Priority Ranking U.S. Army Railroad Track Segments for Major Maintenance and Repair

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The U.S. Army Construction Engineering Research Laboratory and the University of Illinois have developed a microcomputer-based procedure called FORPROP for priority ranking railroad track segments that need major maintenance and repair (M&R). Intended for use by central (Major Command) planners who need to allocate funds to several subordinate installations, this procedure serves as a decision support tool for ranking track segments in a nearly optimal fashion. The model for accomplishing this uses a benefit-cost ratio heuristic. Benefit is defined as an increase in the value of each track segment, should the work be accomplished. Value is measured analytically by a "value factor" derived from utility concepts based on the preferences of Army transportation planners. It represents the relative value of a segment in the overall accomplishment of the railroad mobilization outloading mission. Cost is the total cost of the repair work on a segment. Ratios are computed for individual track segments as well as logical segment groups based on train movements. The groups are ranked by decreasing ratios. Through the use of elaborate bookkeeping and a binary (0-1) knapsack procedure, a group is selected as a function of ratio, precedence (certain segment groups repaired either before or in conjunction with the group being considered), and available budget.

A major task in managing a railroad track network is priority ranking the maintenance, repair, and rehabilitation work that needs to be accomplished in current and future years. Priority ranking work or projects is a complex task. If it is performed correctly, several questions should arise:

1. How much money is available?
2. What are the important parameters needed for decision making?
3. Where is the information about those parameters?
4. What are the consequences of the decision?
5. What are the trade-offs in terms of value gained for dollars expended?

In many instances the answers to these questions come from engineering, management, and "hands-on" experience. If experience is lacking or time constraints limit the level of effort that can be devoted to ranking, decisions are made without knowledge of their full impact. The consequences may be premature facility deterioration, accelerated costs, misallocation of resources, mission impairment, or all of these.

Currently, no structured decision methodology is available to U.S. Army planners for ranking centrally funded and managed major maintenance and repair (M&R) work. In the past, decisions were frequently made on an ad hoc subjective basis. Consequently, it is possible that the most worthwhile projects were not accomplished in a timely manner. This, in turn, could have a severe negative impact on the ability to mobilize via rail in the event of a national emergency. Also, because project costs are a function of condition (which worsens over time), lack of timeliness can have a negative impact on project costs.

The lack of a structured decision methodology is being addressed in two ways. First, maintenance management problems, in general, are being reduced by using a railroad maintenance management system called RAILER that was developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL). RAILER has two parts: (a) RAILER I (*1*), an interim system needed to support a current track rehabilitation program, and (b) RAILER II, a complete and fully capable system. The RAILER I system is complete and the RAILER II system will be ready for widespread implementation within 2 years. When RAILER has been implemented, Directorate of Engineering and Housing (DEH) personnel will be better able to understand and control the condition of their railroad track. The specific priority ranking problem has been solved through the development of a microcomputer-based rail project ranking program called FORPROP (for Forces Command Rail Prioritization Program). FORPROP represents an extension of the decision support management capabilities of the RAILER system.

CONCEPT

FORPROP is a microcomputer-based, stand-alone program. It can be used in either a decision-making or a decision support mode. The program provides a nearly optimal solution for allocating major M&R funds to installation track networks as well as to related facilities (docks, ramps, marshalling yards, and lighting). Flexible override features have been added to permit "what if" scenario building. FORPROP is used by Major Command (specifically U.S. Army Forces Command) planners to allocate major M&R funds for work at subordinate installations.

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The program uses information transmitted to the Major Command from subordinate installation RAILER data bases. FORPROP does not develop or revise individual track segment work needs or cost estimates.

RAILER USE

The use of the priority ranking program requires certain data available from the RAILER I (or eventually RAILER II) Railroad Maintenance Management System data bases that have been established for each installation. Three types of data are transferred for use in the program: (a) installation identification, (b) track segment information, and (c) related facility information.

The network identification data include installation name, installation number, and state. These data are needed to differentiate one installation from another in the program.

