uses information provided to FORSCOM from the RAILER I databases. An example of a FORPROP report is presented in Figure 42. This prioritization approach uses an analytical procedure described elsewhere.[19]

It is important to note that FORMAP-2 also covers repairs to loading docks, ramps, lighting, and marshalling yards. Accordingly, this work needs to be identified and estimated along with the track segment work.

Installation-Funded Work

For this work, the prioritization decisions are made by the DEH or a DEH-appointed representative. RAILER I assists in that decision making.

Deciding What Needs to Be Prioritized. The starting point is deciding whether it is the track segment as a whole or the work within a track segment that needs to be prioritized. The difference is significant. For example, Figure 39 shows that all track segments except M03 need work (M03 is a bridge). Conceivably, the segments could be prioritized in decreasing order of importance. However, if condition levels are considered for these same segments, there are 43 possible work groups. A work group includes all of the work needed to raise a track segment to the next highest condition level. In the decision whether to prioritize by segment or by work group, the deciding factor is whether partial repair in a given year is acceptable. If all the defects in a track segment must be corrected at the same time, the network's segments should be prioritized. Alternatively, if the needed work for a given segment can be scheduled for different years--that is, if partial repair is acceptable, then the work groups throughout the network should be prioritized. Examples later in this chapter will illustrate these approaches.

The two methods can also be combined. In this approach, the goal is to raise a track segment to a given level. It may be the next highest level or even higher. This approach is attractive if a policy exists that establishes a minimum acceptable condition level for different track uses or some other criteria. If this is employed, a work group would consist of all of the needed work to raise the condition to the minimum level. Other work groups for the same track segment would raise the condition to even higher levels, but these would have a lower priority.

The procedure can be complicated further if certain work types are to be done all at once. An example of this would be a tie replacement program for the entire network. The work for each track segment may be small, which makes it attractive to do it all at once. Other work may possibly be deferred until another year.

[19]D. R. Uzarski, J. S. Liebman, C. S. Melching, and D. Plotkin; and S. Karls, D. A. Piland, and D. R. Uzarski.

PAGE 1

TRACK SEGMENT GROUPS SELECTED FOR FUNDING, LISTED BY RANK

INSTALLATION	GROUP	RANK	BENEFIT	COST	RATIO	CUM.COST
CAMP EXAMPLE B	1	1	65.00	14.41	4.51	14.41
			I01			
CAMP EXAMPLE 3	2*	2	61.33	14.48	4.24	28.89
			I01			
CAMP EXAMPLE C	3*	3	61.33	14.48	4.24	43.37
			I01			
CAMP EXAMPLE A	4	4	58.31	15.37	3.79	58.74
			I01			
CAMP EXAMPLE 2	5	5	38.98	14.41	2.71	73.15
			I01			
CAMP EXAMPLE 1	6	6	35.83	15.37	2.33	88.52
			I01			
CAMP EXAMPLE B	7	7	832.12	449.31	1.85	537.83
			M01	M02	M03	M04
			M05	M06	P01	P02
			M07	M08	M09	M10
			M11	M12	M13	701
			M14	Y01	M15	M16
			601	702	703	801
			101	102	103	104
			201	301	401	302
CAMP EXAMPLE C	8*	8	785.19	444.43	1.77	982.26
			M01	M02	M03	M04
			M05	M06	P01	P02
			M07	M08	M09	M10
			M11	M12	M13	701
			601	M14	Y01	M15
			M16	702	801	703
			101	102	103	201
			104	301	401	302
CAMP EXAMPLE A	9	9	746.45	428.89	1.74	1411.15
			M01	M02	M03	M04
			M05	M06	P01	P02
			M07	M08	M09	M10
			M11	M12	M13	701
			601	M14	Y01	M15
			M16	702	703	801
			101	102	103	104
			201	301	401	302
CAMP EXAMPLE 3	10*	10	746.61	444.43	1.68	1855.58
			M01	M02	M03	M04
			M05	M06	P01	P02
			M07	M08	M09	M10
			M11	M12	M13	701
			M14	Y01	M15	M16
			601	702	801	703
			101	102	103	104
			201	301	401	302

AT A FUNDING LEVEL OF $ 1875.00 K
ACHIEVED BENEFIT IS 3431.14 (74.70% OF POSSIBLE)

* INDICATES TRACKS DEPENDENT UPON INADEQUATE COMMERCIAL TRACK

Figure 42. Example of FORPROP report.

The prioritization philosophy (track segment or work group) has an impact on the cost estimating procedures discussed earlier. The difference is whether the work should be estimated based on correcting all of the defects within the track segment or on work groups for the various condition levels.

Prioritization Techniques for Installation-Funded Work

The number of methods possible to either prioritize track segments or work groups is unbounded. Discussed below are three possible approaches and how RAILER I can be used to support them.

Worst First. "Worst first" prioritization could be employed by using the Comparison reports. A worst first track segment prioritization would use the condition summary option (Figure 38); the resulting priority groups for Camp Example are presented in Table 9. The condition comparison by inspection type option (Figure 39), would be used for worst first work group prioritization. In this case the priority groups are simply the four middle columns of Figure 39; so for segment 101, turnouts, vegetation, and ties are respectively included in the first, second, and third priority groups.

Track Rank Versus Condition. A track rank versus condition method of prioritization would involve the use of a matrix such as shown in Figure 43. Since track rank is a measure of a track segment's relative importance, this method will allocate the funds based on importance as well as condition. This matrix can be used to organize either track segments by their worst condition or track segment work group.

The information needed for the matrix can be obtained from the Parameter Report option of the report generation menu. This report indicates which track segments meet the desired parameters (in this case track rank and condition). Further detail on inventory and condition can also be provided.

A series of Parameter Reports are required for prioritizing track segments by condition and track rank. A separate report is generated for each of the 20 priority groups indicated in Figure 43; the first two such reports are presented in Figure 44. The resulting track segment prioritization for Camp Example is presented in Table 10; note the differences from the "worst first" prioritization presented in Table 9.

Prioritizing work groups by condition and track rank requires a Parameter Report only for each row of Figure 43; the first two of these five reports are presented in Figure 45 for Camp Example. This information is combined with the Comparison Report by Inspection Type, Figure 37, to develop the priority groups presented in Table 11. This prioritization is significantly different from the "worst first" work group prioritization discussed above because certain segments appear more than once.

If this track rank approach is used, it must be remembered that track ranks only apply to functional tracks (see Appendix B). Access tracks, by definition, have a track rank of zero because they, in themselves, have no intrinsic value. That is why the matrix in Figure 43 does not go to zero. It is therefore necessary to prioritize access track segments along with the functional track segment to which they lead. This ensures that they are taken together. To find out which access tracks lead to which functional track segments, the Segment Identification option of the Parameter Report can be consulted; the first page of this report for Camp Example is presented in Figure 46. This report includes the functional track uses and the preceding track segment for each track segment number. The Inventory Report could also be used to obtain this information.

Table 9

"Worst First" Track Segment
Prioritization for Camp Example

Prioritization Group	Track Segment(s)
Out of Service	101, 103, 302, 601 702, I01, M01, M04 M05, M06, M08, M09 M14, M16
5 MPH Limit	102, 104, 201, 301 401, 501, 701, 703 801, 901A, M02, M07 M10, M11, M15, P01 P02
10 MPH Limit	902, M12, Y01
No Restrictions	M13

TRACK RANK	CONDITION RATING			
	OUT OF SERVICE	5 MILE/HR LIMIT	10 MILE/HR LIMIT	NO RESTRICTION
.81 – 1.0	1	3	6	13
.61 – .80	2	5	9	16
.41 – .60	4	8	12	18
.21 – .40	7	11	15	19
.01 – .20	10	14	17	20

Figure 43. Track segment or work group track rank/condition prioritization matrix.

```
*************************************************************************
YOU HAVE SELECTED Condition Summary WHERE Out of Service AND Segment
Identification WHERE Track Rank IS GREATER THAN .80
*************************************************************************

                    RAILER I
              COMMON TRACK SEGMENT #
              ====================

                      M16
```

```
*************************************************************************
YOU HAVE SELECTED Condition Summary WHERE Out of Service AND Segment
Identification WHERE Track Rank IS GREATER THAN .6 AND WHERE Track Rank IS
LESS THAN OR EQUAL TO .8
*************************************************************************

                    RAILER I
              COMMON TRACK SEGMENT #
              ====================

                      601
```

Figure 44. Parameter report(s) of track rank and condition for prioritizing track segments.

Table 10

Track Segment Prioritization by Track Rank/Condition for Camp Example

Priority Group*	Condition Rating	Track Rank	Track Segment
1	Out of Service	1.00	M16
2	Out of Service	0.74	601
3	5 MPH Limit	0.81-1.00	None
4	Out of Service	0.50	I01
5	5 MPH Limit	0.80	P01
	5 MPH Limit	0.80	P02
	5 MPH Limit	0.70	104
	5 MPH Limit	0.66	703

* These Priority Group numbers are taken from the Track Rank/Condition Matrix presented in Figure 43.

Table 10 (Cont'd)

Priority Group	Condition Rating	Track Rank	Track Segment
6	10 MPH Limit	0.81-1.00	None
7	Out of Service	0.21-0.40	None
8	5 MPH Limit	0.50	201
	5 MPH Limit	0.44	401
	5 MPH Limit	0.48	501
	5 MPH Limit	0.47	801
9	10 MPH Limit	0.61-0.80	None
10	Out of Service	0.17	302
	Out of Service	0.12	702
	Out of Service	0.12	M14
11	5 MPH Limit	0.21-0.40	None
12	10 MPH Limit	0.41-0.60	None
13	No Restrictions	0.81-1.00	None
14	5 MPH Limit	0.18	901A
	5 MPH Limit	0.12	701
	5 MPH Limit	0.12	M10
	5 MPH Limit	0.12	M11
	5 MPH Limit	0.12	M15
15	10 MPH Limit	0.21-0.40	None
16	No Restrictions	0.61-0.80	None
17	10 MPH Limit	0.12	M12
	10 MPH Limit	0.12	Y01
18	No Restrictions	0.41-0.60	None
19	No Restrictions	0.21-0.40	None
20	No Restrictions	0.12	M13

```
*****************************************************************************
YOU HAVE SELECTED Segment Identification WHERE Track Rank IS GREATER THAN .8
*****************************************************************************

EX111                      RAILER I TRACK SEGMENT INVENTORY               Page:    1
CAMP EXAMPLE                     SEGMENT IDENTIFICATION
                                       12/02/87
                                                                       PRECEDING
 TRACK     BEGIN    END                 TRACK                   TRACK    TRACK
SEGMENT# LOCATION LOCATION  LENGTH  CATEGORY TRACK USE  RANK   SEGMENT#(S)
======== ======== ======== ======== ======== ========== ======= ===========
M16      324+80   348+67   2387 TF    A      LOADING    1.0000  M15
         -0-                                                    -0-


*****************************************************************************
YOU HAVE SELECTED Segment Identification WHERE Track Rank IS GREATER THAN .6
AND WHERE Track Rank IS LESS THAN OR EQUAL TO .8
*****************************************************************************

EX111                      RAILER I TRACK SEGMENT INVENTORY               Page:    1
CAMP EXAMPLE                     SEGMENT IDENTIFICATION
                                       12/02/87
                                                                       PRECEDING
 TRACK     BEGIN    END                 TRACK                   TRACK    TRACK
SEGMENT# LOCATION LOCATION  LENGTH  CATEGORY TRACK USE  RANK   SEGMENT#(S)
======== ======== ======== ======== ======== ========== ======= ===========
104      69+39    78+87     948 TF    A      LOADING    0.7000  103
         -0-                                                    -0-

601      1+11     45+17    4406 TF    A      SERVICE    0.7400  M10
         -0-                                                    -0-

703      21+93    35+15    1322 TF    A      LOADING    0.6600  702
         -0-                                                    -0-

P01      0+89     18+67    1778 TF    A      AUXILIARY  0.8000  M06
         -0-                                                    -0-

P02      18+67    42+90    2423 TF    A      AUXILIARY  0.8000  P01
         -0-                                                    -0-
```

Figure 45. Parameter report(s) for prioritizing work groups by track rank and condition.

Track Use Versus Condition. This prioritization approach is displayed as Figure 47. As before, a matrix approach is used. This variation of the track rank versus condition method is actually a simpler approach. It should be noted that this does not have the restrictions on access tracks. The method can be used for prioritizing both track segments and work groups. As above, the Parameter Report can also be used to obtain the desired information.

Table 11

Work Group Prioritization by Track Rank/Condition for Camp Example

Priority Group*	Work Group	Condition Rating	Track Rank	Track Segment	Work Area(s)
1	1	Out of Service	1.00	M16	Ties
2	2	Out of Service	0.74	601	Ties
3	-	5 MPH Limit	0.81-1.00	None	None
4	3	Out of Service	0.50	I01	Ties
5	4	5 MPH Limit	0.80	P01	Ties & Vegetation
	5	5 MPH Limit	0.80	P02	Ties
	6	5 MPH Limit	0.70	104	Ties
	7	5 MPH Limit	0.66	703	Vegetation
6	8	10 MPH Limit	1.00	M16	Vegetation
7	-	Out of Service	0.21-0.40	None	None
8	9	5 MPH Limit	0.50	201	Ties
	10	5 MPH Limit	0.48	501	Ties & Rail
	11	5 MPH Limit	0.47	801	Ties & Vegetation
	12	5 MPH Limit	0.44	401	Ties
9	13	10 MPH Limit	0.80	P01	Turnout
	14	10 MPH Limit	0.80	P02	Vegetation
	15	10 MPH Limit	0.74	601	Vegetation
	16	10 MPH Limit	0.66	703	Ties
10	17	Out of Service	0.17	302	Ties
	18	Out of Service	0.12	702	Ties
	19	Out of Service	0.12	M14	Turnouts
11	-	5 MPH Limit	0.21-0.40	None	None
12	20	10 MPH Limit	0.50	I01	Vegetation
	21	10 MPH Limit	0.48	501	Vegetation
13	-	No Restrictions	0.81-1.00	None	None

* These Priority Group numbers are taken from the Track Rank/Condition Matrix presented in Figure 43.

Table 11 (Cont'd)

Priority Group	Work Group	Condition Rating	Track Rank	Track Segment	Work Area(s)
14	22	5 MPH Limit	0.18	901A	Rail
	23	5 MPH Limit	0.17	302	Vegetation
	24	5 MPH Limit	0.12	701	Ties
	25	5 MPH Limit	0.12	M10	Ties, Turnout & Vegetation
	26	5 MPH Limit	0.12	M11	Ties
	27	5 MPH Limit	0.12	M15	Ties & Turnout
15	-	10 MPH Limit	0.21-0.40	None	None
16	28	No Restrictions	0.70	104	Vegetation
17	29	10 MPH Limit	0.18	901A	Ties
	30	10 MPH Limit	0.12	702	Turnouts
	31	10 MPH Limit	0.12	M12	Ties & Turnouts
	32	10 MPH Limit	0.12	Y01	Ties & Vegetation
18	33	No Restrictions	0.50	201	Vegetation
	34	No Restrictions	0.50	I01	Rail
	35	No Restrictions	0.44	401	Vegetation & Rail
19	-	No Restrictions	0.21-0.40	None	None
20	36	No Restrictions	0.18	901A	Vegetation
	37	No Restrictions	0.12	701	Vegetation & Rail
	38	No Restrictions	0.12	702	Vegetation
	39	No Restrictions	0.12	M11	Vegetation
	40	No Restrictions	0.12	M12	Vegetation
	41	No Restrictions	0.12	M13	Ties & Vegetation
	42	No Restrictions	0.12	M14	Ties & Vegetation
	43	No Restrictions	0.12	M15	Vegetation

Major and Minor Repairs Combined. It is not uncommon to have a relatively long period of time elapse between the identification of major M&R and the actual performance of the work. This is true whether or not the work is centrally or locally funded. This creates the problem of how to keep the deteriorated track segments operational in the interim. "Stop gap" repairs may be necessary. These are repairs that would alleviate the "out of service" defects so that trains can keep rolling until the major M&R work is completed. Most likely, this work will also have to be prioritized by methods such as those above.

```
*****************************************************************************
YOU HAVE SELECTED Segment Identification
*****************************************************************************
```

EX111 — RAILER I TRACK SEGMENT INVENTORY — Page 1

CAMP EXAMPLE — SEGMENT IDENTIFICATION

11/18/87

TRACK SEGMENT#	BEGIN LOCATION	END LOCATION	LENGTH	TRACK CATEGORY	TRACK USE	TRACK RANK	PRECEDING TRACK SEGMENT#(S)
1001	0+85 -0-	14+27	1342 TF	B	STORAGE	0.0000	902 -0-
101	1+11 -0-	50+16	4905 TF	A	ACCESS	0.0000	M08 -0-
102	50+16 -0-	62+37	1221 TF	A	ACCESS	0.0000	101 -0-
103	62+37 -0-	69+39	702 TF	A	ACCESS	0.0000	102 -0-
104	69+39 -0-	78+87	948 TF	A	LOADING	0.7000	103 -0-
201	0+89 -0-	10+95	1006 TF	A	LOADING	0.5000	103 -0-
301	0+89 -0-	6+85	596 TF	A	ACCESS	0.0000	102 -0-
302	6+85 -0-	17+52	1067 TF	A	LOADING	0.1700	301 -0-
401	0+87 -0-	10+37	950 TF	A	SERVICE	0.4400	301 -0-
501	0+89 -0-	8+65	776 TF	A	SERVICE	0.4800	101 -0-
601	1+11 -0-	45+17	4406 TF	A	SERVICE	0.7400	M10 -0-
701	0+89 -0-	6+87	598 TF	A	AUXILIARY	0.1200	M12 -0-
702	6+87 -0-	21+93	1506 TF	A	AUXILIARY	0.1200	701 Y01
703	21+93 -0-	35+15	1322 TF	A	LOADING	0.6600	702 -0-
801	0+89 -0-	14+77	1388 TF	A	LOADING	0.4700	702 -0-
901A	1+60 -0-	12+83	1123 TF	A	STORAGE	0.1800	M15 -0-
901B	12+83 INACCESSABLE BECAUSE OF PAVED OVER CROSSING.	[illegible]5+35	1352 TF	B	STORAGE	0.0000	901A -0-

Figure 46. First page of inventory segment identification parameter report for Camp Example.