Because FORPROP ranks groups of track segments, specific information on a track segment by track segment basis is needed from the RAILER data bases. These data include each track segment number, condition, most important car type that uses the segment, heaviest load carried, track rank, preceding track segment number, and total cost of M&R to restore the track segment to a "No Defect" condition according to the U.S. Army Track Maintenance Standards (*2*). A brief explanation of why these data elements are needed is given later in this paper and elsewhere (*3*). A description of each and an explanation of how they are obtained can also be found elsewhere (*1, 4, 5*).

Because the program will also priority rank work at related facilities associated with track segments, specific items of information concerning them are also needed, where appropriate. These include track segment number serving the facility, condition, and total cost of M&R to restore the facility to a fully operational condition. This cost is treated as part of the segment cost discussed previously.

The data are transferred from a special computer feature associated with the RAILER system. The information is transferred onto a 5¼-in. floppy diskette and mailed to the Major Command for entry into FORPROP.

MODEL

Background

This budgeting problem requires the solution of a large integer programming problem with potentially more than 500 binary variables, a single budget constraint, and possibly more than 500 precedence constraints (depending on the number of installations considered in the analysis). The precedence constraints arise because a railroad network consists of a tree in which the usability of certain track segments is dependent on the condition of other track segments in the same tree, namely the track segment that is immediately connected to a given track segment as a train travels into the installation.

Budget Allocation Problem

Mathematically the problem is formulated as

$$\text{Max} \sum_i \sum_j B_{ij} X_{ij} \tag{1}$$

$$\text{s.t.} \sum_i \sum_j C_{ij} X_{ij} \leq Budget \tag{2}$$

Number of precedence constraints (3)

where

B_{ij} = amount of benefit gained by repairing Track Segment i at Installation j (discussed later);
C_{ij} = cost of repairing Track Segment i at Installation j;
X_{ij} = 1 if Track Segment i at Installation j is repaired, 0 otherwise; and
$Budget$ = budget available for repair of track.

Equations 1 and 2 describe what is known in operations research as the binary knapsack problem. This is a problem for which several highly efficient solution algorithms exist. Because of the nature of the typical U.S. Army installation railroad network, it is necessary to add precedence constraints to the formulation of the budget allocation problem. For example, in Figure 1, Track Segment 103, an access track segment, must be repaired in order to obtain the benefits from Segments 104 and 201, which are loading tracks, even though Segment 103 does not, by Army definition, directly contribute to the mobilization mission itself. Thus the condition of Track Segment 103 poses a constraint on the use of Track Segments 104 and 201. Such precedence constraints may be modeled as

$$X_{103} - X_{201} \geq 0, \qquad X_{103} - X_{104} \geq 0$$

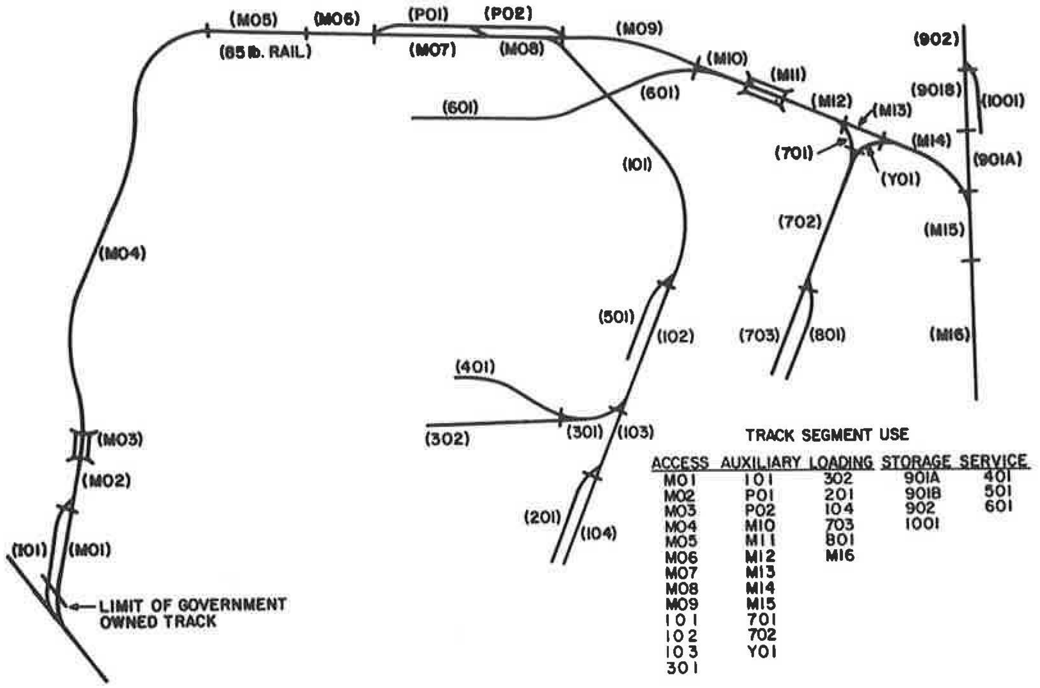
or, equivalently,

$$X_{201} + X_{104} - 2X_{103} \leq 0 \tag{4}$$

Solution Methodology

With several installations under consideration and anywhere from 5 to more than 100 track segments per installation, an extremely large integer programming problem can result. Thus, for this problem, traditional integer programming cannot be used, and it is questionable whether modified schemes involving implicit enumeration and dynamic programming can solve it. For solving binary knapsack problems, an approach is needed that handles precedence constraints. The approach taken was to create and rank groups of track segments. By using cost information transferred from RAILER and benefit information computed within FORPROP (discussed later in this paper), the track segment groups are first developed by combining connected track segments such that the best benefit-cost ratio for a group is obtained. These groups are then ordered by decreasing values of the benefit-cost ratio.

The next step places the created track segment groups on either an eligible or an ineligible list for selection based on precedence and budget level. If a preceding track segment (as part of a group) has not been selected, all following track segment groups are ineligible for selection. If a preceding track segment has been selected, the following track segment group is eligible for selection.



TRACK SEGMENT USE

ACCESS	AUXILIARY	LOADING	STORAGE	SERVICE
M01	101	302	901A	401
M02	P01	201	901B	501
M03	P02	104	902	601
M04	M10	703	1001	
M05	M11	801		
M06	M12	M16		
M07	M13			
M08	M14			
M09	M15			
101	701			
102	702			
103	Y01			
301				

FIGURE 1 Camp Example track network.

By using the sorted list concept developed by Nauss (*6*) as a starting point, an elaborate bookkeeping procedure was developed for listing selected, eligible for selection, and ineligible track segment groups. Bookkeeping comes into play when one of the eligible segment groups is selected to enter the solution. When this happens, the track segment groups for which this selected group is a direct predecessor are added to the eligible list. Any additional groups are then selected from this updated list. The process continues until the budget is consumed.

Two simple processes are employed to further allocate funds when the cost to repair the next track segment group on the ranked eligible list exceeds the remaining available funds. The first simply ignores this next group, moves down the eligible ranked list, and tries to consume the remaining available funds with a different group. The second accepts the next segment group, ignored earlier, on the list. Because this creates a budget overrun, previously selected segment groups beginning with the lowest benefit-cost ratios are withdrawn until budget feasibility is obtained. The first process is then reemployed.

A complete description of the development of this budget allocation solution methodology has been published (*7*).

Example of Bookkeeping Routine for Camp Example

For illustrative purposes, Table 1 gives cost and benefit information for a portion of a fictional installation called Camp Example (Figure 1).

Step 1

The benefit-cost ratios (R) for Track Segments 201 and 104 are placed on the candidate project list. The model always first considers track segments that are not, in themselves, predecessors. During the first step, those individual track segments constitute individual groups.