TRACK USE	CONDITION RATING			
	OUT OF SERVICE	5 MILE/HR LIMIT	10 MILE/HR LIMIT	NO RESTRICTION
LOADING	1	4	7	11
ACCESS	2	5	8	14
AUXILIARY	3	9	12	17
STORAGE	6	13	15	19
SERVICE	10	16	18	20

Figure 47. Track segment or work group track use/condition prioritization matrix.

Networking Considerations

An important issue that should be considered when developing work plans is that the track segments, in themselves, are not independent entities. They are dependent, to some degree, on each other. Thus, the benefit of maintaining or repairing a given track segment and raising its condition to some level depends on raising certain other track segments to the same level. For example, consider the instance of a loading track segment which has an access track leading to it. Both need work and are in a 5 MPH restricted condition. If the loading track is to be raised to a higher condition, the access track must also be raised to at least that level, in order for the benefit of the work on the loading track segment to be realized.

It is recommended that networking be considered when developing work plans. It may have a major influence on prioritization and on adjustments to the final work plan. When the plan is finalized, it may be found that some track segments and condition levels do not match up.

Networking relationships are represented in RAILER I by the preceding track segment number data element. Also, RAILER I's network-based algorithms require access tracks to have a track rank of zero, because they have no value independent of the functional tracks they serve. Both data elements are used extensively in FORPROP.

Budgeting

There is no specific budget planning feature with RAILER I. However, a budget can be compiled by summing all individual costs based on the work plan.

Additionally, by summing the costs from all of the segments by looking at the Repair Cost Report (Figure 37), the user can quickly calculate the total dollar backlog. The difference between these funding needs and the total amount allocated in the annual work plan represents the unfunded requirement. This is the backlog of maintenance and repair (BMAR).[20]

However, it must be remembered that this is calculated based on the track conditions obtained from the last inspection. Because RAILER I has no condition forecasting capabilities, forecasted budget and backlog values will have to be adjusted based on expended deterioration (using the last inspection as a starting point) and appropriate inflationary factors.

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[20] AR 420-16, *Facilities Engineering Reports* (Department of the Army, 15 July 1983).

8 PROJECT LEVEL MANAGEMENT

There are several aspects to project level management. The most important is determining the most feasible M&R alternative for each track segment. This is performed by first determining all of the feasible alternatives along with a cost estimate for each. After the most feasible alternative is selected (based on cost, practicability, and expected performance), final designs, estimates, and work scope documentation are done. Last, after the actual work on the track segment is completed, the RAILER I database is updated to reflect the effort. This last step completes the project level management phase.

Like network level activities, project level management activities can generally be placed in two categories, (1) major M&R and (2) maintenance and minor repair.

Project level management focuses on those track segments that were scheduled during network level planning for the upcoming year. Also, project level management may consider segments scheduled for major M&R over a multiyear period. This latter case would occur when a multisegmented major M&R project is needed and requires either approval or funding by a MACOM or possibly a higher authority. Rather than having individual projects for each year, a single, multiphase project is developed, approved, and funded.

Timeframe

Project level management will not normally need to be performed on every track segment every year. In order to be meaningful, it should only begin just prior to or in conjunction with design for rehabilitation or with the preparation of a work order for maintenance or minor repair. If performed too far in advance of design or preparation of the work order, conditions may change, requiring a change in the scope of work.

Detailed Track Segment Evaluation

To properly design a rehabilitation project or develop a work order, each track segment to be worked on must receive a thorough evaluation so that the specific problems can be corrected. This involves the visual and automated inspection procedures discussed in Chapter 4. Additional data collection, as discussed below, may also be necessary. If the timing is favorable, this inspection can be done at the same time that the routine network level inspections are performed.

The work will normally already have been classified as major M&R or maintenance and minor repair from the results of the network level management phase. However, this is subject to change as a result of the detailed evaluation. It may be found that seemingly simple repairs are not adequate and that a major M&R effort would be needed. Also, it may have been thought that a major restoration effort was needed, but careful analysis may show that minor repairs would suffice.

Major M&R

When major M&R is indicated, certain questions must be answered. These include:

- What are the existing track segment lengths, turnout characteristics, and other physical attributes of the track components?
- Is the track structure (rail, ties, ballast, and subgrade) structurally adequate?
- Is moisture causing or accelerating the deterioration?
- Is there a material durability problem (i.e., ties, ballast, etc.)?
- Is the subgrade contributing to the deterioration?
- Are there clearance restrictions to contend with?
- What are the anticipated wheel loads and their frequency of occurrence?
- Are there curvature, superelevation, or turnout size problems that restrict car types or speeds?
- What are the funding constraints?

Many of these questions require a rigorous engineering analysis. However, because RAILER I represents an interim system designed to fulfill an immediate need, the analysis capabilities are limited and many required analyses are beyond the system's capabilities. Until the overall RAILER system (which will do many analyses internally) is completed, much of the analysis will need to be performed external to RAILER I.

Although RAILER I is limited in its analysis capabilities, it can still aid in the analysis process. By combining the information provided by RAILER I with accepted engineering analysis and design procedures such as those established by WES[21] and the American Railway Engineering Association (AREA),[22] competent engineers will be able to formulate several feasible M&R alternatives that would correct the problems being encountered in the track segment. The main focus must be on solving the true cause of the problems and not just on treating the symptoms. The least costly alternative would normally be chosen that would result in the desired performance over the analysis period. The life cycle cost should be estimated based on engineering economics procedures. Generally, present worth or uniform equivalent annual costing procedures are used.

There are four typical causes of problems that necessitate major M&R for track segments. These are loads (structural failure or inadequacies [loose or worn] of components), environment (rotten ties, excessive vegetation, freeze-thaw), materials (fouled ballast), certain rail defects, and geometry (tight curves and turnouts). Moisture can

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[21] David Coleman, Waterways Experiment Station (WES) Working Paper (WES, Vicksburg, MS).

[22] *AREA Manual for Railway Engineering* (American Railway Engineering Association [AREA], Washington, DC, current edition).

accelerate the distress in the first three cases. The detailed evaluation must recognize these causes so that proper solutions are selected.

Maintenance and Minor Repair

Maintenance and minor repairs require significantly less evaluation effort. The network level inspection normally would suffice as the prime source of information. Accordingly, when developing work orders, the latest visual, automated geometry, and internal rail flaw information is normally all that is required if it is fairly recent. If necessary, additional inspections can be conducted if they are deemed appropriate, for example, if a derailment or flooding occurred.

By the very nature of maintenance and minor repair, the work needs are localized and serve to restore the track to a desired condition level. Engineering analysis and design are usually not necessary. Identification of each defect, however, is fundamentally important so that they are included in the work.

Use of RAILER I Reports in Project Level Management

In network level management, as discussed above, the segment selection option is used to generate multisegment reports for prioritizing and coordinating the long-term work plan. On the other hand, for project level management, reports should focus on single track segments or selected groups.

Major M&R

Although RAILER I does not have any features for performing the analyses required for determining the most feasible alternative for major M&R, it does provide a valuable source of information needed for those analyses.

Figure 32 illustrates the report generation menu. Most of the report options provide needed information that can be used outside of RAILER I in engineering analyses (see Table 7 for option descriptions). Examples of each of these reports follow. An introduction to report generation was provided in Chapter 6. Detailed procedures for running the reports can be found in the computer user's guide.

Condition Comparison to Maintenance Standards (Comparison Report). This report verifies that major M&R is needed and what component(s) require the major rehabilitation. This report consists of three parts, any or all of which may be obtained at the user's discretion: a condition summary, a condition summary by inspection type, and a detailed comparison. The difference in each is the amount of detail provided. This report uses the results from the latest track segment inspection. Figures 48 through 50 display the three parts for a Camp Example track segment, M04, where major M&R is indicated. The overall condition coupled with the number and kind of defects indicate that major M&R is probably needed. The conditions shown in Figure 48 represent those found in the Interim U.S. Army Railroad Track Maintenance Standards and the U.S. Army IFS System.

Track Segment Inspection Information (Inspection Report). This report, shown in Figure 51 for Camp Example segment M04, provides additional, detailed information on the track segment. The actual inspection results of any past inspection may be obtained. This also includes any available track deflection information and computed track modulus values.

EX111 RAILER I Page: 1
CAMP EXAMPLE CONDITION SUMMARY
12/02/87

TRACK SEGMENT#	MAINTENANCE STANDARD CONDITION	IFS CONDITION
M04	OUT OF SERVICE	C3 - UNSATISFACTORY

Figure 48. Comparison report—condition summary for Camp Example Segment MO4.

EX111 RAILER I Page: 1
CAMP EXAMPLE CONDITION COMPARISON BY
INSPECTION TYPE
12/02/87

TRACK SEGMENT#	OUT OF SERVICE	5 MPH SPEED LIMIT	10 MPH SPEED LIMIT	NO RESTRICTIONS	NO DEFECTS
M04	TIES	VEGETATION RAIL	-0-	-0-	-0-

Figure 49. Comparison report—by inspection type for Camp Example Segment MO4.

EX111 CAMP EXAMPLE	RAILER I DETAILED COMPARISON 11/23/87	Page: 1
TRACK SEGMENT #	MAINTENANCE STANDARD CONDITION	QUANTITY
M04		
	*** OUT OF SERVICE ***	
	TIES - 5 OR MORE CONSECUTIVE DEFECTIVE TIES	7
	*** 5 MPH SPEED LIMIT ***	
	RAIL - FRACTURE - ENGINE BURN	
	TIES - 4 CONSECUTIVE DEFECTIVE TIES	16
	TIES - MISSING/BUNCHED/BADLY SKEWED TIES	4
	VEGETATION - LEFT - INTERFERES WITH TRAINS OR TRACK VEHICLES	2%
	VEGETATION - CENTER - INTERFERES WITH TRAINS OR TRACK VEHICLES	7%
	VEGETATION - RIGHT - INTERFERES WITH TRAINS OR TRACK VEHICLES	5%
	*** 10 MPH SPEED LIMIT ***	
	RAIL - PIPED RAIL	
	TIES - 3 CONSECUTIVE DEFECTIVE TIES	95
	TIES - ALL JOINT TIES DEFECTIVE	8
	VEGETATION - LEFT - PREVENTS TRACK INSPECTION	7%
	VEGETATION - CENTER - PREVENTS TRACK INSPECTION	10%
	VEGETATION - RIGHT - PREVENTS TRACK INSPECTION	8%
	*** NO RESTRICTIONS ***	
	TIES - 2 CONSECUTIVE DEFECTIVE TIES	217
	TIES - AVERAGE SPACING PER RAIL LENGTH > 22 INCHES	2
	TIES - SKEWED TIES	2
	TIES - PERCENTAGE OF TOTAL DEFECTIVE TIES	19%
	TIES - TOTAL DEFECTIVE TIES	1689
	VEGETATION - LEFT - INSUFFICIENT, WHERE NEEDED	3%
	VEGETATION - RIGHT - INSUFFICIENT, WHERE NEEDED	5%
	VEGETATION - CENTER - GROWING IN BALLAST	77%
	VEGETATION - LEFT - INTERFERES WITH WALKING	3%
	VEGETATION - CENTER - INTERFERES WITH WALKING	8%
	VEGETATION - RIGHT - INTERFERES WITH WALKING	5%
	VEGETATION - LEFT - INTERFERES WITH VISIBILITY OF SIGNS	11%
	VEGETATION - RIGHT - INTERFERES WITH VISIBILITY OF SIGNS	15%
	VEGETATION - LEFT - BRUSHES SIDES OF ROLLING STOCK	17%
	VEGETATION - CENTER - BRUSHES SIDES OF ROLLING STOCK	5%
	VEGETATION - RIGHT - BRUSHES SIDES OF ROLLING STOCK	13%
	VEGETATION - LEFT - PRESENTS A FIRE HAZARD	5%
	VEGETATION - CENTER - PRESENTS A FIRE HAZARD	5%
	VEGETATION - RIGHT - PRESENTS A FIRE HAZARD	12%

Figure 50. Comparison report--detailed comparison for Camp Example Segment MO4.

EX111
CAMP EXAMPLE

RAILER I INSPECTION
RAIL INSPECTION
11/23/87

Page 1

TRACK SEGMENT # DATE	LOCATION	RAIL	DEFECT TYPE	DEFECT DESCRIPTION
M04 03/26/87	158+43 -0-	N	11	FRACTURE - ENGINE BURN
M04 03/26/87	78+45 -0-	N	13	PIPED RAIL

EX111
CAMP EXAMPLE

RAILER I INSPECTION
TIE INSPECTION
11/23/87

Page 1

TRACK SEGMENT# DATE	CONSECUTIVE DEFECTIVE TIES 2	3	4	>=5	JOINT TIES DEFECTIVE	AVE SPACING > 22	SKEWED TIES	MISSING/BUNCHED/BADLY SKEWED TIES	TOTAL DEFECT TIES
M04 03/30/87	217 -0-	95	16	7	8	2	2	4	1689
	217	95	16	7	8	2	2	4	1689

EX111
CAMP EXAMPLE

RAILER I INSPECTION
VEGETATION INSPECTION
11/23/87

Page 1

TRACK SEGMENT #	DEFECTS	LEFT	CENTER	RIGHT
M04	NO DEFECTS	58 %	22 %	48 %
03/30/87	INSUFFICIENT, WHERE NEEDED	3 %	0 %	5 %
	GROWING IN BALLAST	0 %	77 %	0 %
	PREVENTS TRACK INSPECTION	7 %	10 %	8 %
	INTERFERES WITH WALKING	3 %	8 %	5 %
	INTERFERES WITH VISIBILITY OF SIGNS	11 %	0 %	15 %
	BRUSHES SIDES OF ROLLING STOCK	17 %	5 %	13 %
	INTERFERES WITH TRAINS OR TRACK VEHICLES	2 %	7 %	5 %
	PREVENTS A FIRE HAZARD	5 %	5 %	12 %
COMMENTS	-0-			

NO INFORMATION SATISFIES CONDITION FOR TRACK GEOMETRY, TURNOUT INSPECTION, TRACK DEFLECTION.

Figure 51. Inspection report for Camp Example Track Segment M04.

Track Segment Inventory Information (Inventory Report). When a track segment is being analyzed or major M&R is being designed, the analyst or designer must know the attributes of the various components that make up the segment. This includes such items as the segment length, turnout characteristics, drainage structures, rail weight, etc. This information is obtained from the Inventory Report, Figure 52.

Car Type Information (Car Type Report). This report, Figure 53, provides information concerning the types of cars and the tonnage they carry. This information is needed when performing a structural analysis of the track and/or when planning to strengthen track components (e.g., subgrade stabilization, rail weight increase, etc.).

Work History Information (Work History Report). Information on past work can help the engineer choose solutions to current problems. Knowing what was done and when helps in evaluating the performance of past techniques and methods. Figure 54 shows the Work History Report for Camp Example segment M04.

Repair Cost Information (Repair Cost Report). If the M&R project for a given track segment has been planned at the network level, the rough estimated cost (scoping estimate) as well as a generalized description will have been stored in the RAILER I database. This report provides information that can serve as a starting point in the alternative formulations. This would be particularly useful if the person doing the project level evaluation and design is not the same one who did the network level planning, or if a significant period of time has elapsed between the network planning phase and the project analysis and design.

Additionally, once the design is completed and the cost is estimated, this file should be updated to reflect the current status. The Repair Cost Report for Camp Example segment M04 is shown in Figure 55.

Maintenance and Minor Repair

Work orders for rectifying maintenance and minor repair problems can be developed with the help of RAILER I. The system can easily report the defects that need to be corrected. Additionally, RAILER I can help the DEH determine the condition level at which a specific track segment needs to be maintained. This decision is a function of track use, frequency of operations, mobilization needs, rate of deterioration, loads, and available funds. The cost estimating associated with developing the work orders is accomplished through normal planning and estimating procedures.

The same series of reports discussed above for major M&R are also used for minor M&R, but for slightly different purposes. Camp Example track segment M15 requires minor M&R; reports for segment M15 are used here for illustration.

Comparison Report. The key portion of this report is the detailed comparison. By using this report the DEH can see exactly what needs to be done to raise the track segment condition to the next level. The detailed comparison report for Camp Example track segment M15, presented in Figure 56, indicates a variety of tie, turnout, and vegetation defects. By replacing a few ties, including some in the turnout, the track condition can be raised from a 5 MPH restriction to a 10 MPH restriction. All operating restrictions can be removed if two more ties are replaced and some parts in the turnout are tightened.

EX111 RAILER I TRACK SEGMENT INVENTORY Page: 1
CAMP EXAMPLE 11/23/87

****

SEGMENT IDENTIFICATION

TRACK SEGMENT#	BEGIN LOCATION	END LOCATION	LENGTH	TRACK CATEGORY	TRACK USE	TRACK RANK	PRECEDING TRACK SEGMENT#(S)
M04	30+69	189+43	15874 TF	A	ACCESS	0.0000	M03
	-0-						-0-

****

BALLAST

TRACK SEGMENT #	DEPTH	COMMENTS
M04	21 inches	6" LIFT IN 1973.

****

CULVERTS

TRACK SEGMENT #	CENTERLINE LOCATION	COMMENTS
M04	163+24	-0-

****

CURVES

TRACK SEGMENT #	CURVE ID #	CURVATURE	SUPERELEVATION	MAX SPEED	COMMENTS
M04	1CM	3.00	0.00 inches	25 MPH	-0-
M04	2CM	4.50	0.00 inches	25 MPH	-0-
M04	3CM	3.00	0.00 inches	25 MPH	-0-
M04	4CM	6.00	0.00 inches	20 MPH	-0-

****

PLATES/FASTENINGS

TRACK SEGMENT #	TIE PLATES	RAIL ANCHORS (#/200 TF)	GAGE RODS	COMMENTS
M04	Y	80	N	-0-

****

RAIL

TRACK SEGMENT #	WEIGHT	SECTION	BEGIN LOCATION	END LOCATION	LENGTH	COMMENTS
M04	90 lbs/yd	RA	30+69	189+43	31748 LF	-0-

Figure 52. Inventory report for Camp Example Track Segment MO4.