TABLE 1 EXAMPLE COSTS AND BENEFIT LEVELS FOR TRACK NETWORK SHOWN IN FIGURE 1

Track Segment	$k Cost (C)	Benefit (B)
102	8.190	0
103	7.122	0
104	10.548	93
201	9.940	71
301	25.168	0
302	9.972	48

$$R_{201} = B_{201}/C_{201} = 71/9.940 = 7.143$$

$$R_{104} = B_{104}/C_{104} = 93/10.548 = 8.817$$

Step 2

The segment that offers the largest return on investment and uses common Track Segment 103 must be found. To do this, the precedence constraints must be worked through.

For the deepest common track segment, 103, the "best" segment group is found by combining Segment 103 with the "best" segment that it precedes, in this instance, Segment 104. Mathematically,

$$R_{103} = B_{103}/C_{103} = 0$$

$$\begin{aligned} R_{103,104} &= (B_{103} + B_{104})/(C_{103} + C_{104}) \\ &= (0 + 93)/(7.122 + 10.548) \\ &= 5.263 \end{aligned}$$

$$\begin{aligned} R_{103,201} &= (B_{103} + B_{201})/(C_{103} + C_{201}) \\ &= (0 + 71)/(7.122 + 9.940) \\ &= 4.161 \end{aligned}$$

$R_{103,104}$ is best and, thus, a group has been created. Now Segment 201 should be considered for group improvement.

$R_{20} = 7.143$ (from preceding).

Because R_{201} is greater than $R_{103,104}$, adding it to the group will result in improvement. Thus Segment 201 is also added. Had the ratio been less, Segment 201 would not have been added and two groups would have resulted. (For continuation of the example, assume for brevity that Segments 301 and 302 make up a group, and that Segment 401 makes up a group.)

Step 3

The segment group that offers the largest return on investment and uses common Track Segment 102 must be found.

$R_{102} = B_{102}/C_{102} = 0$

$$\begin{aligned} R_{102,103,104,201} &= (B_{102} + B_{103} + B_{104} + B_{201})/ \\ &\quad (C_{102} + C_{103} + C_{104} + C_{201}) \\ &= (0 + 0 + 93 + 71)/(8.190 + 7.122 + 10.548 \\ &\quad + 9.940) \\ &= 4.581 \end{aligned}$$

$$\begin{aligned} R_{102,301,302} &= (B_{102} + B_{301} + B_{302})/(C_{102} + C_{301} + C_{302}) \\ &= (0 + 0 + 48)/(8.190 + 25.168 + 9.372) \\ &= 1.123 \end{aligned}$$

The group of Segments 102, 103, 104, and 201 is best. Now the group of Segments 301 and 302 needs to be reconsidered for possible improvement with the group of Segments 102, 103, 104, and 201.

$$\begin{aligned} R_{301,302} &= (B_{301} + B_{302})/(C_{301} + C_{302}) \\ &= (0 + 48)/(25.168 + 9.372) \\ &= 1.389 \end{aligned}$$

Because $R_{301,302}$ is less than $R_{102,103,104,201}$, adding Track Segments 301 and 302 to the group of Segments 102, 103, 104, and 201 offers no improvement to the return on investment ratio. Thus Group 102, 103, 104, 201 will move forward for consideration at the next lower level of the tree network. Segment Group 301, 102 must wait to be considered until the 102, 103, 104, 201 group is selected. In general, the bookkeeping algorithm checks at each level of group building to see if "waiting" track segments result in an improvement.

Step 4

Continue as in Step 3 for the rest of the network.

BENEFIT

Concept

The benefit used in the benefit-cost ratio heuristic is defined as the increase in "value" of the track segment with respect to its role in meeting the U.S. Army's mobilization mission after the work is completed.

Assessing Value

The approach selected for application in this project uses utility concepts. "Utility," as applied here, is a subjective preference rating that users, transportation planners, engineers, and managers can apply to the track segments to assess value at any given time. This rating represents the potential mobilization utility of a given track segment.

The value rating is scalar ranging from 0 to 100, the higher number indicating higher preference or value.

Because each track segment at each installation contributes to the mobilization mission in a somewhat different fashion, the relative value ratings for each segment may not be the same regardless of condition.