EX111
CAMP EXAMPLE

RAILER I
CAR TYPE INFORMATION
12/02/87

Page: 1

TRACK SEGMENT #	CAR TYPE	HEAVIEST LOAD (TONS)
M04		
	HEAVY FLAT	140.00
	FLAT	80.000
	GONDOLA	98.000
	BOX	55.000
	HOPPER	100.00
	6 AXLE LOCOMOTIVE	190.00
	4 AXLE LOCOMOTIVE	110.00

Figure 53. Car type report for Camp Example Track Segment MO4.

EX111
CAMP EXAMPLE

RAILER I
WORK HISTORY INFORMATION
12/02/87

Page: 1

TRACK SEGMENT #	YEAR	COST	WORK DESCRIPTION
M04	1984	$30,600.00	REPLACE 630 TIES, CLEAN DITCHES AND CULVERTS.
M04	1980	$27,600.00	SOUTH END: REPAIR FLOOD DAMAGE, REPLACE 400 TIES, BALLAST AND SURFACE 1,000 FEET, TIGHTEN/REPLACE BOLTS.

Figure 54. Work history report for Camp Example Track Segment MO4.

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CAMP EXAMPLE — REPAIR COST INFORMATION

12/02/87

TRACK SEGMENT #	DATE	COST/SEGMENT	COST/100 TF	COMMENTS
M04	03/31/87	$87,510.00	$551.28	Tie renewal - 1987 and 1988, Vegetation eradication - 1988

Figure 55. Repair cost report for Camp Example track segment MO4.

Inspection Report. As discussed earlier, this report provides the actual inspection results of any past inspection. Normally, for maintenance and minor repair only the latest inspection report is needed. As shown in Figure 57, this report provides more detail on defects. While the Comparison Report (Figure 56) showed defects by component and condition category, the Inspection Report shows all of the inspection findings.

Inventory Report. Pertinent inventory information is very important to developing a work order. Lengths, sizes, and other physical dimension data are needed when ordering parts and materials to match existing components. For example, as previously shown in Figure 56, turnout and vegetation defects exist within the given track segment. From the Inventory Report for segment M15 (Figure 58), the switch point length and frog size can be used to order missing turnout parts such as frog bolts and guard rail filler and bolts. Also, the segment length from the Inventory Report can be coupled with the vegetation defect percentages (from either the Comparison Report, Figure 56, or the Inspection Report, Figure 57) to estimate the required work. For this example, approximately 500 TF (Track Feet) needs vegetation control.

The track use and track category are also obtained from this report. This is necessary information if a local policy has been established that sets different minimum acceptable condition levels for different track uses. For example, Category B track (inactive) should only require minimum maintenance.

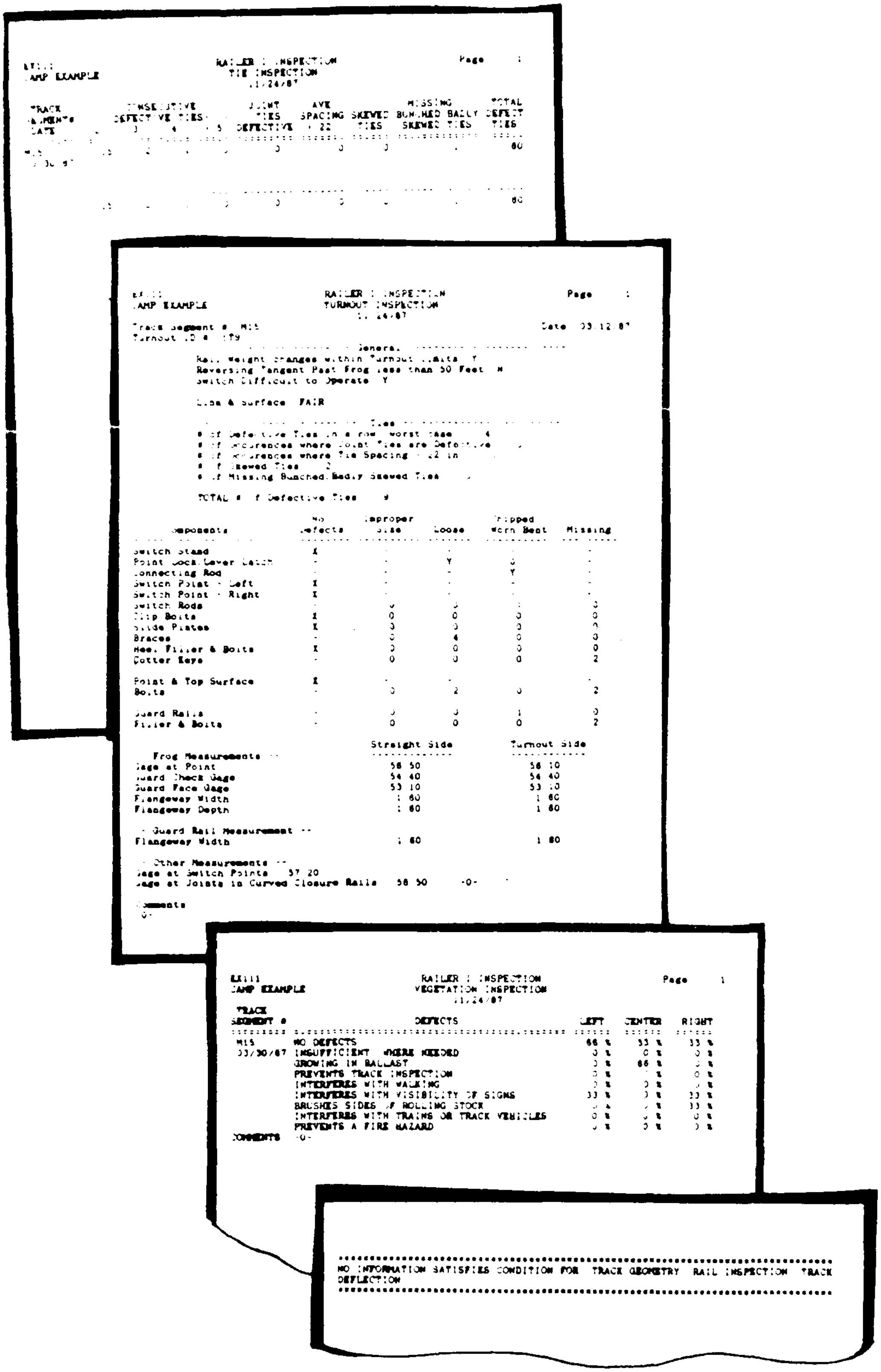
EX111 CAMP EXAMPLE

RAILER I
DETAILED COMPARISON
11/24/87

Page: 1

TRACK SEGMENT #	MAINTENANCE STANDARD CONDITION	QUANTITY
M15		
	*** 5 MPH SPEED LIMIT ***	
	TIES - 4 CONSECUTIVE DEFECTIVE TIES	1
	TIES - MISSING/BUNCHED/BADLY SKEWED TIES	1
	TURNOUT - DEFECTIVE TIES IN A ROW	4
	*** 10 MPH SPEED LIMIT ***	
	TIES - 3 CONSECUTIVE DEFECTIVE TIES	2
	TURNOUT - POINT LOCK/LEVER LATCH LOOSE	Y
	*** NO RESTRICTIONS ***	
	TIES - 2 CONSECUTIVE DEFECTIVE TIES	15
	TIES - PERCENTAGE OF TOTAL DEFECTIVE TIES	20%
	TIES - TOTAL DEFECTIVE TIES	80
	VEGETATION - CENTER - GROWING IN BALLAST	66%
	VEGETATION - LEFT - INTERFERES WITH VISIBILITY OF SIGNS	33%
	VEGETATION - RIGHT - INTERFERES WITH VISIBILITY OF SIGNS	33%
	VEGETATION - RIGHT - BRUSHES SIDES OF ROLLING STOCK	33%
	TURNOUT - RAIL WEIGHT CHANGES WITHIN TURNOUT LIMITS	Y
	TURNOUT - SWITCH DIFFICULT TO OPERATE	Y
	TURNOUT - LINE & SURFACE	FAIR
	TURNOUT - MISSING, BUNCHED OR BADLY SKEWED TIES	2
	TURNOUT - CONNECTING ROD BENT, BROKEN OR ALTERED	Y
	TURNOUT - SWITCH RODS BENT, CRACKED, BROKEN, CORRODED OR ALTERED	1
	TURNOUT - BRACES LOOSE	4
	TURNOUT - COTTER KEYS MISSING	2
	TURNOUT - FROG BOLTS LOOSE	2
	TURNOUT - FROG BOLTS MISSING	2
	TURNOUT - GUARD RAILS BENT, CRACKED, BROKEN, CORRODED OR ALTERED	1
	TURNOUT - FILLER & BOLTS MISSING	2
	TURNOUT - FROG GAGE AT POINTS (TURNOUT SIDE)	56.10''
	TURNOUT - GAGE AT SWITCH POINTS	57.20''
	TURNOUT - FROG GUARD CHECK GAGE (STRAIGHT SIDE)	54.40''
	TURNOUT - FROG GUARD CHECK GAGE (TURNOUT SIDE)	54.40''
	TURNOUT - FROG GUARD FACE GAGE (STRAIGHT SIDE)	53.10''
	TURNOUT - FROG GUARD FACE GAGE (TURNOUT SIDE)	53.10''
	TURNOUT - FROG FLANGEWAY WIDTH (STRAIGHT SIDE)	1.60''
	TURNOUT - FROG FLANGEWAY WIDTH (TURNOUT SIDE)	1.60''
	TURNOUT - FROG FLANGEWAY DEPTH (STRAIGHT SIDE)	1.60''
	TURNOUT - FROG FLANGEWAY DEPTH (TURNOUT SIDE)	1.60''
	TURNOUT - GUARD RAILS FLANGEWAY WIDTH (STRAIGHT SIDE)	1.60''
	TURNOUT - GUARD RAILS FLANGEWAY WIDTH (TURNOUT SIDE)	1.60''

Figure 56. Comparison report—detailed comparison for Camp Example Track Segment M15.



EX111
CAMP EXAMPLE

RAILER I INSPECTION
TIE INSPECTION
11/24/87

Page 1

TRACK SEGMENT # DATE	CONSECUTIVE DEFECTIVE TIES 3	4	5	JOINT TIES DEFECTIVE	AVE SPACING > 22	SKEWED TIES	MISSING BUNCHED BADLY SKEWED TIES	TOTAL DEFECT TIES
M15 03/30/87	2	[illegible]	[illegible]	0	0	0	[illegible]	60
	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	60

EX111
CAMP EXAMPLE

RAILER I INSPECTION
TURNOUT INSPECTION
11/24/87

Page 1

Track Segment # M15
Turnout ID # 179

Date 03/12/87

General

Rail Weight changes within Turnout Limits Y
Reversing Tangent Past Frog less than 50 Feet N
Switch Difficult to Operate Y

Line & Surface FAIR

Ties

# of Defective Ties in a row (worst case) 4
# of Occurences where Joint Ties are Defective [illegible]
# of Occurences where Tie Spacing > 22 in [illegible]
# of Skewed Ties 2
# of Missing/Bunched/Badly Skewed Ties [illegible]

TOTAL # of Defective Ties 9

Components	No Defects	Improper Size	Loose	Chipped Worn Bent	Missing
Switch Stand	X	-	-	-	-
Point Lock/Lever Latch	-	-	Y	0	-
Connecting Rod	-	-	-	Y	-
Switch Point - Left	X	-	-	-	-
Switch Point - Right	X	-	-	-	-
Switch Rods	-	0	0	[illegible]	0
Clip Bolts	X	0	0	0	0
Slide Plates	X	0	0	0	0
Braces	-	0	4	0	0
Heel Filler & Bolts	X	0	0	0	0
Cotter Keys	-	0	0	0	2
Point & Top Surface	X	-	-		-
Bolts	-	0	2	0	2
Guard Rails	-	0	0	1	0
Filler & Bolts	-	0	0	0	2

-- Frog Measurements --	Straight Side	Turnout Side
Gage at Point	56 50	56 10
Guard Check Gage	54 40	54 40
Guard Face Gage	53 10	53 10
Flangeway Width	1 60	1 60
Flangeway Depth	1 60	1 60

-- Guard Rail Measurement --
Flangeway Width 1 60 1 60

-- Other Measurements --
Gage at Switch Points 57 20
Gage at Joints in Curved Closure Rails 56 50 -0-

Comments
-0-

EX111
CAMP EXAMPLE

RAILER I INSPECTION
VEGETATION INSPECTION
11/24/87

Page 1

TRACK SEGMENT #	DEFECTS	LEFT	CENTER	RIGHT
M15	NO DEFECTS	66 %	33 %	33 %
03/30/87	INSUFFICIENT WHERE NEEDED	0 %	0 %	0 %
	GROWING IN BALLAST	0 %	66 %	0 %
	PREVENTS TRACK INSPECTION	0 %	[illegible] %	0 %
	INTERFERES WITH WALKING	0 %	0 %	0 %
	INTERFERES WITH VISIBILITY OF SIGNS	33 %	0 %	33 %
	BRUSHES SIDES OF ROLLING STOCK	0 %	0 %	33 %
	INTERFERES WITH TRAINS OR TRACK VEHICLES	0 %	0 %	0 %
	PREVENTS A FIRE HAZARD	0 %	0 %	0 %

COMMENTS -0-

****
NO INFORMATION SATISFIES CONDITION FOR TRACK GEOMETRY RAIL INSPECTION TRACK DEFLECTION
****

Figure 57. Inspection report for Camp Example Track Segment M15.

EX111 RAILER I TRACK SEGMENT INVENTORY Page 1
CAMP EXAMPLE 11/24/87

SEGMENT IDENTIFICATION

TRACK SEGMENT#	BEGIN LOCATION	END LOCATION	LENGTH	TRACK CATEGORY	TRACK USE	TRACK RANK	PRECEDING TRACK SEGMENT#(S)
M15	317+51 -0-	324+80	729 TF	A	AUXILIARY	0.1200	M14 -0-

BALLAST

TRACK SEGMENT #	DEPTH	COMMENTS
M15	17 inches	6" LIFT IN 1973.

PLATES/FASTENINGS

TRACK SEGMENT #	TIE PLATES	RAIL ANCHORS (#/200 TF)	GAGE RODS	COMMENTS
M15	Y	36	N	-0-

RAIL

TRACK SEGMENT #	WEIGHT	SECTION	BEGIN LOCATION	END LOCATION	LENGTH	COMMENTS
M15	90 lbs/yd	AS	317+51	324+80	1458 LF	-0-

TURNOUTS

TRACK SEGMENT#/ TURNOUT #	SWITCH POINT LOCATION	FROG SIZE	DIR.	RAIL WEIGHT	POINT LENGTH	FROG TYPE	GUARD RAIL LENGTH
M15 1T9	319+12 -0-	15	LH	90 lbs/yd	22.0 LF	RAIL BOUND MANGANESE	13 LF

Figure 58. Inventory report for Camp Example Track Segment M15.

Car Type Report. Generally, this information is only needed when considering maintenance and minor repair if a policy has been established that sets different minimum acceptable condition levels for differing car types and/or load levels. For example, it may be desired that a storage track used only by empty hopper cars have a minimum acceptable condition of 5 MPH. The DEH would then fix only those defects that would place the track segment out of service. This report was shown as Figure 53.

Work History Report. Any available work history information should be reviewed when planning new work. It may be found that there is a recurring type of maintenance or minor repair within the track segment. Consequently, the previous maintenance or minor repair work may have only treated the symptom of a more deep seated or serious engineering problem. If so, a different solution may be necessary, or the track segment may be a candidate for major M&R. This report was shown as Figure 54.

Repair Cost Report. This report may provide a starting point for developing maintenance and minor repair work. There should be a rough scoping estimate present from the network level analysis. Also, there may be information available from a previously developed work order that for some reason was not done. An example of this report was shown as Figure 55. As stated in the discussion of major M&R earlier in this chapter, this file should be updated once the work order has been prepared.

Combining Segments into Work Units

Quite often, major M&R or maintenance and minor repairs are not done on just one track segment. Typically, several segments are combined into one major M&R project or one maintenance and minor repair work order. This would initially involve a work request (Job Order Request [JOR]), Department of the Army (DA) Form 4283, followed by a work order (Individual Job Order [IJO]), DA Form 4284, if the work is to be done in-house, or contractor data form, DA Form 4286, if the work is to be done by a contractor.[23]

The procedures described above are applied to each individual track segment selected for work. In completing the analyses, designs, and/or scopes of work, it is simply a matter of combining the individual results into one project (or project phase for a multiyear project).

However, when calculating the project costs, simply adding the individual track segment costs is likely to produce an overly conservative estimate. This is because as the quantity of work increases, the unit cost typically drops. Thus, once the work to be done for the group of track segments has been scoped and/or designed, the cost estimate should be adjusted based on that entire amount. The total should then be divided appropriately among the track segments for work history purposes.

Final plans and specifications for major M&R need to be prepared for the entire group, not for individual segments.

[23]Department of the Army Pamphlet (DA PAM) 420-6, *Facilities Engineering Resources Management* (DA, 15 May 1978); DA Form 4283, *Facilities Engineering Work Request* (DA, August 1978); DA Form 4284, *Facilities Engineering Work Order* (DA, August 1978); DA Form 4286, *Facilities Engineering Contract Data* (DA, January 1979).

Preventive Maintenance

Preventive maintenance (PM) is planned and performed outside of RAILER I. PM is generally performed periodically and consists of those activities designed to ensure the smooth operation of mechanical parts or to retard deterioration. This may include such procedures as oiling switches, tightening loose bolts, replacing missing cotter keys, etc., although the work items will possibly vary from installation to installation depending on local policy on PM versus normal maintenance and repair.

Emergency or Service Work

Emergency Work

Emergency work becomes necessary when a catastrophic event such as a derailment or washout occurs. Usually the track segment will require immediate restoration. These tasks involve very little planning because of the very short or nonexistent lead time required for the work. The intent is to simply restore the track to its previous condition. Therefore, RAILER I is only needed for its inventory reporting, which quickly provides information on the existing components that may need to be replaced.

Snow removal is also considered an emergency task, but a snow removal plan should be developed. RAILER I's inventory report can be used in developing the plan.

Service Work

Sometimes the amount of work to be done is very small and within the scope of a service order. Service orders may be generated when a train operating crew spots a certain defect or when the tracks are inspected. This work requires little or no planning, engineering, or estimating. A work crew is normally dispatched to the site and performs the task called for. Again, because of the nature of the work, RAILER I is only needed for inventory information.

Updating the Database

Once the work on specific track segments has been done, certain RAILER I database files need to be updated. These include work history, inventory, and inspection. The procedures for updating the database are included in the computer user's guide.

Work History

The work history file should definitely be updated shortly after the performance of major M&R or maintenance and minor repair work. This includes emergency work, except snow removal. Preventive maintenance and service order work reporting are not as critical for work history purposes, but they are still recommended, to ensure a complete history.

Inventory

Any time completed work has resulted in a change in the physical attributes of the track segment components, the inventory file should be updated. This should be done when the work is completed.

Inspection

Since completed work has corrected defects that were previously recorded in the database, the inspection and comparison reports will no longer represent actual conditions. Accordingly, the inspection file must be updated. This may be done three ways: (1) reinspect after the work has been completed, (2) perform a "dummy" inspection (record the defects from the last inspection minus those corrected by the work), or (3) use the next scheduled annual inspection. For practical considerations, the last choice will usually suffice.

9 OTHER RAILER I USES

RAILER I can be a valuable tool for aiding in the completion of special studies of the railroad track network. These studies serve many purposes, but generally they are needed to answer specific issues that arise. Although RAILER I is intended to be a DEH support tool, others outside the DEH organization can benefit from the information that RAILER I provides. Described below are only a few of the possible studies that could be done using RAILER I.

MTMCTEA Installation Transportation System Capability Studies (TSCS)

MTMCTEA periodically updates the mobilization outloading reports for those installations that have track and a mobilization outloading (and/or inloading) mission. RAILER I, through various reports, can provide essential information that will help them prepare the study more easily and quickly. These include the Installation Report, the Inventory Report and the Car Type Report. The Installation Report for Camp Example is shown in Figure 59; examples of the other two reports were shown previously in Figures 52, 53, and 58. If necessary, the Parameter Report can also provide a variety of very specific data.

Installation Transportation Office (ITO) Requests

The ITO may be planning a movement that would involve a special car type, extra-heavy load, etc. Thus, it may be necessary to know the curvatures of the various track segments, turnout frog numbers, etc. The desired information can be obtained from the Parameter Report.

Determining Operating Speed Restrictions

There are two sources in RAILER I for operating speed restrictions which should be communicated to the ITO and others responsible for operating trains on installation tracks (such as commercial railroads).

The Interim U.S. Army Railroad Track Maintenance Standards specify speed restrictions for a variety of track defects. These speed restriction/track defect relationships are incorporated in Railer I and are discussed in Appendix D. The speed restrictions for all track segments are easily obtained from the RAILER I Comparison Report--Condition Summary (see Figure 38).

As discussed in Chapter 6, the Army track standards also specify a relationship between operating speed, degree of curvature, and curve superelevation. Because for all practical purposes the degree of curvature is fixed, the superelevation restriction implies an operating speed restriction for some curves. These curves may be determined by examining an Inventory Report or a properly specified Parameter Report.

RAILER I

12/02/87 CAMP EXAMPLE OR Page: 1

Installation #(s): EX111 -0-

Relation Codes(s): EX111 -0-

Serving Railroad(s)

UNION PACIFIC RAILROAD
-0-
-0-
-0-

Installation Trackage

Track #	Track Length (TF)	# of Segments
1	7887	4
10	1427	1
2	1095	1
3	1752	2
4	1037	1
5	865	1
6	4517	1
7	3515	3
8	1477	1
9	3255	3
I	2681	1
M	34867	16
P	4368	2
Y	775	1

Total # of Installation Tracks = 14
Total # of Segments = 38
Total Track Feet (TF) = 69518

Figure 59. Installation report for Camp Example.

DD Form 1391 and Program Development Brochure (PDB)

Major M&R projects with estimated costs over $1 million require approval by higher authority. This requires Department of Defense (DD) Form 1391[24] and creating a Project Development Brochure (PDB).[25] All RAILER I reports can provide needed information to help with the completion of these forms.

Special DEH Studies

Instances occur when it is desirable to know specific information concerning the railroad network. Examples of the special questions that would be asked include:

- Where are the locations where rail weight is less than 90 lbs/yd?

- What track segments carry heavy flat cars, have a rail weight less than 90 lb/yd, and have defective tie clusters?

- What track segments are classified as inactive?

The Parameter Report answers these and many other questions.

---

[24] AR 420-17, *Real Property and Resources Management* (DA, 13 December 1987); Department of Defense (DD) Form 1391, *FY( ) Military Construction Project Data* (DD, December 1976).

[25] AR 415-20, *Project Development and Design Approval* (DA, 28 March 1974); Technical Manual 5-800-3, *Project Development Brochure* (DA, 15 July 1982).

10 IMPLEMENTATION PROCEDURES

Recommendations and Assistance

Special procedures are recommended when RAILER I is first installed at a specific installation. The following implementation procedures should ensure a trouble-free and efficient process. The steps described below constitute a logical and consecutive process. Steps 1, 2, 3, 8, 9, and 10 can be easily performed by one person. All other steps can be accomplished by a crew of two. With additional personnel, some steps can be performed concurrently (3 through 10).

Installation personnel are not currently expected to install RAILER I. Installations may request assistance from their MACOM and the U.S. Army Engineering and Housing Support Center (USAEHSC). Recommendations for skilled contractors and other governmental agencies that can provide the actual on-site assistance needed are available through USAEHSC.

Step-by-Step Procedure

1. Determine Initial Track, Turnout, and Curve Numbers

Track, turnout, and curve numbers are determined with the help of a map or track diagram and with information from someone familiar with the network. This is done in the office.

2. Divide Tracks into Track Segments

Next each track is divided into logical track segments, and consecutive track segment numbers are assigned. Existing network maps or diagrams must then be marked up with the track, track segment, turnout, and curve numbers. This marked-up map will serve as a guide for the field work. This step is also done in the office.

3. Verify Track Network and Track Use

Once track, track segment, turnout, and curve numbers are established, this information is verified in the field, along with track uses. It may be necessary to solicit the help of someone familiar with network operations. DEH personnel should be consulted for concurrence with the numbering sequence. ITO personnel can help determine track uses. This will ensure that all identification numbers and track uses are clear, logical, and accurate.

4. Station the Track

With the aid of an appropriate measuring device, such as a measuring wheel, each track is stationed and permanently marked at 200-ft intervals. A measuring wheel, either held manually or attached to a track cart, provides sufficient accuracy; these two methods are shown in Figures 60 and 61, respectively. It is strongly recommended that 2-in.-square aluminum plates stamped with the station number be affixed to the nearest tie for permanent marking of 200-ft intervals. Paint or crayons can be used to temporarily mark station locations at the track segment origins, turnouts, culverts, rail and road crossings, and bridge ends. This will greatly aid in the inventory process that follows. As an alternative to temporary marks, the station locations can be immediately

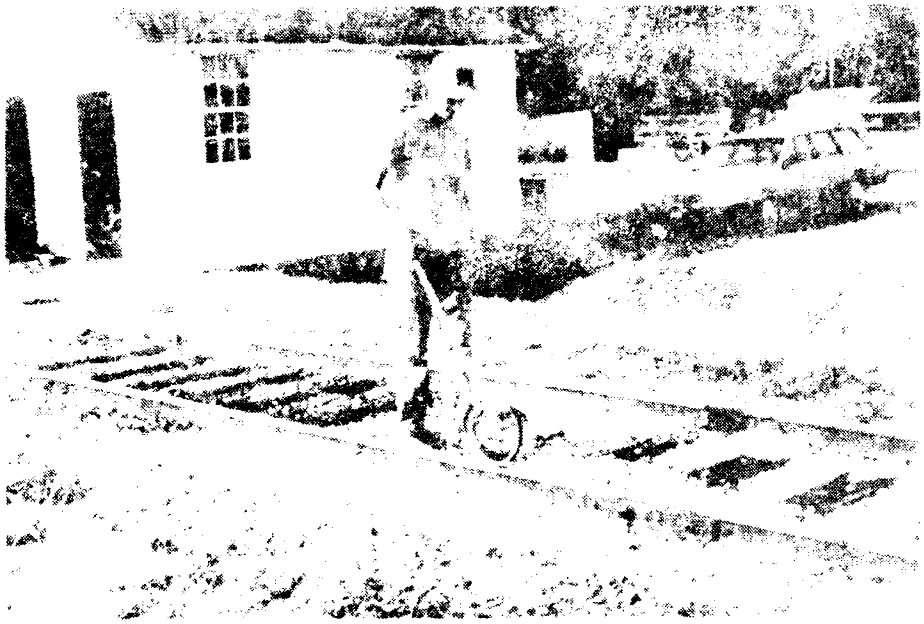


Figure 60. Manual use of measuring wheel.

Figure 61. Measuring wheel mounted to track cart with wheel on rail head.

written on the track segment inventory forms. This stationing process is discussed and illustrated in Chapter 3.

5. Complete the Inventory

The track segment inventory form (Appendix A) is used to complete the inventory for each segment. It is especially helpful when conducting the inventory to have the marked-up map present. As each segment is inventoried, it should be checked off on the map, thus ensuring that no segments are omitted or duplicated. The map will also aid in identifying segments, turnouts, curves, and other items in the field. At the end of each work day, each data sheet should be carefully checked for errors. Any errors found should be corrected the next working day.

Particular care must be taken when listing the preceding track segment numbers (data element 6, Table 2). If these are recorded incorrectly, errors will occur later when the RAILER I computer procedures assign car types to access tracks. Also, FORPROP will not perform correctly if this data element is improperly recorded.

One inventory data element, track rank (data element 5, Table 2) will be normally completed in the office after the field work is complete. As discussed in Chapter 3, the computational procedures described in Appendix B should be used for FORSCOM installations. A subjective ranking, made with the concurrence of the installation ITO, should be used otherwise.

6. Collect Car Type, Network Inventory, and Work History Information

The car types and heaviest loads that are expected to use each functional track segment must also be determined. This is best accomplished with the aid of ITO personnel since they are knowledgeable about what is shipped over the network. Additionally, the various names and codes needed to complete the network inventory must be obtained. These are available from the DEH office. The numbers of segments for each track are summarized and recorded along with the track lengths. This is easily obtained from the segment inventory by citing the ending station from the last segment for each track. Any available work history information should be obtained from the DEH. Car type and network inventory forms are provided in Appendix A.

7. Field Inspection

Each track segment must be inspected in accordance with the established procedures discussed in Chapter 4. The forms provided in Appendix A are used for this purpose. All data collection sheets should be checked daily so that errors, omissions, etc. can be corrected the next day.

8. Create Computer Database

Once the field data has been collected, the computerized database can be created. When specific batches of information have been loaded (e.g., segment inventory, car type, inspection, etc.) the data must be checked for entry errors. This is best accomplished by running appropriate reports that best display the data. These include network inventory, track segment inventory, car type, work history, and inspection reports. Any errors found can be corrected through the edit feature.

9. Update Station Track Maps

New station maps that clearly identify all track segments and components should be prepared. This provides a visual cross reference to the computer database.

10. Develop Annual and Long Range Work Plan

Experience with EMSs has shown that installation personnel are more able and willing to adopt a system, and maintenance management in general, if an initial work plan has been established as part of the implementation. The procedures described in Chapter 7 should be used by the implementing agent in developing the plan. If appropriate, project level planning activities, as described in Chapter 8, should also be developed for impending work.

If track segments requiring maintenance, repair, rehabilitation, or minor construction are to be centrally funded through FORSCOM, repair cost information on a segment by segment basis is needed so that the segments can be prioritized by the FORPROP program. Normal cost estimating procedures need to be employed, outside RAILER I, but the results must be entered into the database. When requested by FORSCOM, the cost information (along with certain other elements) will be transferred and sent via a floppy diskette. This portion of the database can also be used to store normal work plan information that is of value to the DEH.

11. Train Personnel

Since this system is intended to be a decision support tool for the DEH, appropriate personnel must be trained to use it. USA-CERL has developed a 3-day RAILER I short course, which is cosponsored by USAEHSC. This course provides the balance between field and office operations, lecture and "hands-on" opportunities, and a blend of maintenance management, railroad, computer, and DEH philosophies.

12. Routine Operations

After the system has been initially implemented and installation personnel have been trained, the system is ready for routine use. Not only does this include operating the computer in its decision support role, but the database must be kept current by DEH personnel. This involves performing annual network level inspections and updating the 5 year (long-range) work plan. Also, as the inventory, car types, work history, and the 5 year work plan changes, the appropriate data files should be updated.

11 TESTING

Four phases of testing were performed as part of RAILER I development. These included laboratory, field simulation, field testing, and system acceptance.

Laboratory

Laboratory testing consisted of specific data elements being entered and run in the various portions of the RAILER I computerized program. This ensured that specific portions of the program were performing correctly. This testing step was employed to locate program errors, test algorithms, create or modify screen and file formats, and determine speed of operations. The data used was fictitious, but it was representative of what may be found at installations and was valid for the test performed. This data was discarded when no longer needed.

Field Simulation

The purpose of this phase of the testing was to ensure that the computer programming worked correctly for a total installation database.

For this purpose, a fictional installation called "Camp Example" was created. This was simulated to represent a typical FORSCOM installation mission and network size. A complete database was created using the computerized data loading and editing features. All reports were run and analyzed to ensure that the programming was working correctly. The "Camp Example" network developed during this phase was used for the examples given throughout the report.

Field Testing

Specific aspects of field procedures have been tested at Fort Devens, MA, and at the Consolidated Rail Corporation (Conrail) yard in Urbana, IL. Partial implementation of the system, which also served to test the procedures, has occurred at Fort Campbell, KY, Fort Carson, CO, Camp Roberts, CA, Fort Pickett, VA, and Camp Edwards, MA. Feedback from each implementation was used to improve the procedures and the data gathering process to ensure efficient collection and useful data.

The field work consisted of several parts. USA-CERL personnel did the initial track segmenting and component identification. Segmenting, identity verification, and inspection were generally performed by personnel from the Transportation Systems Center (TSC). Data checking was later jointly performed by USA-CERL and TSC. Data requiring correction or collection due to omission was gathered by TSC. Track ranks were computed by USA-CERL personnel using the procedure described in Appendix B. Finally, USA-CERL loaded the data into individual computerized databases.

This phase of the testing was crucial to finalizing the field data collection procedures and data collection forms. After each site was completed, the researchers analyzed the time needed for collection, the usefulness of the data, needed data not collected, and ease of collection. In some cases, significant changes were needed in either the collection method or the data collection forms.

During this phase, 3 days of formalized training on the system, both field procedures and computer operations, were conducted by USA-CERL at Fort Devens, MA. Attendees included representatives from TSC, Fort Devens, FORSCOM, and the T.K. Dyer Corp.

Initial Track Segmenting and Component Identification

The office work of track segmenting and component identification was easily done by one person. Having accurate maps made the defining process very simple. Inaccurate maps led to many revisions during the validation step. The installations gave USA-CERL the maps well prior to any field work.

Field Work Crew Size

For the field work it was found that a knowledgeable and experienced two-person crew works most efficiently and that two passes over the track are necessary to complete the stationing and inventory process. Two additional passes are generally needed for inspection. Fortunately, stationing and inventory are "one-time" efforts (except when changes occur which necessitate updating). Inspections are intended to be recurring. One person can perform the inspections, but this will require more passes over the track.

Stationing

The first pass should serve to validate the segments and all assigned identification numbers. The track stationing can be easily done concurrently with the validation. The inventory is best done on the second pass.

The stationing procedure must be done with great care. To date, it has been done with measuring wheels. As part of the testing procedure, USA-CERL employed different procedures, including walking with the wheel on the rail and using a track cart with the wheel mounted on the cart in one of two ways. In the first track cart method, the wheel rests on the rail; this is illustrated in Figure 61. In the second, as illustrated in Figure 62, the wheel rides on the wheel of the cart. The cart was pulled or pushed three ways: manually, with a motor car, or with a locomotive. Generally, all stationing procedures worked well, except walking with the wheel on the rail is very slow. Accordingly, it is recommended that this method only be used for short tracks or where it is inconvenient or impossible to use the other methods. When the wheel is mounted on a cart, productivity can be 9 to 10 miles/day. TSC only employed the manual method.

A problem encountered with measuring wheels is the inherent inaccuracy associated with them. For USA-CERL field work, the wheels used were checked against a steel tape to determine the error. Errors less than or equal to 0.5 percent were accepted. The wheel measurement was rejected if the error exceeded that amount. Some wheels were found to have an error as high as 5 percent. All station markings were taken to the nearest foot. This is a reasonable degree of accuracy for maintenance management purposes. Another error associated with wheels is that it rides on one rail. Error is introduced because distance should be measured along the track centerline. As long as the track is straight there is no error, but once curves are encountered, the measured distance is either too long or too short depending on whether the outside or inside rail is used. Generally, this error is not significant enough to correct, and in the case of reverse curves, it is somewhat self-correcting.

Figure 62. Measuring wheel mounted to track cart with wheel on cart wheel.

Different methods were employed for marking the stations in the field. Paint, lumber crayons, and metal plates nailed to ties have all been used. The stamped metal plates worked best as far as permanency and ease of installation (they were nailed to the nearest tie), but they were also the most expensive due to their manufacture. When paint or crayons were used, the station was written on the rail base. Paint could, at best, be considered semi-permanent, and crayons are considered temporary markings. At some locations, permanent metal plates with paint markings were used, but these are considered semi-permanent, at best, since the paint will fade.