Empirical Approach

Difficulties arise in the practical application of preference ratings. One is that they must be applied to each of the several hundred track segments. That task is huge even if done only once, but the problem is compounded because value rating is dependent on condition, which varies over time. A second difficulty is related to the problem of who does the ratings. Practically speaking, no person can routinely travel from installation to installation for the purpose of rating track segments.

The solution is to develop an empirical method of calculating a value factor (*VF*) that would reasonably match the subjective value ratings and use routinely collected RAILER data.

Value Factor

Equation

Through interaction with Forces Command personnel certain factors were identified that strongly influenced the decision process: (a) installation importance and geographic factor, (b) individual installation network layout and traffic movements factor, and (c) operational capability factor for each track segment.

The first two, when combined, represent a time-independent constant for individual track segments. The third is time dependent and will decrease as the track segment or related facility condition deteriorates and will increase with work accomplishment.

The factors were combined into the following empirical equation in order to obtain *VF*:

$$VF_{ij} = 246.63 * [I * D]_j^{0.8} * R_{t\,ij}^{0.5} * [\ln(1.0 + 0.5 * C_t^1 * C_r)]_{ij}^c \qquad (5)$$

where VF_{ij} is the value factor of the *i*th track segment at the *j*th installation. *VF*, like the value rating it represents, gives the relative value of a track segment at a given time for accomplishing the overall mobilization mission via rail. A discussion of each factor follows.

VF Factors

The variables and constants associated with the *VF* factors were identified and agreed to during interaction with Forces Command. The possible values of the variables and the specific constant values were derived through sensitivity analysis (*2*).

Installation Importance and Geographic Factor This factor addresses the total installation and is represented by $[I * D]_j^{0.8}$ in the *VF* equation. It serves to place more value on important installations and those farther from alternate mobilization loading sites. The exponent limits the influence of the entire factor the desired amount.

Herein, *I* is installation weight, a subjective factor ranging from 0 to 1.0 that describes the relative importance (1.0 = most important) of each installation. This reflects the installation mission and may change over time. *D* is distance factor to nearest available yard. This factor takes into account the availability of alternate railroad loading sites. The effect is to give priority to installations with little or no practical alternative (due to distance) for loading or unloading and moving railcars in the event of mobilization. If the distance is greater than 25 mi, the factor is 1.0; it is 0.9 otherwise.

Individual Installation Network Layout and Traffic Movements Factor This factor consists of a track rank (*R*) and an exponent limiting its influence. Track rank addresses the relative value of given track segments within the installation. Track ranks are obtained analytically (*1*) and range from 0 to 1.0 (1.0 = most important). Higher value is placed on track segments with more traffic, those that allow easy and minimal (less switching and time) train movements, specific functional use, longer functional length, less curvature, and the presence of ramps and lighting (where appropriate). By Army definition, access track segments have a track rank of zero. The effect of a zero track rank is that access tracks cannot be in a group without the functional track segment or segments that they serve.

Operational Capability Factor This factor addresses primarily the condition of each track segment and related facility, as appropriate, and is denoted by $[\ln(\ldots)]_{ij}^c$.

C_t is track segment condition rating. This rating ranges from 0 to 1.0. Table 2, tied to the U.S. Army track standards (*2*), has been developed as part of RAILER I (*2*). The range within a specific category is due to the effects of multiple defects. A given track segment will have a specific value assigned that is determined analytically within RAILER I. After repair this value is assumed to be 1.0.

TABLE 2 TRACK CONDITION RATING VALUES

Value	Meaning
1.0	Track meets or exceeds interim standards
<1.0 to >0.7	Track has defects, but none that leads to operating restrictions
0.7 to >0.5	Track has defects resulting in 10-mph speed limit
0.5 to >0.3	Track has defects resulting in 5-mph speed limit
0.3 to 0.0	Track segment is out of service because of deterioration

l is load factor. This analytical factor ranges from 1.0 to 2.25. It serves to account for the negative effects of heavy loadings (*8, 9*). Table 3 gives the equations used in the computation.