The use of permanent markers is considered essential. They save time when locating track deficiencies later in the management process. Also, the marked stations could be used to position flags or other temporary markers trackside every 1000 ft to aid in location referencing when performing automated track geometry and/or rail flaw testing. By placing temporary markings during the stationing process at locations where the station will be needed for inventory (e.g., switch points, culverts, etc.), the inventory process can be greatly speeded up.

Inventory

The inventory itself was quick and easy to do. Between 2 and 7 miles were walked a day, depending on the skill and experience of the crew, the number of segments, the variability of data elements, and the number of turnouts. The most time-consuming data element to collect was rail weight. U.S. Army rail is generally very old (most between 1880 and 1945), and rail brands can be difficult to read. Also, weights vary greatly and each time a pair of compromise joints is encountered the location (average station for staggered joints) and the new weight must be recorded. This procedure, although a bit slow, is necessary to get an accurate compilation of the amount of each weight present.

Ballast depths were estimated based on the knowledge of local personnel. This method is highly inaccurate and the results must be used with great care in rehabilitation planning. Test pits and penetrometer testing can be used to determine the depth to a reasonable degree of accuracy, but the expense and time needed for the data collection precludes routine use. Since this information is generally not needed unless it is believed that ballast and subgrade problems exist, its collection can be deferred until needed, and then ballast depth can be collected selectively.

Inspection

The visual inspection procedures described in Chapter 4 were carried out at all test installations. Generally, turnout inspections are quite straightforward, and little difficulty was encountered. However, tie and vegetation inspection does require a degree of subjectivity. Consequently, different inspectors may have different inspection results. This was apparent when the inspection results of different inspection teams were compared. The solution to this problem lies with proper training, adherence to the inspection procedures described in Chapter 4, and a working knowledge of the Interim U.S. Army Railroad Track Maintenance Standards. Productivity rates can match those during inventory for the same reasons.

Automated track geometry measurements were collected by TSC using their track geometry cart. This device measures gage and cross level (without loading the track); warp is calculated. Data is collected for every foot of each track segment. All of the data was transferred onto a floppy disk as an ASCII file and loaded by USA-CERL into RAILER I.

Two problems were encountered. First, the cart records an absolute cross level. This requires superelevations in curves to be factored out within RAILER I. This, in itself, is no problem if the curve numbers are recorded, but it is not possible to factor out the transitions into and out of curve superelevation. This problem with the TSC cart remains. Commercial track geometry measuring devices measure a relative cross level as well as superelevation. This data can be used directly in RAILER I. The second problem is that the amount of data collected is very large. The amount from Fort Pickett alone filled seven floppy disks. This created storage problems within the database. To store a reasonable amount within the RAILER I database, the data must be pared to "exception reporting," where geometry data with no defects (according to the Interim U.S. Army Railroad Track Maintenance Standards) are disregarded. Although only the "excepted" data is stored in RAILER I, the rest of the data is available to the user as ASCII files on floppy disks.

Rail flaw information (internal defects) was also collected by TSC and included in the field testing.

System Acceptance

This phase of the testing consisted of FORSCOM personnel using the RAILER I computer programs to load data and generate reports. Field procedures were not tested because of the extensive effort expended during the field testing phase. The purpose of this phase was to ensure that the programs operated on designated hardware, that the features worked, that reasonable results were obtained, and that the documentation was adequate to support the use. As part of delivering the completed program, additional training was provided, along with a draft version of the computer user's guide. As a result of the favorable testing, the system was accepted.

12 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The RAILER I Railroad Maintenance Management System is an interim system that can be implemented until the more fully capable planned RAILER versions become available. Although limited in scope, RAILER I can be used to effectively manage U.S. Army railroad track networks. RAILER I technology and methods represent an improvement over existing, ad hoc, subjective management approaches.

With data collected by procedures described in Chapters 2 through 5, the RAILER I computer program generates numerous reports which show the condition of the network track in varying levels of detail. From these reports, DEHs can make decisions about needed maintenance. RAILER I is easy for the user to comprehend and incorporate into the daily management routine. Field procedures and data-gathering methods have been designed to ensure that only relevant information is collected and that this collection is feasible with available resources. The computer environment is completely menu-driven.

The computer program uses a three-part database structure with sections for rail maintenance standards, installation information, and track segment data. The last is the most important, consisting of five subsections: car type, repair cost, inventory, work history, and inspection data. These databases make it possible to keep both historical and dynamic records.

Through the management procedures discussed in Chapters 7 through 9, RAILER I can provide considerable technical assistance in locating and identifying physical assets, assessing current conditions, determining M&R needs, and planning M&R work systematically. Condition prediction will be incorporated into later RAILER versions through the development of a Track Structure Condition Index (TSCI). TSCI will replace the Track Condition Rating used in RAILER I. This feature, in turn, will greatly enhance the DEH's ability to determine long-range M&R needs.

RAILER I can be used immediately in developing the multiyear FORMAP-2 program. The inventory, inspection, and condition comparison features of the system can serve to identify or validate track deficiencies, quantify the scope of work, and (through FORPROP) prioritize the actual work. Once the FORMAP-2 work is completed at any given installation, DEHs can use RAILER I as a basic decision support tool for keeping the track in proper condition to meet mission needs.

During the field testing phase of the work (Chapter 11), RAILER I was introduced to several installations. Their feedback to USA-CERL regarding the system as a whole was positive and constructive. It is believed that most installations will support the system as its merits become more widely known. Installation personnel who participated in the field tests offered positive comments regarding these procedures. All personnel who used the computer program found it very user-friendly, including those with little or no previous computer experience. However, this ease of use does not preclude the need for training on the system. Although it is simple to use, training helps avoid the potential problems of newness amd unfamiliarity.

Although the possibility was not investigated as part of the field testing, the researchers believe RAILER I can be effectively used in a manual (noncomputer) mode at installations with smaller networks. A cutoff on size has not been determined formally, but networks with fewer than about 10 track sections and/or track about 1 mile or less in length should be candidates for the manual application on an optional basis. Installations with networks larger than this should only consider the computerized application due to the speed, flexibility, and cost-effectiveness of computerized data processing.

Recommendations

The key to the success of the system is the interest and support at the installation level. It has been learned from experience with other EMS applications that, to promote acceptance and integration of the system into daily work, installation personnel must believe the system will actually help them perform their duties. This process comes about from training, a willingness to accept change, an admission that maintenance management practices could be improved, and a liberal MACOM policy supporting the system's use. Although the following recommendations are specific to FORSCOM, RAILER I can be used at any military installation that has track. (However, the work prioritization performed by FORPROP would not be applicable since it is very FORSCOM-specific.)

FORSCOM Implementation, Use, and Training

RAILER I should be implemented at all FORSCOM installations requiring work under the FORMAP-2 program. The implementation should include the complete development of individual RAILER I databases. This should be done as soon as funding allows to permit early identification of FORMAP-2 work needs and a logical prioritization through FORPROP.

Implementation should be funded through a centrally managed FORSCOM program. This would improve the efficiency of prioritization and coordination.

The system should be implemented through USAEHSC. USAEHSC, in turn, should contract out the implementation to qualified contractors experienced in maintenance management implementation procedures.

Upon completion of the FORMAP-2 work at any given installation, the database should be updated to reflect the work accomplished and the system turned over to installation users.

In conjunction with the system turnover, all installation personnel involved in the railroad management program should be trained on the system. Training should be available through a USA-CERL/USAEHSC-developed RAILER course or from a similar course that may be offered by a qualified vendor.

MTMC should be given a copy of the RAILER I programs and should also maintain a library of FORSCOM installation RAILER databases. Thus, essential information would be available on request to MTMC engineers and planners when revising outloading/inloading studies.

Other Suggested FORSCOM Actions

To encourage installations to use RAILER I, and to ensure that it is used correctly and effectively, the authors suggest that FORSCOM take the following actions.

- Ensure that installations receive and/or dedicate adequate resources to the maintenance management process. Ultimately this action will lead, if the system is properly used, to M&R cost avoidance by negating the need for a FORMAP-3 program.

• Implement management policies and practices to ensure that the system is being used properly, thus preserving the investment made in both track rehabilitation and RAILER's development and implementation. One possible practice might be for the Deputy Chief of Staff, Engineers (DCSENGR) to request a computerized condition summary (Comparison Report) from all installations on an annual basis, then tie this report to budget requests.

• Encourage installations that display a strong interest in the system by providing extra support for early implementation and system/database turnover and for resource allocation. Supporting interested installations is key to gaining a "grass roots" acceptance which will stimulate interest at other locations.

• Promote and suggest--rather than require--use of the system. This approach should lead installations to request the system rather than resist it.

The conceptual basis of RAILER I could be enhanced by efforts to:

• Determine the most cost-effective, mission-based maintenance strategies for FORSCOM trackage.

• Establish a track performance index known as a "mobilization index" for evaluating and rating tracks to sustain an imposed heavy mobilization loading.

• Develop an installation level work selection optimization program based on FORPROP concepts.

• Develop computer generated work plans.

All of these features would build on the RAILER system. These efforts will require FORSCOM leadership.

Enhancements to Procedures and Program

Continued active FORSCOM support is needed to sustain the overall RAILER development, particularly in TSCI formulation, condition prediction, and work strategy/maintenance index efforts in progress. Successful completion of these activities will permit track performance to be maximized at minimal cost.

RAILER I should be modified to include manual track geometry data and automated data that may be obtained from commercial sources. Currently, RAILER I handles only automated track geometry data obtained from the TSC track geometry cart.

To provide greater utility and accuracy, the program could be enhanced to include capabilities for automatic data checking to spot unreasonable entries; deletion of whole segments and/or related facilities at once; quick deletion of old inspection information; automatic splitting of segments when desired; automatic computation of track lengths; enhanced report generation; and faster data processing.

METRIC CONVERSION FACTORS

1 ft = 0.304 m
1 lb/yd = 0.496 kg/m
1 in. = 25.4 mm

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APPENDIX A:

BLANK RAILER I DATA COLLECTION FORMS

RAILER I
INSTALLATION INFORMATION DATE ____________

INSTALLATION INFORMATION				
Installation Number	Relation Code	Installation Name	State Code	Serving Railroad Company Name

INSTALLATION TRACKAGE								
Track Number	Track Length	# of Segments	Track Number	Track Length	# of Segments	Track Number	Track Length	# of Segments

12/15/86

TRACK SEGMENT ______________ RAILER I DATE: ______________

INSTALLATION NAME ______________ TRACK SEGMENT INVENTORY INFORMATION

SEGMENT IDENTIFICATION						BALLAST
Begin Location (Station)	End Location (Station)	Track Category	Track Use	Track Rank	Preceding Track Segment Number (s)	Depth (inches)
		A B	Acc Aux L Se St			
Comments:						Comments:

BRIDGES			CULVERTS	CURVES										
Facility Numbe	Construction Type	Deck Type	Centerline Location (Station)	Curve ID Number	Curvature (Degrees)									Max Desired Speed (m.p.h.)
					1	2	3	4	5	6	7	8	Avg	
		Open Ballast Open Ballast												
Comments			Comments	Comments										

PLATES/FASTENINGS			RAIL			RAIL CROSSINGS				
Tie Plates	Rail Anchors ($/200 TF)	Gage Rods	Weight (lbs/yd)	Section	Begin Location (Station)	Centerline Location (Station)	Crossing Segment Number	Rail Weight (lbs/yd)	Frog Type	Crossing Angle (degree)
N Y N Y N Y N Y		N Y N Y N Y N Y							B MI SM B MI SM B MI SM B MI SM	
Comments:			Comments:			Comments:				

ROAD CROSSINGS				
Road Name	Centerline Location (Station)	Crossing Length (feet)	Crossing Type	Bolted Joints
				N Y N Y N Y
Comments:				

TURNOUTS							
Turnout ID Number	Switch Point Location (Station)	Direction	Point Length (LF)	Rail Weight (lbs/yd)	Frog Type	Frog Size	Guard Rail Length (LF)
		LH EQ RH LH EQ RH			B SG RBM SP B SG RBM SP		
Comment:							

12/15/86

RAILER I

INSTALLATION NAME ____________ CAR TYPE INFORMATION DATE ____________

Complete Car Type Information for AUXILIARY, LOADING, SERVICE, and STORAGE Tracks only.
Car Type options are FLAT, HEAVY FLAT, BOX, HOPPER, GONDOLA, 6 AXLE LOCOMOTIVE, 4 AXLE LOCOMOTIVE, and 2 AXLE LOCOMOTIVE.
List all Car Types that are appropriate for each Track Segment.
For cars, "Heaviest Load" is the heaviest loading (net tons) placed on the car; for locomotives, "Heaviest Load" is the total weight (gross tons) of the locomotive.

Track Segment #	Car Type	Heaviest Load (Tons)	Track Segment #	Car Type	Heaviest Load (Tons)

7/17/87
MRB

RAILER I
RAIL INSPECTION

INSTALLATION NAME ________ DATE ________

TRACK SEGMENT NUMBER	DATE	LOCATION (STATION)	RAIL 'LEFT OR RIGHT	DEFECT TYPE	COMMENTS

RAIL DEFECT TYPES

1 = Bolt Hole Crack
2 = Broken Base
3 = Corroded Base
4 = Complete Break
5 = Crushed Head
6 = Defective Weld
7 = End Batter (>1/4")
8 = Fissure-Compound
9 = Fissure-Transverse
10 = Fracture-Detail
11 = Fracture-Engine Burn
12 = Head/Web Separation
13 = Piped Rail
14 = Split Head-Horizontal
15 = Split Head-Vertical
16 = Split Web
17 = Torch Cut
18 = Wear-Side (>1/2")
19 = Wear-Vertical (>1/2")
20 = Overflow
21 = Shelling
22 = Corrugation
23 = Chip/Dent in Head
24 = Engine Burn
25 = Flaking
26 = Rail Weight Insufficient for Mission

RAILER I INSPECTION
TURNOUTS

TRACK SEGMENT # ____________ DATE ____________

TURNOUT ID # ____________ INSPECTOR ____________

GENERAL		TIES	
Rail Weight changes within Turnout limits	N Y	# of Defective Ties in a row (worst case)	
Reversing Tangent Past Frog Less than 50 Feet	N Y	# of Occurrences where Joint Ties are Defective	
Switch Difficult to Operate	N Y	# of Occurrences where Tie Spacing 22 in.	
		# of Skewed Ties	
Line & Surface	GOOD FAIR POOR	# of Missing/Bunched/Badly Skewed Ties (Tie spacing along either rail>48 in.)	
		TOTAL # of Defective Ties	

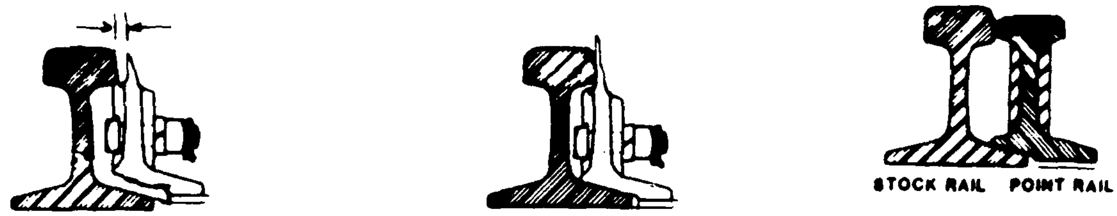
	COMPONENTS	NO DEFECTS	IMPROPER SIZE TYPE/POSITION (Y or #)	LOOSE (Y or #)	CHIPPED/WORN/BENT CRACKED/BROKEN/ CORRODED/ALTERED (Y or #)	MISSING (Y or #)
SWITCH & STAND	Switch Stand		Y	Y	Y	Y
	Point Lock/Lever Latch		Y	Y	Y	Y
	Connecting Rod		Y	Y	Y	Y
	Switch Point - Left		Y*	Y	Y	Y
	Switch Point - Right		Y*	Y	Y	Y
	Switch Rods					
	Clip Bolts					
	Slide Plates					
	Braces					
	Heel Filler & Bolts					
	Cotter Keys					
FROG	Point & Top Surface		Y	Y	Y*	Y
	Bolts					
GUARD RAILS	Guard Rails					
	Filler & Bolts					

	MEASUREMENTS (inches)	STRAIGHT SIDE	TURNOUT SIDE
FROG +	Gage at Point		
	Guard Check Gage		
	Guard Face Gage		
	Flangeway Width		
	Flangeway Depth		
GUARD RAILS +	Flangeway Width		
OTHER	Gage at Switch Points		
	Gage at Joints in Curved Closure Rails		

COMMENTS

* See reverse for illustrations of wear and improper positions

\+ See reverse for illustrations of measurements

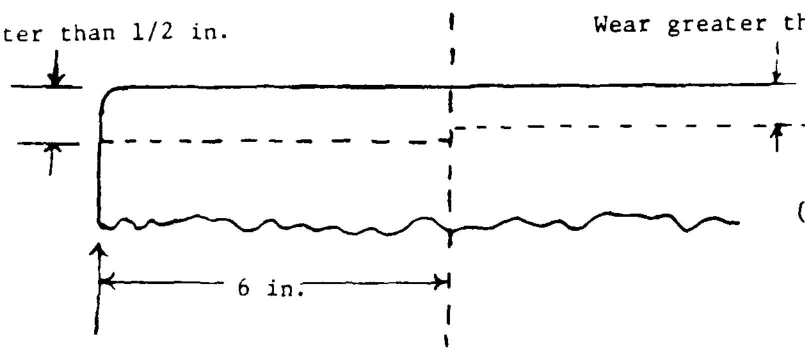


Gap greater than 1/8 in. between switch point and stock rail when switch is thrown and locked

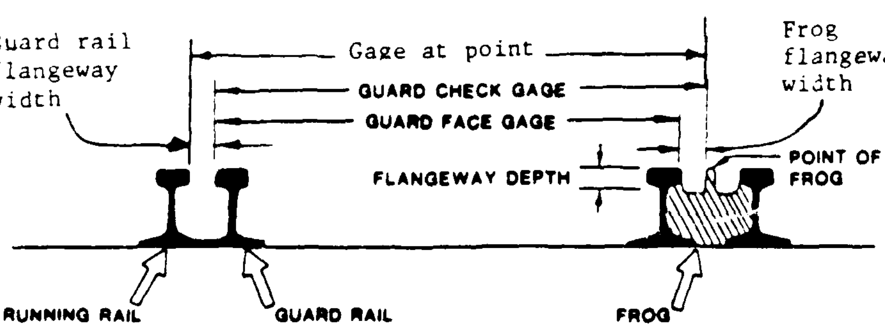
Point of switch higher than stock rail

Point rail (beyond taper) lower than stock rail

TYPES OF IMPROPER SWITCH POINT POSITION



FROG WEAR REQUIRING RESTORATION OR REPLACEMENT



MEASUREMENTS AT FROG AND GUARD RAILS

RAILER I INSPECTION
TIES

DATE: ____________

INSPECTOR: ____________

TRACK SEGMENT #	DEFECTIVE TIE CONDITIONS: CONSECUTIVE DEFECTIVE TIES 2	3	4	5 or more	ALL JOINT TIES DEFECTIVE	AVERAGE SPACING PER RAIL LENGTH >22 in.	SKEWED TIES	MISSING/ BUNCHED/ BADLY SKEWED TIES (tie spacing along either Rail>48 in.)	TOTAL DEFECTIVE TIES
# OF OCCURRENCES									
TOTAL									
COMMENTS:									
# OF OCCURRENCES									
TOTAL									
COMMENTS:									
# OF OCCURRENCES									
TOTAL									
COMMENTS:									
# OF OCCURRENCES									
TOTAL									
COMMENTS.									Ver. 12/86

RAILER I INSPECTION
VEGETATION

DATE: ______________

INSPECTOR: ______________

TRACK SEGMENT *	DEFECTS	LOCATION * Left Occurrences	Left Total	Center Occurrences	Center Total	Right Occurrences	Right Total
	No Defects Insufficient, where needed Growing in Ballast Prevents Track Inspection Interferes with Walking Interferes with Visibility of Signs Brushes Sides of Rolling Stock Interferes with Trains or Track Vehicles Presents a Fire Hazard						
	COMMENTS:						
	No Defects Insufficient, where needed Growing in Ballast Prevents Track Inspection Interferes with Walking Interferes with Visibility of Signs Brushes Sides of Rolling Stock Interferes with Trains or Track Vehicles Presents a Fire Hazard						
	COMMENTS:						
	No Defects Insufficient, where needed Growing in Ballast Prevents Track Inspection Interferes with Walking Interferes with Visibility of Signs Brushes Sides of Rolling Stock Interferes with Trains or Track Vehicles Presents a Fire Hazard						
	COMMENTS:						
	No Defects Insufficient, where needed Growing in Ballast Prevents Track Inspection Interferes with Walking Interferes with Visibility of Signs Brushes Sides of Rolling Stock Interferes with Trains or Track Vehicles Presents a Fire Hazard						
	COMMENTS.						

* See reverse for illustrations of location

RAILROAD SYSTEM RELATED FACILITIES INSPECTION

LOADING DOCKS, RAMPS, AND MARSHALLING YARDS

Date ____________

STRUCTURAL

LOADING DOCKS AND RAMPS

Track Segment Number	Facility Number	Deck		Support Structure		Overall Condition Code	Comments:
		Material Type	Condition Code	Material Type	Condition Code		

Material Type	CONDITION CODING: C1 = EXCELLENT/GOOD C2 = FAIR C3 = POOR/FAILED
A = Concrete/ Asphalt	C1 = Few or no defects, scattered surface cracking C2 = Medium severity cracking and deterioration C3 = High severity cracking and deterioration
B = Masonry	C1 = Few or no defects; Scattered surface cracking C2 = Medium severity cracking of stone and/or mortar joints C3 = High severity cracking of stone and/or mortar joints
C = Wood	C1 = Few or no defects. Peeling of paint, delamination, or splintering C2 = Loose connections, splitting; Holes in wood, pieces missing C3 = Mold/fungus growth; Decay/rot; Rodent/insect infestation
D = Metal	C1 = Few or no defects; Low severity corrosion C2 = Medium severity corrosion; Some broken welds or connections C3 = High severity corrosion; Several broken welds/connections; Members fractured
E = Earth/ Gravel	C1 = Few or no defects; Scattered small holes; High fill level C2 = Nominally high fill level; Medium severity potholes and ruts C3 = Low fill level; Large potholes; Severe erosion and rutting

MARSHALLING YARD PAVEMENTS

Track Segment Number	Facility Number	Pavement Type	Condition Code	Comments:

	CONDITION CODING: C1 = EXCELLENT/GOOD C2 = FAIR C3 = POOR/FAILED
A = UNPAVED/ GRAVEL	C1 = Few or no defects; Low severity corrugations, potholes, rutting; Good drainage C2 = Medium severity corrugations, potholes, rutting; Fair drainage C3 = High severity corrugations, potholes, rutting
B = CONCRETE/ ASPHALT	C1 = Low severity cracking and deterioration. Paver PCI > 70 C2 = Medium severity cracking and deterioration; Paver PCI > 30 but < 70 C3 = High severity cracking and deterioration; Paver PCI < 30

RAILROAD SYSTEM RELATED FACILITIES INSPECTION
LOADING DOCKS, RAMPS, AND MARSHALLING YARDS

______________ Date

LIGHTING

Track Segment Number	Facility Number (Note A)	Lighting Area	Condition Code (Note B)	Comments:

Lighting Area	CONDITION CODING: C1 = EXCELLENT/GOOD C2 = FAIR C3 = POOR/FAILED
A = LOADING DOCKS, RAMPS, AND ADJACENT TRACKAGE (NOTE C)	C1 = AVERAGE LIGHTMETER READING OF 5 OR GREATER C2 = AVERAGE LIGHTMETER READING > 3.5 BUT < 5 C3 = AVERAGE LIGHTMETER READING < 3.5; NO LIGHTING AVAILABLE
B = MARSHALLING YARDS	C1 = AVERAGE LIGHTMETER READING OF 2 OR GREATER C2 = AVERAGE LIGHTMETER READING > 1 BUT < 2 C3 = AVERAGE LIGHTMETER READING < 1; NO LIGHTING AVAILABLE

A. IF LIGHTING HAS ITS OWN FACILITY NUMBER, WHEN THIS NUMBER SHALL BE USED.
B. READINGS TAKEN AT 40 FOOT INTERVALS.
C. READINGS SHOULD BE TAKEN ALONG THE ADJACENT LENGTH OF TRACK GENERALLY USED DURING LOADING OPERATIONS.

APPENDIX B:

RECOMMENDED PROCEDURES FOR CALCULATING TRACK RANK AT FORSCOM INSTALLATIONS

Formula Description

Installation tracks are important because they either fulfill a function such as loading or storage or provide access to other tracks that fulfill those functions. Functional tracks and their respective access tracks are interdependent--an access track has no inherent value; however, a functional track is of no value if it is inaccessible. Functional tracks can be ranked according to the functions they perform. In some cases, a track can perform several functions; therefore, it should be assigned a rank based on the function it can perform best. Each track will be ranked according to how well it can perform these functions: circus-style loading, boxcar loading, storage of railcars, service (such as engine-servicing facility), or auxiliary functions (turning trains or letting trains pass each other). The final track rank is the track's highest functional ranking, normalized by dividing by the highest track rank on the installation.

The functional track ranking formulas are as follows:

Circus loading value:

$$LOD_c = \frac{(AL)(C)(T)(LI)(E)(L_t)}{S} \qquad \text{[Eq B1]}$$

Boxcar loading value:

$$LOD = 50(AL)(C)(T)(LI)(P)(S) \qquad \text{[Eq B2]}$$

Initial storage track value:

$$STR' = 0.15(AL)(C)(L)(S)(ARF) \qquad \text{[Eq B3]}$$

Final storage track value:

$$STR = \begin{cases} 0.5 \; MAX & \text{for track with highest STR' value} \\ STR' & \text{otherwise} \end{cases} \qquad \text{[Eq B4]}$$

Service track value:

$$SER = 500(AL)(C)(T)(U_e)(S) \qquad \text{[Eq B5]}$$

Initial auxiliary track value:

$$AUX' = 0.1(AL)(C)(L_a)(S)(W) \qquad \text{[Eq B6]}$$

Final auxiliary track value:

$$AUG = \begin{cases} 0.8\ \text{MAX} & \text{for track with highest AUX' value} \\ AUX' & \text{otherwise} \end{cases} \quad \text{[Eq B7]}$$

Where: AL: Access length factor

$$= \text{Min}\begin{pmatrix} 0.2 + 5{,}000{,}000/(500 + ATL)^2 \\ 1 + 70{,}000/(500 + ATL)^2 \end{pmatrix} \quad \text{[Eq B8]}$$

ATL: Access track length (in feet)

ARF: Alternate route factor

$$= \begin{cases} 0.0 & \text{if track provides only access to some other track} \\ 1.0 & \text{otherwise} \end{cases} \quad \text{[Eq B9]}$$

C: Curvature factor

$$= \begin{cases} 1.1 & \text{if no curve exceeds 10 degrees on the track or its access tracks} \\ 0.7 & \text{if some curve exceeds 12 degrees} \\ 1.0 & \text{otherwise (or if curvature unknown)} \end{cases} \quad \text{[Eq B10]}$$

E: Endramp factor

$$= \begin{cases} 1.25 & \text{if concrete} \\ 1.0 & \text{if nonconcrete fixed endramp} \\ 0.8 & \text{if no fixed endramp but portable endramp is available} \\ 0.4 & \text{if no endramp is available} \end{cases} \quad \text{[Eq B11]}$$

L: Length of track (in feet)

L_a: Auxiliary Length factor

$$= \begin{cases} \text{for balloon tracks: 1500} \\ \text{for wyes: 1500 or length of shortest tail in feet, whichever is less} \\ \text{for passing sidings: 4000 ft or length of siding plus length of bypassed main in feet, whichever is less} \end{cases} \quad \text{[Eq B12]}$$

L_t: Length of continuous tangent track measured from stub end of track

LI: Lighting factor

$$= \begin{cases} 1.75 & \text{if fixed lights} \\ 1.5 & \text{if no fixed lights but portable lights are available} \\ 1.0 & \text{if no lights are available} \end{cases} \qquad \text{[Eq B13]}$$

MAX: Maximum prenormalized track rank (over all tracks)

P: Number of boxcar loading positions

S: Switch factor

$$= \begin{cases} 1.0 & \text{if track has a switch at only one end} \\ 1.3 & \text{if track has a switch at both ends} \end{cases} \qquad \text{[Eq B14]}$$

T: Turnout factor

$$= \begin{cases} 1.0 & \text{if track served by tangent side of turnout} \\ 0.9 & \text{if track served by curved side of turnout} \end{cases} \qquad \text{[Eq B15]}$$

U_e: Engine house service factor

$$= \begin{cases} 0.0 & \text{if track does not serve an engine house or other service activity} \\ 1.0 & \text{if track serves an engine house or other service activity but locomotive need not be kept there} \\ 10.0 & \text{if track serves an engine house where locomotive must be kept} \end{cases} \qquad \text{[Eq B16]}$$

W: Receiving requirement factor

$$= \begin{cases} 3.0 & \text{for wye and balloon tracks if installation has a rail receiving requirement} \\ 1.0 & \text{otherwise} \end{cases} \qquad \text{[Eq B17]}$$

For switching flexibility, it is important that an installation have a storage track and at least one wye track or passing siding (auxiliary track). However, additional wyes, passing sidings, and storage tracks are far less valuable than the first one; this is why the highest ranking auxiliary tracks and storage tracks have their values raised to a multiple of the highest installation track rank. This is reflected in Equations B4 and B7.

Track rank is determined by first calculating Equations B1, B2, B3, B5, and B6 for each track segment (or appropriate track segment group). The largest of these five values is then assigned to the track segment; the maximum of the assigned values is MAX. Equations B4 and B7 are then calculated for each track segment and appropriate changes in track rank are made. MAX is then used to normalize all track rank values.

This process is illustrated with Camp Example. The values of Equations B1 through B7 for all Camp Example track segments are presented in Table B1, together with the final prenormalized value and the normalized track rank. Note that all access and category C track segments have zero track rank. The underlying data values (including Equations B8 through B17) are presented in Table B2.

Note that some of the data required for these track ranking procedures are not necessarily available in the RAILER I database. These additional data elements, listed in Table B3, may be indicated in appropriate Inventory comments fields (see Table 2).

These track rank procedures can be calculated easily using a spreadsheet software package such as LOTUS. The procedures were tested extensively with the Fort Campbell, KY, track network by MTMCTEA and USA-CERL personnel.

Table B1

Equation Values (B1 Through B7) for Camp Example

FUNCTIONAL TRACK NAME	all type values	LOD(C)	LOD(M)	STR	SER	AUX	AUX'	STR'	NORMALIZED TRACK RANK
104	451	451	0	31	0	0	0	31.3	1.00
M16	414	414	0	0	0	0	0	0.0	0.92
601	153	0	0	153	104	0	0	152.7	0.34
P01	361	0	0	0	0	361	108	0.0	0.80
P02	361	0	0	0	0	361	108	0.0	0.80
101	226	0	0	226	0	0	0	705.6	0.50
302	35	0	35	32	0	0	0	32.0	0.08
703	294	294	0	30	0	0	0	29.9	0.65
201	325	325	0	33	0	0	0	33.2	0.72
801	208	208	0	29	0	0	0	29.1	0.46
501	99	0	20	25	99	0	0	24.9	0.22
401	90	0	0	29	90	0	0	28.5	0.20
Y01,701-2,M10-15	26	0	0	0	0	26	26	0.0	0.06
901A	0	0	0	0	0	0	0	0.0	0.00
901B	0	0	0	0	0	0	0	0.0	0.00
1001	0	0	0	44	0	0	0	44.3	0.00

Table B2

Track Rank Input Values for Camp Example (from Equations B8 through B17)

FUNCTIONAL TRACK NAME	ATL	AL	C	T	LI	E	L(t)	P	S	L	W	La	ARF	Ue
104	34396	0.20	1.1	1.0	1.75	1.25	938		1.0	948	1		1	0
M16	32480	0.20	1.1	1.0	1.00	0.80	2350		1.0	2387	1		0	0
601	29913	0.21	1.1	0.9	1.00	0.00	2200		1.0	4406	1		1	1
P01	23276	0.21	1.1	0.9	1.00	0.00			1.3	0	1	4000	1	0
P02	25054	0.21	1.1	0.9	1.00	0.00			1.3	0	1	4000	1	0
I01	0	1.28	1.1	0.9	1.00	0.00			1.3	2570	1		1	0
302	34379	0.20	1.0	1.0	1.75	0.00	1057	2	1.0	1067	1		1	0
703	33192	0.20	0.7	1.0	1.50	1.00	1400		1.0	1422	1		1	0
201	34396	0.20	1.1	0.9	1.75	1.25	750		1.0	1006	1		1	0
801	33192	0.20	0.7	0.9	1.50	1.00	1100		1.0	1388	1		1	0
501	32473	0.20	1.1	0.9	1.00	0.00	500	2	1.0	756	1		1	1
401	34379	0.20	1.0	0.9	1.00	0.00	310		1.0	950	1		1	1
Y01,701-2,M10-15	30999	0.21	0.7	0.9	1.00	0.00	0		1.3		1	1500	0	0
901A	34867	0.20	1.1	1.0	1.00	0.00			1.0	1123	1		0	0
901B	36150	0.20	1.1	1.0	1.00	0.00			1.0	1352	1		0	0
1001	37502	0.20	1.1	0.9	1.00	0.00			1.0	1342	1		1	0

Table B3

Track Rank Data Not Explicitly Collected via RAILER I Inventory or Related Facilities Procedures

E: Portable endramp availability

L_t: Tangent track length

LI: Portable lighting availability

P: Number of boxcar loading positions

U_e: If locomotive must be kept at engine house

W: If installation has rail receiving requirement

APPENDIX C:

RELATED FACILITY CONDITION RATING

The related facility condition rating is a number between 0.0 and 1.0 which summarizes the maintenance condition of all related facilities (ramps and docks, lighting equipment, and marshalling yards) associated with a given track segment. These values are calculated within RAILER I for all of an installation's track segments as part of the procedures for preparing a diskette for FORPROP (see Chapter 6). The rating is discrete (i.e., not continuous) and completely determined by the worst condition of a related facility associated with a given track segment. If there are no related facilities associated with a track segment, then the related facility rating is set equal to one.

For track segments with related facilities, the rating is determined by first assigning to each related facility one of three possible condition rating values, 1.0, 0.7, or 0.0. These values correspond respectively to the C1, C2, and C3 IFS condition codes which are assigned to each related facility during their inspection (see Chapter 5). Of the three condition codes collected for each loading dock or ramp, the "Overall Condition" code is the one used for determining the related facility condition rating.

After a condition rating value is assigned to each related facility of a given segment, the related facility condition rating of the segment is determined by the lowest of these individual facility values.

APPENDIX D:

TRACK CONDITION RATING

The track condition rating presented here is calculated within RAILER I as part of the procedures for preparing a diskette for FORPROP (see Chapter 6). This rating is a number between 0.0 and 1.0 which summarizes the track defects of each track segment. Like the maintenance standard condition discussed in Chapter 6, this condition rating indicates the single worst track defect in terms of operating restrictions. In addition, this rating also accounts for all other track defects of a given segment.

In this appendix, the track condition rating procedures are presented with progressively more detail; thus, the reader can stop after obtaining the desired level of understanding. The underlying design characteristics of the rating system are discussed first, followed by a progressively detailed mathematical presentation. The negative exponential function plays an important role in the rating system thus presented. However, this function cannot be directly implemented in R:base 5000, the RAILER I computer software environment. Instead, a piece-wise linear approximating function is implemented. This appendix ends with a presentation of this approximating function and a discussion of its impact on the track condition rating.