C_r is related facilities condition rating. This is an analytical rating from 0 to 1.0 addressing the condition of the related facilities needed to support railroad operations. Table 4 gives the ratings. After repair this value is assumed to be 1.0.

TABLE 3 LOAD FACTOR EQUATIONS

Equation	Application
1 = 1.0	For weights less than 50 tons
1 = W/50	For weights between 50 and 100 tons
1 = (W/160) + 1.375	For weights between 100 and 140 tons

c is car type factor, a subjective factor ranging from 1.0 to 3.0 that describes the relative importance of the kinds of cars that must be moved in a mobilization. This serves as an indirect factor for considering the kind of materials and equipment moved on the cars because some items (e.g., tanks) are less readily moved by an alternate means of transport than others. This factor provides preference to track segments carrying those loads. Table 5 gives the factors established for the kinds of cars moved in a mobilization.

TABLE 4 RELATED FACILITIES CONDITION RATINGS

Rating	Interpretation
1.0	Fully operational
0.7	Operational, but deficiencies exist
0.0	Not operational or nonexistent

TABLE 5 CAR TYPE FACTORS

Factor	Application
1.0	Heavy flatcars
1.4	Flatcars
1.6	Gondolas
2.0	Boxcars
3.0	Hopper cars

Computing Benefit

Benefit is expressed mathematically as

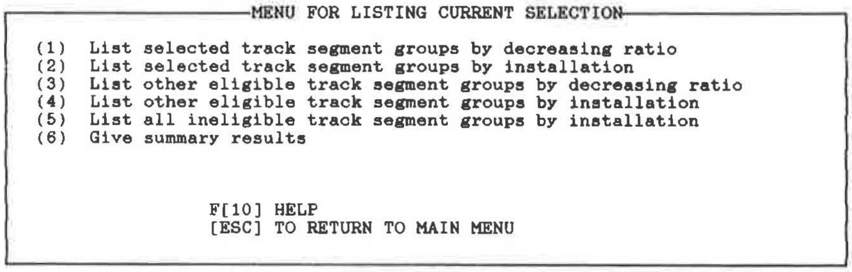
$$B_{ij} = VF_{ija} - VF_{ijb} \qquad (6)$$

where B_{ij} is the benefit associated with performing maintenance or repair to the *i*th track segment at the *j*th installation, VF_{ijb} is the value factor before the work was performed, and VF_{ija} is the value factor afterwards. Both are obtained from Equation 5 using the different condition ratings described previously.

PROGRAM USE

When the program is accessed, the user first selects the installations that should be included in the analysis. FORPROP then establishes and ranks the segment groups. Next, the user enters a budget level and FORPROP selects the groups. The menu shown in Figure 2 is accessed and the user has various options for displaying the results. Figure 3 shows the results from the first option. If the user elects to make changes to the analysis, the menu shown in Figure 4 is available.

It is intended that the user first set a total budget covering the entire multiyear planning period and apply it to all installations needing work. A report, similar to the one shown in Figure 3, is obtained. The user can then mark the ranking limits on the report on the basis of the yearly budget projection. The spread of work at the same installations over time must be studied to determine if the selection should be modified. This is done for a practical reason: the desire to not carry over small work packages consisting of a group or two at a given installation into the next year or possibly the year after.



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                    MENU FOR LISTING CURRENT SELECTION

 (1)  List selected track segment groups by decreasing ratio
 (2)  List selected track segment groups by installation
 (3)  List other eligible track segment groups by decreasing ratio
 (4)  List other eligible track segment groups by installation
 (5)  List all ineligible track segment groups by installation
 (6)  Give summary results


                 F[10] HELP
                 [ESC] TO RETURN TO MAIN MENU
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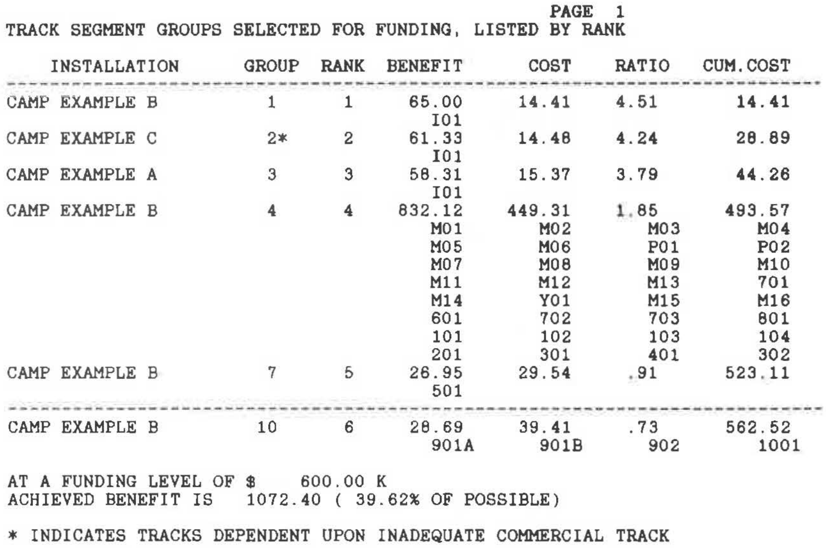
FIGURE 2 Menu for listing current selection.



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                                                   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 C          2*     2     61.33     14.48    4.24        28.89
                                      I01
CAMP EXAMPLE A          3      3     58.31     15.37    3.79        44.26
                                      I01
CAMP EXAMPLE B          4      4    832.12    449.31    1.85       493.57
                                      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 B          7      5     26.95     29.54     .91       523.11
                                      501
-------------------------------------------------------------------------------
CAMP EXAMPLE B         10      6     28.69     39.41     .73       562.52
                                      901A      901B      902       1001

AT A FUNDING LEVEL OF $     600.00 K
ACHIEVED BENEFIT IS    1072.40 ( 39.62% OF POSSIBLE)

* INDICATES TRACKS DEPENDENT UPON INADEQUATE COMMERCIAL TRACK
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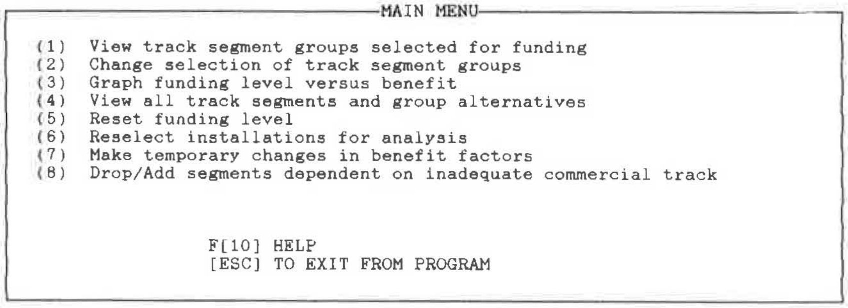
FIGURE 3 Track segment groups selected for funding.



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                              MAIN MENU

 (1)  View track segment groups selected for funding
 (2)  Change selection of track segment groups
 (3)  Graph funding level versus benefit
 (4)  View all track segments and group alternatives
 (5)  Reset funding level
 (6)  Reselect installations for analysis
 (7)  Make temporary changes in benefit factors
 (8)  Drop/Add segments dependent on inadequate commercial track


                 F[10] HELP
                 [ESC] TO EXIT FROM PROGRAM
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FIGURE 4 Main menu.

Any group that needs to be shifted from one year to another should be noted. The program is then rerun for a first-year budget only and the selected segment groups analyzed. The desired groups that were not automatically selected during the total multiyear budget run accomplished earlier for a first-year budget limit are now added to the selected list through a menu feature (Figure 5).

Because the budget is now overrun, other segment groups are deleted through the same menu feature. When that has been accomplished and all of the desired groups have been selected for the first year, all (or entire installations, if appropriate) are then deleted from the analysis. The process of budget limit and segment group addition and deletion is repeated for the next and subsequent years' analyses. Of course, this entire multiyear planning process should be repeated annually when budget figures are established for the current and following years.