Design Characteristics

The track condition rating and underlying calculations are based on a classification of all possible track defect types. The Interim U.S. Army Railroad Track Maintenance Standards prescribe three levels of train operating restrictions for several track defect types. These three levels are 10 MPH, 5 MPH, and No Operations; the defect types associated with each of these restriction levels are specified in Table D1. Most defect types have no operating restrictions. The restrictions thus imply a four-group classification scheme for track defect types:

Group 1: No Restrictions

Group 2: 5 MPH Operating Restriction

Group 3: 10 MPH Operating Restriction

Group 4: No Operations

These four group titles, together with "No Defects", are the five possible maintenance standard conditions presented in Chapter 6, which simply specify the worst operating condition implied by a track segment's defects (or that there are no defects). The track condition rating presented here is a conceptual extension of the maintenance standard conditions.

The track condition rating range is partitioned according to the worst defect group found on any given track segment, as indicated in Table D2. The maintenance standard conditions have only one "value" for each of the worst defect categories specified in Table D2; in contrast, the track condition rating allows for a continuum of values for each category. These additional values permit the track condition rating to account for multiple occurrences of the worst defect group and occurrences of other, less severe

Table D1

Operating Restriction Defects

Defect				Operating Restriction
Rail:				
Bolt Hole Crack				10 MPH
Broken Base				5 MPH
Corroded Base				10 MPH
Complete Break				No Operations
Crushed Head				10 MPH
Defective Weld				10 MPH
End Batter (>1/4")				10 MPH
Fissure - Compound				5 MPH
Fissure - Transverse				5 MPH
Fracture - Detail				5 MPH
Fracture - Engine Burn				5 MPH
Head/Web Separation				No Operations
Piped Rail				10 MPH
Split Head - Horizontal				5 MPH
Split Head - Vertical				No Operations
Split Web				5 MPH
Rail Weight Insufficient for Mission				5 MPH
Ties:				
3 Consecutive Defective Ties				10 MPH
4 Consecutive Defective Ties				5 MPH
5 or more Consecutive Defective Ties				No Operations
All Joint Ties Defective				10 MPH
Missing, Bunched or Badly Skewed Ties				5 MPH
Track Geometry:				
Gage:				
	57.50 in.	and	< 57.75 in.	10 MPH
	57.75	and	58.00	5 MPH
	> 58.00	or	< 56.00	No Operations
Crosslevel* on Tangent Track or Curves Less than 12°:				
	1.50 in.	and	< 2.50 in.	10 MPH
	2.50	and	3.00	5 MPH
	> 3.00			No Operations
Warp* on Tangent Track or Curves Less than 12°:				
	1.75 in.	and	< 2.50 in.	10 MPH
	2.50	and	3.00	5 MPH
	> 3.00			No Operations

* These Crosslevel and Warp numbers are absolutevalues with respect to possibly negative field measurements. For examples of field measurements, see Table 4.

Table D1 (Cont'd)

Defect	Operating Restriction
Turnout:	
Poor Line and Surface	10 MPH
3 Consecutive Defective Ties	10 MPH
4 Consecutive Defective Ties	5 MPH
5 or more Consecutive Defective Ties	No Operations
All Joint Ties Defective	10 MPH
Missing, Bunched or Badly Skewed Ties	5 MPH
Switch Stand - Loose	10 MPH
Switch Stand - Missing	No Operations
Point Lock/Lever Switch - Loose	10 MPH
Point Lock/Lever Switch - Missing	10 MPH
Connecting Rod - Missing	No Operations
Switch Point - Missing	No Operations
Frog Point - Missing	No Operations
Gage at Points, Frog Point or Curved Closure Rails:	
57.50 in. and < 57.75 in.	10 MPH
57.75 and 58.00	5 MPH
> 58.00 or < 56.00	No Operations
Guard Check Gage:	
54.25 in. and > 54.125 in.	10 MPH
54.125	No Operations
Guard Face Gage:	
53.125 in. and < 53.25 in.	10 MPH
53.25	No Operations
Flangeway Width and Depth:	
1.5 in. and > 1.375 in.	10 MPH
1.375	No Operations
Vegetation:	
Prevents Track Inspection	10 MPH
Interferes with Trains or Track Vehicles	5 MPH

defect groups. If the segment has not received a complete RAILER I inspection because of extreme deterioration (as discussed in Chapters 4 and 6), then the track condition rating is automatically set equal to zero, as indicated in Table D2.

If there is only one defect on a segment and it implies an operating restriction, then the condition rating is equal to the upper limits of the range for that operating restriction, i.e., 0.7, 0.5, or 0.3. If the only track defect is from defect Group 1 (no operating restrictions), then the condition rating will fall somewhere between 0.7 and 1.0, depending on the defect type and extent. Each additional defect of the same or lesser severity reduces the condition rating within the bounds of the range identified by the worst defect. This requires the rating to approach the lower bound of each range asymptotically with more defects of the same or lesser severity. This is illustrated in Figure D1.

To summarize the preceding discussion, the track condition rating is based on three fundamental design characteristics:

1. The maximum rating is determined by the defect(s) with the worst associated operating restriction (or by the most severe defect) found on the track segment.

2. Each additional defect reduces the rating.

Table D2

Track Condition Rating Ranges

Worst Defect Group	Operating Restriction	Track Condition Rating Range
-	(No Defects)	1.0
1	No Restrictions	0.7 < x < 1.0
2	10 MPH Restriction	0.5 < x 0.7
3	5 MPH Restriction	0.3 < x 0.5
4	No Operations	0.0 < x 0.3
-	(Complete Railer I inspection not performed because track segment is extremely deteriorated)	0.0

3. Additional defects cannot cause the condition rating to enter the rating range of a more severe defect than was found in the track segment.

The last two design characteristics are modified slightly by the piece-wise linear approximating function presented at the end of this appendix.

Detailed Presentation and Mathematical Formulation

The curves depicted in Figure D1 are best represented by a negative exponential function:

$$f(x) = \exp(-x) \qquad \text{[Eq D1]}$$

This function is illustrated in Figure D2. The negative exponential function can be modified to restrict it to any given range $a<x\leq b$:

$$f(x) = a + (b-a)\exp(-x) \qquad \text{[Eq D2]}$$

This function is illustrated in Figure D3.

Using Equation D2, the four curves of Figure D1 can be represented respectively by:

$$TC(S) = 0.7 + [U(S) - 0.7]\exp[-F_1(S)] \qquad \text{[Eq D3]}$$

$$TC(S) = 0.5 + 0.2\exp[-F_2(S)] \qquad \text{[Eq D4]}$$

$$TC(S) = 0.3 + 0.2\exp[-F_3(S)] \qquad \text{[Eq D5]}$$

$$TC(S) = 0.3\exp[-F_4(S)] \qquad \text{[Eq D6]}$$

where TC(S): Track condition rating

S: Set of defect occurrences in track segment

U(S): Upper limit implied by the no restriction defects

$F_i(S)$, $i=1,\ldots,4$: Increasing functions on defect set S, where i is an index of worst defect group found.

For both U(S) and the $F_i(S)$ functions, defect occurrences are treated in two ways. For some defect types, occurrences are treated individually (discretely); for the remaining types, occurrences are considered aggregately, by percent density (discussed below). These two defect type categories are indicated in Table D3. However, for the $F_i(S)$ functions, defect percent density values are converted to an equivalent number of discrete defects.

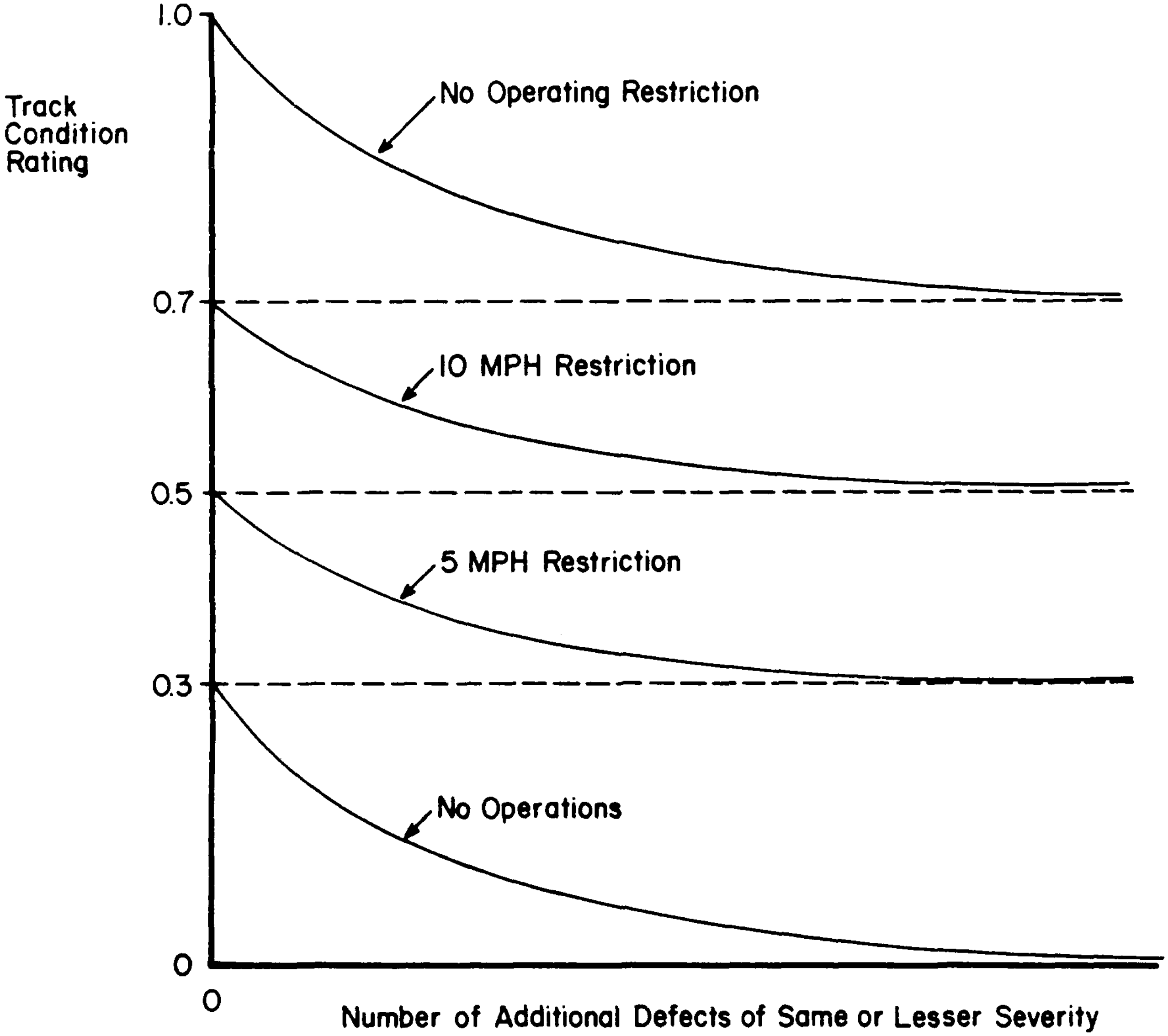


Figure D1. Illustration of track condition rating curves as functions of additional defect occurrences.

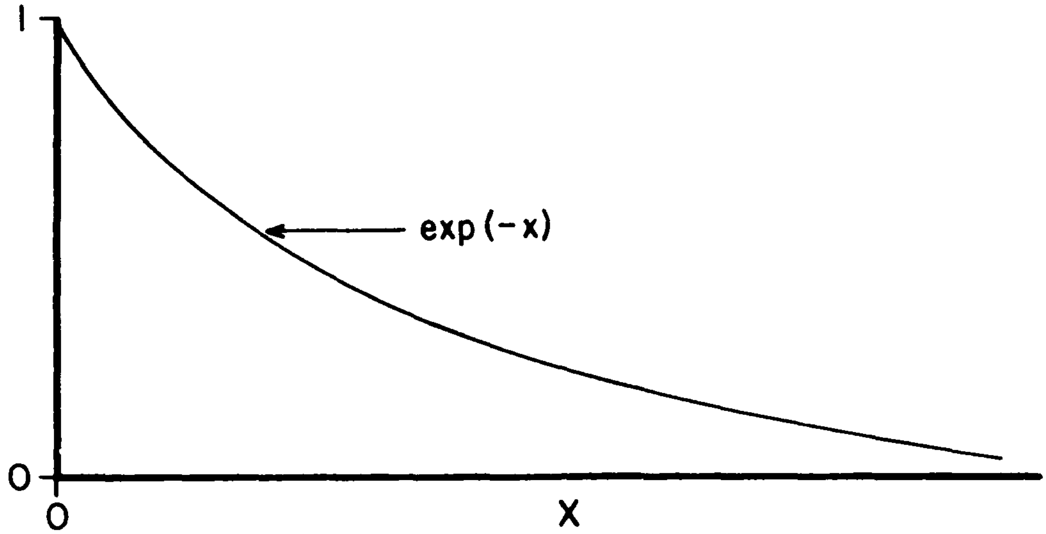


Figure D2. Simple negative exponential function.

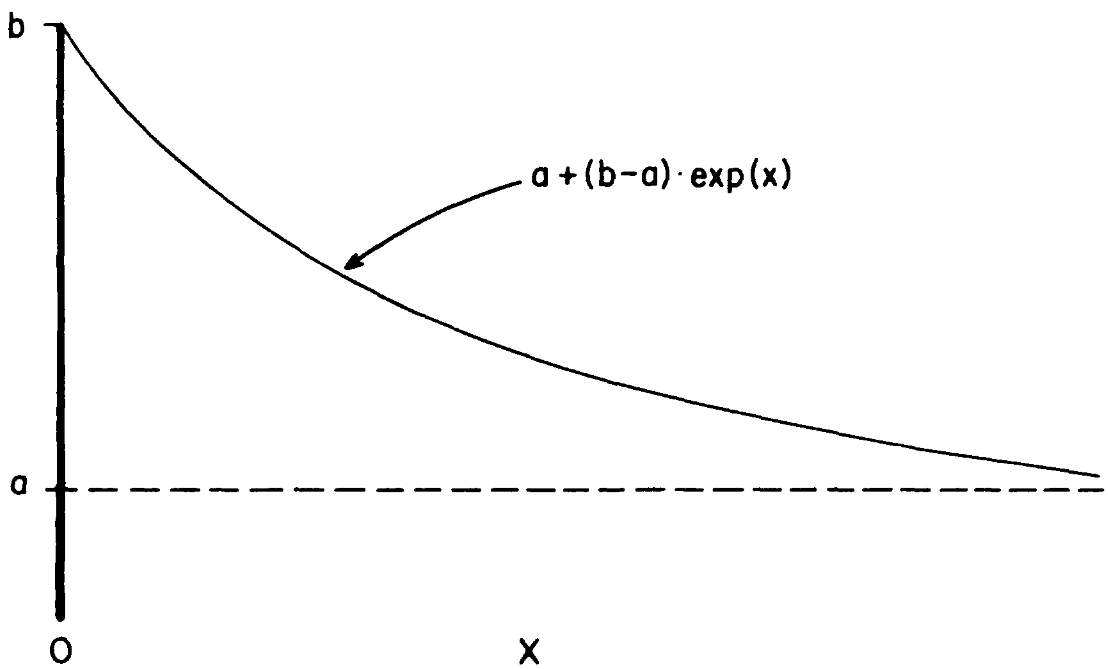


Figure D3. Modified negative exponential function restricted to the range a < x ≤ b.

Table D3

Defect Occurrence Treatment by Defect Type

Defect occurrences are treated individually	Defect occurrences are treated by percent density in segment
All rail defects	All track geometry defects
All turnout defects	All vegetation defects
Tie defects:	Tie defects:
Consecutive defective ties	Total defective ties
All joint ties defective	Skewed ties
Average spacing > 22 in.	
Missing/bunched /badly skewed ties	

The $F_i(S)$ functions strictly increase with each additional defect after the single worst defect. As previously discussed, the single worst defect determines which track condition equation [Equation D3 through D6] is used. If there are no additional defects, then $F_i(S)$ must equal zero. The $F_i(S)$ functions have a general form:

$$F_i(S) = \sum_{j=1}^{i} \alpha_j [N_j^*(S)] \qquad \text{[Eq D7]}$$

where $$N_j^*(S) = \begin{cases} N_j(S) - 1 & \text{if } j = i \\ N_j(S) & \text{if } j \neq i \end{cases} \qquad \text{[Eq D8]}$$

and $N_j(S)$: Sum of discrete defect occurrences j and discrete defect equivalents of defect group j, where j is an index of the defect groups.

α_j: Coefficient which determines sensitivity to each additional occurrence (or discrete defect equivalent) of defect group j (further defined below).

The four defect groups were defined earlier. The "- 1" in Equation D8 forces $F_i(S)$ to equal zero if there is only the single worst defect (or equivalent discrete defect) of defect group i.

Within the context of the simple negative expotential function (Equation D1), each α_i value in Equation D7 implies a constant percent reduction in the track condition rating for each additional defect occurrence or discrete equivalent of the given group:

$$1 - \frac{\exp[-\alpha(k+1)]}{\exp(-\alpha k)} = 1 - \exp(-\alpha) \quad \text{(for all real k)} \qquad \text{[Eq D9]}$$

The α_i values used in RAILER I and the corresponding percent reductions in the track condition rating are specified in Table D4. Note that the percent values approximate the second through fifth powers of 2 (4, 8, 16 and 32). When the negative exponential function is restricted to the range $a < x \leq b$ (see Equation D2) and a is nonzero, as in Equations D3 through D5, the constant percent reduction is with respect to the pseudo-zero, a.

U(S) and the individual F_i (S) functions are fully described in the remainder of this section, thus completing the specification of Equations D3 through D6. This is done in two parts. First the no operating restriction functions U(S) and F_1(S) are discussed, followed by the operating restriction functions F_2(S) through F_4(S).