"What if" scenarios can be developed by changing budget levels, installation weight factors, and the like, and the effects on the priority ranked plan can be readily seen. Uzarski et al. (*3*) describe several methods, with examples, for using FORPROP results in a decision support mode for developing a priority ranked plan. When the user performs "what if" scenario studies, temporary internal changes are made but never saved. The original data remain intact. Should the user decide that certain permanent changes should be made, such as a change in mission necessitating a change in the installation weight factor, a procedure is available to accomplish that task. Installation data, discussed earlier, provided annually from the RAILER data bases result in permanent changes to the FORPROP data base.

FORPROP is written in FORTRAN and operates on an IBM XT, AT, or 100 percent compatible microcomputer with a 10-megabyte hard disk, 640K RAM, and a dot matrix 80-column printer (with IBM standard character set). A complete description of FORPROP operation and use is available (*3, 10*).

TESTS

Three phases of testing of the FORPROP program were performed: laboratory, field (simulation and actual), and systems acceptance. Modifications resulted from each phase.

Laboratory testing consisted of specific data elements being entered and run to ensure that specific portions of the model and program were operating correctly. This was done to locate program errors, test algorithms and heuristics, create or modify screen and file formats, and calculate the speed of operations.

The purpose of the field phase of the testing was to ensure that the program worked correctly for multiple installations and that the results were reasonable.

RAILER I data bases were first created for three fictitious installations called Camp Example A, Camp Example B, and Camp Example C. Installation weight factors and distances to the nearest yard varied along with the condition of each track segment and related facilities. Condition defects were randomly generated through an external generation program developed for this application. As a result, similar segments at different installations had different conditions. Repair costs were then calculated using unit costing techniques. When all data had been generated or calculated, the data were transferred to FORPROP. Actual installation data were incorporated later.

Systems acceptance testing was accomplished by USA-CERL and U.S. Army Forces Command personnel to ensure that the program operated on the desired hardware, the features worked, reasonable results were obtained, and the documentation was adequate to support use. Training and a user's guide (*10*) were provided by USA-CERL.

CONCLUSIONS

Under laboratory and field test conditions, the program worked efficiently and provided enough flexibility for "what if" scenarios to be studied. The program proved to be easy to use with minimal introductory training, and the model provided optimal solutions to the budget allocation problem. However, two issues are worthy of further research and follow-on work. First, it would be better if benefit were defined in terms of the increase in track performance expected for the expenditure of funds. Unfortunately, the performance of Army track cannot be predicted at this time. Second, if additional programming were performed to permit the modification of projects or the addition of multiple alternatives for M&R to the model, more sophisticated analyses could be made.

ACKNOWLEDGMENTS

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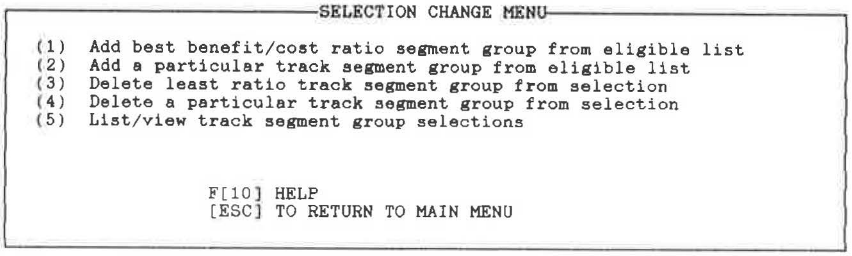

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                         SELECTION CHANGE MENU

(1)  Add best benefit/cost ratio segment group from eligible list
(2)  Add a particular track segment group from eligible list
(3)  Delete least ratio track segment group from selection
(4)  Delete a particular track segment group from selection
(5)  List/view track segment group selections



               F[10] HELP
               [ESC] TO RETURN TO MAIN MENU
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FIGURE 5 Selection change menu.

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