No Operating Restrictions

The "no restriction" track defect group is easily the largest of the four defect groups defined above. This group is not homogenous with respect to defect severity; the various "no restriction" defect types imply different severity levels, either because of their intrinsic character and/or the density of their occurrence. The U(S) function in Equation D3 delineates the upper limit of the "no restriction" range. This value is determined by the severest defect found in the track segment. Again, the worst defect determines the maximum condition rating.

For the "no restriction" defect types which are treated individually (see first column, Table D3), the possible U(S) values are specified in Table D5.

The possible U(S) values for the defect types which are treated by percent density (see second column, Table D3) are determined by first calculating Total Percent Density (TPD) values. A TPD value is obtained for each of the four defect type sets specified in the second column of Table D3. For example, with vegetation there are 11 combinations of defect type and position which imply no operating restriction; thus the maximum possible vegetation TPD is 1,100 percent. To account for differences in maximum possible TPD and defect type severity, each TPD value is reduced by a different coefficient and then subtracted from 1. These calculations and their associated minimum values of U(S) are presented in Table D6. For example, the vegetation minimum value is obtained by inserting 1100 percent for TPD in the vegetation calculation.

Table D4

Alpha Coefficients and Implied Percent Reductions*

$\tilde{a}_j$	Percent Reduction $100 \cdot [1 - \exp(-\tilde{a}_j)]$
0.04	3.92 %
0.08	7.69 %
0.17	15.63 %
0.39	32.29 %

Table D5

Candidate U(S) Values for Discrete No Restrict Defects

Defect	Values
Rail:	
Torch Cut	0.90
Wear - Side (>1/2")	0.90
Wear - Vertical (>1/2")	0.90
Overflow	0.97
Shelling	0.90
Corrugation	0.90
Chip/Dent in Head	0.90
Engine Burn	0.95
Flaking	0.95
Ties:	
2 Consecutive Defective Ties	0.90
Average Tie Spacing per Rail Length > 22 in.	0.90
Turnout:	
Rail Weight Changes within Turnout Limits	0.95
Reversing Tangent Past Frog Less than 50 ft.	0.95
Switch Difficult to Operate	0.90
Fair Line and Surface	0.90
2 Consecutive Defective Ties	0.90
Average Tie Spacing per Rail Length > 22 in.	0.90
Skewed Ties	0.90
Total Number of Defective Ties > 0	0.90
Switch Stand - Improper Size	0.95
Switch Stand - Chipped/Worn/Bent	0.90
Point Lock/Lever Switch - Improper Size	0.90
Point Lock/Lever Switch - Chipped/Worn/Bent	0.90
Connecting Rod - Improper Size	0.90
Connecting Rod - Loose	0.90
Connecting Rod - Chipped/Worn/Bent	0.90
Switch Point - Improper Size	0.90
Switch Point - Loose	0.80
Switch Point - Chipped/Worn/Bent	0.90
Switch Rods - Improper Size	0.90
Switch Rods - Loose	0.90
Switch Rods - Chipped/Worn/Bent	0.90
Switch Rods - Missing	0.80
Clip Bolts - All Defect Types	0.90
Slide Plates - All Defect Types	0.90

Table D5 (Cont'd)

Defect			Values
Turnout (Continued):			
Braces - All Defect Types			0.90
Heel Filler & Bolts - All Defect Types			0.90
Cotter Keys - Improper Size			0.97
Cotter Keys - Loose			0.97
Cotter Keys - Chipped/Worn/Bent			0.97
Cotter Keys - Missing			0.95
Frog Point - Improper Size			0.95
Frog Bolts - All Defect Types			0.90
Guard Rails - Improper Size			0.90
Guard Rails - Loose			0.80
Guard Rails - Chipped/Worn/Bent			0.90
Guard Rails - Missing			0.80
Guard Rail Filler and Bolts - All Defect Types			0.90
Gage at Points, Frog Point or Curved Closure Rails:			
57.00 in.	and	< 57.50 in.	0.90
56.00	and	56.25	0.90
Guard Check Gage:			
54.50 in.	and	> 54.25 in.	0.90
Guard Face Gage:			
53.00 in.	and	< 53.125 in.	0.90
Flangeway Width and Depth:			
1.625 in.	and	> 1.50 in.	0.90

U(S) is thus determined by defect occurrences. It equals the lowest of the values associated with the defects present which are either listed in Table D5 or calculated by the equations in Table D6.

The algebraic formulation of the $F_1(S)$ function in Equation D3 is:

$$F_1(S) = 0.17(N - 1) \qquad \text{[Eq D10]}$$

where

$$N = N_{nrd} + N_{tdt} + N_{st} + N_{tg} + N_v \qquad \text{[Eq D11]}$$

N: Sum of no restriction discrete defect occurrences and discrete defect equivalents.

N_{nrd}: Number of No Restriction discrete defect occurences.

N_{tdt}: Number of Total Defective Tie discrete defect equivalents.

$$= \frac{TPD_{tdt}}{4} \qquad \text{[Eq D12]}$$

N_{st}: Number of Skewed Tie discrete defect equivalents.

$$= \frac{TPD_{st}}{25} \qquad \text{[Eq D13]}$$

N_{tg}: Number of no restriction tract geometry discrete defect equivalents.

$$= \frac{TPD_{tg}}{30} \qquad \text{[Eq D14]}$$

N_v: Number of no restriction vegetation discrete defect equivalents.

$$= \frac{TPD_v}{100} \qquad \text{[Eq D15]}$$

Equations D12 through D15 provide initial values for N_{tdt}, N_{st}, N_v, and N_{tg}; some of these are modified below. The numerators of these expressions are the same TPD values used in the equations of Table D6. The denominators are different because of the different TPD value ranges. If this value for N (Equation D11) is greater than 0.0 but less than 1.0, then it is reset equal to 1.0; this forces $F_i(S)$ to be zero.

Because bad ties and track geometry defects are strongly interrelated, they should not be simultaneously included in the calculation of N (see Equation D11). The minimum of these two values is set equal to zero:

If $N_{tdt} \geq N_{tg}$ then $N_{tg} = 0$

otherwise $N_{tdt} = 0$

Table D6

U(S) Calculations and Minimum Values for
No Restriction Defects Treated via Percent Density

Defect Type Set	Calculation	Minimum Value
Total Defective Ties:		
for: 0 TPD 20	$U(S) = 1 - (0.005)\,'TPD^{*}_{tdt}$	0.90
for: 20 < TPD 39	$U(S) = 1.1 - (0.01)\,'TPD_{tdt}$	0.71
for: 39 < TPD	$U(S) = 0.71$	0.71
Skewed Ties	$U(S) = 1 - (0.001)\,'TPD_{st}$	0.90
Track Geometry	$U(S) = 1 - (0.00095)\,'TPD_{tg}$	0.715
Vegetation	$U(S) = 1 - (0.0002)\,'TPD_{v}$	0.78

* As discussed in the text, a different TPD (Total Percent Density) value is used for each defect type set.

As previously discussed, U(S) is determined by the worst defect. If this defect type is treated on percent density basis, then the corresponding "N-value" is set equal to one. (If this defect type is either bad ties or track geometry, then the other N-value of the two is set equal to zero, as above.) This last adjustment of the discrete defect equivalent values permits the "- 1" expression in Equation D10 to function as previously discussed (in relation to Equation D8).

This concludes the specification of $F_1(S)$ and hence Equation D3, which is used only when there are no operating restriction defects.

Operating Restrictions

If operating restrictions are implied by defect occurrences, then either Equation D4, D5 or D6 is used, depending on the worst restriction. The corresponding $F_i(S)$ functions (i = 2, 3, and 4) have common subcomponents and are similarly structured.

For each of the four defect groups defined in Table D2, a defect occurrence number is defined as the sum of discrete defect occurrences and discrete defect equivalents (for those defect types treated on a percent density basis). In the case of group 1 (no operating restrictions), the defect occurrence number is:

$$N_{nr} = N_{nrd} + \frac{\text{Total \% No. Restriction Defects}}{20} \qquad \text{[Eq D16]}$$

N_{nrd} was previously defined with respect to Equation D11. The numerator of the last term on the right is the sum of the numerators in Equation D12 through D15.

The defect occurrence numbers for each of the other three defect groups is similarly specified:

$$N_{10} = N_{10d} + \frac{\text{Total \% 10 MPH Restriction Defects}}{20} \qquad \text{[Eq D17]}$$

$$N_{5} = N_{5d} + \frac{\text{Total \% 5 MPS Restriction Defects}}{20} \qquad \text{[Eq D18]}$$

$$N_{no} = N_{nod} + \frac{\text{Total \% No Operations Defects}}{20} \qquad \text{[Eq D19]}$$

In each case, the first term on the right is the number of discrete defect occurrences of the given defect group.

The remaining three $F_i(S)$ functions can now be specified:

$$F_2(S) = 0.17N_{nr} + 0.39(N_{10} - 1) \qquad \text{[Eq D20]}$$

$$F_3(S) = 0.08N_{nr} + 0.17N_{10} + 0.39(N_5 - 1) \qquad \text{[Eq D21]}$$

$$F_4(S) = 0.04N_{nr} + 0.08N_{10} + 0.17N_5 + 0.39(N_{no} - 1) \qquad \text{[Eq D22]}$$

These follow the previously presented general form, Equation D7. Note that the coefficients in these equations are specified so that higher severity defects have a greater impact (i.e., imply a greater percent reduction, see Table D4).

This completes the mathematical presentation of the track condition rating design. However, the implementation of this design within RAILER I requires some minor modifications. These are discussed next.

Negative Exponential Approximating Function and Implications

The negative exponential function plays a central role in the above mathematical formulation. However, this function cannot be directly implemented in R:Base 5000, the RAILER I computer software environment. Instead, a piece-wise linear approximating function is implemented:

$$E(x) \approx \exp(-x) \qquad \text{[Eq D23]}$$

This approximating function, in turn, implies other minor modifications in both the basic design characteristics and the mathematical formulation of the track condition rating.

This approximating function consists of seventeen connected line segments, hence the term "piece-wise linear." The first and last segments are infinitely long. The function is specified with the slope-intercept form of the line equation:

$$E(x) = m_i x + b_i \quad \text{for} \quad a_i \leq x < a_{i+1} \qquad i = 1,..,15 \qquad \text{[Eq D24]}$$

The m_i, b_i and a_i values are specified in Table D7. Note that the first line segment (for $x < 0$) is generally irrelevant to this application.

The function equals exp(-x) at all but the last common line segment endpoint. For example, at the common endpoint of the forth and fifth line segments (see Table D7):

$$0.69768 = \exp(-0.36)$$

$$= (-0.74887)(0.36) + 0.96727 \text{ [with } m_4 \text{ and } b_4\text{]}$$

$$= (-0.64787)(0.36) + 0.93091 \text{ [with } m_5 \text{ and } b_5\text{]}$$

At the last common endpoint, 110.0 (between the 16th and 17th segments), function value is zero.

Between the endpoints, the approximating function values are almost always greater than the negative exponential; again, the exception occurs with the last line segment and the extreme righthand end of the 16th, where the approximating function is below the negative exponential. Through the first seven finite line segments, the approximating error is less than one percent at the segment midpoints. After that the percent error increases dramatically because of the proximity to zero, reaching 12 percent with the 13th line segment and 75 percent with the 15th. At the last endpoint (110.0) and beyond, the percent error is essentially infinity. However, this percent error is somewhat misleading, as the absolute error at the segment midpoints decreases after the 10th segment. After the last endpoint, the absolute error is essentially zero (with 45 decimal points of accuracy).

The exponential of a sum is equal to a product of exponentials:

$$\exp(a+b) = \exp(a)\exp(b) \qquad \text{[Eq D25]}$$

This useful property can be extended to the negative exponential approximating function:

$$E(a+b) \approx E(a)E(b) \qquad \text{[Eq D26]}$$

Table D7

Coefficient and Parameter Specification for
Negative Exponential Approximating Function*

i	a_i	a_{i+1}	m_i	b_i
1	----	0.00	0.0	1.0
2	0.00	0.11	-0.94696	1.0
3	0.11	0.22	-0.84832	0.98915
4	0.22	0.36	-0.74887	0.96727
5	0.36	0.51	-0.64787	0.93091
6	0.51	0.69	-0.54955	0.88077
7	0.69	0.92	-0.44807	0.81075
8	0.92	1.20	-0.34759	0.71830
9	1.20	1.60	-0.24824	0.59909
10	1.60	2.10	-0.15888	0.45610
11	2.10	2.80	-0.08807	0.30740
12	2.80	3.60	-0.04186	0.17801
13	3.60	4.60	-0.01727	0.08950
14	4.60	6.90	-0.00393	0.02814
15	6.90	9.20	-0.00039	0.00370
16	9.20	110.00	-0.000001	0.00011
17	110.00	----	0.0	0.0

* See Equation D23.

The percent error of the approximating function increases in a manner such that the left side of Equation D26 will generally have a larger error than the right side. The four track condition rating equations are therefore implemented as follows:

$$TC(S) = 0.7 + [U(S) - 0.7]E[F_i(S)] \quad \text{[Eq D27]}$$

$$TC(S) = 0.5 + 0.2E[0.17N_{nr}]E[0.39(N_{10} - 1)] \quad \text{[Eq D28]}$$

$$TC(S) = 0.3 + 0.2E[0.08N_{nr}]E[0.17N_{10}]E[0.39(N_5 - 1)] \quad \text{[Eq D29]}$$

$$TC(S) = 0.3E[0.04N_{nr}]E[0.08N_{10}]E[0.17N_5]E[0.39(N_{no} - 1)] \quad \text{[Eq D30]}$$

These equations respectively replace Equations D3 through D6. As discussed above, the choice of these equations depends on the single most severe track defect.

Implementation of the track condition rating with E(x) instead of exp(-x) [via Equations D27 through D30] implies two minor deviations from the previously presented design characteristics. The key difference between the two functions is that exp(-x) only approaches zero asymptotically while E(x) equals zero for all values of x greater than or equal to 110.0 (last line segment).

If there are enough defects of a given restriction group for E(x) to equal zero, then the track condition rating will equal one of the lower limits specified in Table D2 (0.7, 0.5, 0.3, or 0.0), depending on the equation. These values cannot be lowered by additional occurrences from any defect group which does not require a different (more severe) equation. This is a deviation from the second design characteristic, as summarized in the Design Characteristics section of this appendix.

The value ranges specified in Table D2 are all open on the low end and all but one are closed on the high end. Each range does not include its lower limit; instead these condition rating values are associated with the next worse operating restriction (if there is one). Thus the condition rating of a segment could be associated with a more severe operating restriction than the worst restriction directly implied by defect occurrences. This is a deviation from the third design characteristic.

These two deviations are illustrated with an example. Assume that the most severe defect implies a 5 MPH restriction and that there are at least 648 10 MPH restriction defects. Then the track condition rating will equal 3.0. This value cannot be lowered by additional defects from the first three defect groups (no restriction, 10 MPH, and 5 MPH), a violation of the second design characteristic. Furthermore, this value is within the condition rating range used when the most severe defect implies no operations, a violation of the third design characteristic.

These two deviations only occur when there are a very large number of occurrences from a single defect group, and even then their impact is minor.

GLOSSARY

Ballast -- Selected material placed on the roadbed for the purpose of holding the track in line and surface.

Classification Yard -- A yard in which cars are classified or grouped in accordance with train operating requirements.

Compromise Joint -- A rail joint between rails of different height and section (weight), or rails of the same section but of different joint drillings.

Crib -- The space between two adjacent ties.

Crossover -- Two turnouts with the track between the frogs arranged to form a continuous passage between two nearby and generally parallel tracks.

Curve -- Bends in track designed to change the direction of travel.

Derail -- A track structure for derailing rolling stock in case of emergency.

Flangeway -- The open way through a track structure which provides a passageway for wheel flanges.

Frog -- A track structure used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.

Interchange Point -- The geographical point, yard, junction, or track common to the operations of two railroads where cars are routinely interchanged from one railroad to another. For military purposes, an interchange point is where a military installation interchanges cars with a commercial railroad.

Interchange Track -- A track which is used as the interchange point.

Interchange Yard -- A yard which is used as the interchange point.

Passing Track -- A track auxiliary to main track for meeting of passing trains; a type of siding.

Right-of-Way -- Lands or rights used or held for railroad operations.

Rolling Stock -- A general term used when referring collectively to a large group of railway cars and sometimes locomotives.

Runaround Track -- A track designed for getting around stationary rolling stock; similar to a passing siding. This facilitates switching operations.

Siding -- A track which is connected at both ends to another (usually superior) track. Possible uses of sidings include loading cars, storing cars, switching movements, and the passing of trains.

Subgrade -- The finished surface of the roadbed below the ballast and track.

Switch -- Track structures used to divert rolling stock from one track to another.

Track Segment -- A portion of a track. Segments represent the basic unit for railroad maintenance management.

Turnout -- An arrangement of a switch and frog with closure rails used to divert trains from one track to another.

Wye -- A term used to describe a track arrangement shaped like the letter "Y" but with a connecting segment between the upper legs. This layout allows equipment to be turned around without a turntable.

Yard - A system of tracks within defined limits provided for making up trains, storing cars, and other similar purposes.

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The U.S. Army Construction Engineering Research Laboratory (USA-CERL) is developing the RAILER system for managing the inspection, evaluation, and repair of Army railroad networks. This report describes RAILER I, an interim system whose capabilities support FORMAP-2, a multiyear rail rehabilitation program at U.S. Army Forces Command (FORSCOM) and National Guard installations.

RAILER I consists of a set of data collection procedures and a computer program which will help Directorates of Engineering and Housing (DEHs) locate and identify their installation's railroad assets, assess current network conditions, determine short- and long-term maintenance and repair (M&R) needs, and systematically plan and prioritize M&R work.

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This report describes the structure of RAILER I, details the inspection and inventory procedures needed to collect the data used by the computer program, explains how the program's output can be used to support network and project level planning, and describes the testing and evaluation of the program. It also makes recommendations regarding the implementation and enhancement of the program and suggests some actions FORSCOM could take to encourage its use. Instructions for operating the program are provided in a companion manual, USA-CERL ADP Report M-88/16, *The RAILER System for Maintenance Management of U.S. Army Railroad Networks: RAILER I Computer User's Guide.*