5. APPLICATION OF DOT RESOURCE ALLOCATION PROCEDURE

5.1 DOT ACCIDENT AND CASUALTY PREDICTION FORMULAS

5.1.1 Manual Calculation of Predicted Accidents and Casualties

If the number of predicted accidents or casualties is required for a few crossings, a convenient manual procedure can be used, employing the formula tables presented in Sections 3.2 and 3.3. Manual use of the DOT accident and casualty prediction formulas is illustrated in the following example. Characteristics of the hypothetical crossing for which the number of predicted accidents and casualties is to be determined are shown in Table 5-1.

TABLE 5-1. CHARACTERISTICS OF SAMPLE CROSSING

CHARACTERISTIC	VALUE
Present warning device	Crossbucks
Annual average daily highway taffic (c)	350
Total number of train movements per day (t)	15
Total number of thru trains per day (tt)	10
Total number of switch trains per day (ts)	5
Number of main tracks (mt)	2
Total number of tracks (main and other) (tk)	2
Number of thru trains per day during daylight (d)	5
Highway paved? (hp)	yes
Maximum time table speed, mph (ms)	40
Number of highway lanes (hl)	2
Urban - rural location (ur)	Rural
Number of years accident data, T	5
Number of accidents, N, in T years	2

First, the basic formula (1) is used to determine the unnormalized prediction (a):

$$a = K \times EI \times DT \times MS \times MT \times HP \times HL$$

where:

a = unnormalized initial accident prediction

K = constant

EI = factor for exposure (product of highway and train traffic)

DT = factor for number of thru trains per day during daylight

MS = factor for maximum timetable speed

MT = factor for number of main tracks

HP = factor for highway paved (yes or no)

HL = factor for number of highway lanes

The basic formula factor values (K, EI, DT, MS, MT, HP, and HL) can be determined from Table 3-2 for passive crossings, using the crossing's characteristics listed in Table 5-1:

K = 0.0006938

EI = exposure index factor value for the product of 350 average daily highway vehicle and 15 total train movements per day (c x t = 5250) = 42.39

DT = 1.79

MS = 1.36

MT = 1.00

HP = 1.00

HL = 1.00

Substituting the factor values into the basic formula yields:

$$
\begin{aligned}
a &= K \times EI \times DT \times MS \times MT \times HP \times HL \\
&= 0.0006938 \times 42.39 \times 1.79 \times 1.36 \times 1.00 \times 1.00 \times 1.00 \\
&= 0.072
\end{aligned}
$$

The value of (B) is determined by combining the unnormalized prediction (a) with the crossing's accident history using Tables 3-5 through 3-9, which are developed from equation (2a). For the sample crossing, two accidents (N) occurred over the past 5 years (T); therefore, Table 3-9 is used. With an unnormalized accident prediction (a = 0.072) between 0.07 and 0.08, it can be seen from Table 3-9 that the value of B will be between 0.194 and 0.206. A reasonable estimate of (B) can be determined by linear interpolation to be B = 0.196. Thus, from equation (2b), since this is a passive crossing, the final accident prediction (A) is:

$$
\begin{aligned}
A &= .8644 \times .196 \\
&= 0.169 \text{ accidents per year}
\end{aligned}
$$

To determine the number of fatal accidents at the sample crossing, the fatal accident probability is first obtained using equation (3):

$$P(FA|A) = 1/(1 + KF \times MS \times TT \times TS \times UR)$$

where: KF = formula constant
MS = factor for maximum timetable train speed
TT = factor for thru trains per day
TS = factor for switch trains per day
UR = factor for urban or rural crossing

The factor values for the fatal accident probability formula can be determined from Table 3-12 using the sample crossing characteristics from Table 5-1:

KF = 440.9
MS = 0.025
TT = 0.811
TS = 1.169
UR = 1.000

Substituting the factor values into the fatal accident probability formula yields:

$$P(FA|A) = 1/(1 + KF \times MS \times TT \times TS \times UR)$$
$$= 1/(1 + 440.9 \times 0.025 \times 0.811 \times 1.169 \times 1.000)$$
$$= 0.087 \text{ probability of a fatal accident given an accident}$$

The fatal accident probability is then multiplied by the predicted accidents, computed above using equation (2), to obtain the predicted number of fatal accidents from equation (5) for the sample crossing:

$$FA = P(FA|A) \times A$$
$$= 0.087 \times 0.169$$
$$= 0.015 \text{ fatal accidents per year}$$

To determine the number of casualty accidents at the sample crossing, the casualty accident probability is first obtained using equation (4):

$$P(CA|A) = 1/(1 + KC \times MS \times TK \times UR)$$

where: KC = formula constant

MS = factor for maximum timetable train speed

TK = factor for number of tracks

UR = factor for urban or rural crossing

The factor values for the casualty accident probability formula can be determined from Table 3-13 using the sample crossing characteristics from Table 5-1:

KC = 4.481

MS = 0.282

TK = 1.259

UR = 1.000

Substituting the factor values into the casualty accident probability formula yields:

$$P(CIA|A) = 1/(1 + 4.481 \times 0.282 \times 1.259 \times 1.000)$$
$$= 0.386 \text{ probability of a casualty accident given an accident}$$

The casualty accident probability is then multiplied by the predicted accidents, computed above using equation (2), to obtain the predicted number of casualty accidents for the sample crossing from equation (6):

$$\begin{aligned} CA &= P(CA|A) \times A \\ &= 0.386 \times 0.169 \\ &= 0.065 \text{ casualty accidents per year} \end{aligned}$$

The combined casualty index (CCI) is obtained from equation (8) for the sample crossing:

$$CCI = (k-1) \times FA + CA$$

where: k = fatality factor selected by user
FA = fatal accidents per year from equation (5)
CA = casualty accidents per year from equation (6)

Substituting a value of 50 for k and the above values for FA and CA, the combined casualty index formula yields:

$$\begin{aligned} CCI &= 49 \times 0.015 + 0.065 \\ &= 0.80 \end{aligned}$$

5.1.2 Computer Program for Calculation of Predicted Accidents and Casualties

This section describes procedures for using the DOT accident and severity prediction formula computer program to obtain the number of predicted accidents or casualties per year for large numbers of crossings, and to list the crossings ranked by number of predicted accidents or casualties. Complete information for making the computer runs is supplied, provided the required input data are available and are in the format specified here. Modifications can be made to the programs to accept a different format. Data in the format specified here can be obtained from the Federal Railroad Administration, Office of Safety Analysis.

A SAS computer procedure called ACPD.NEW is written to generate accident and severity prediction listings. The program listing for ACPD.NEW is contained in Appendix A-1. The program executes a number of data steps which accomplish the following subtasks:

a. Data Subsetting

From the data set comprising all the grade crossings, select the set of crossings for which accident prediction is to be made and ranked.

b. Accident and Severity Prediction

Compute basic predicted accidents (H) for every selected crossing based on its warning device type. Using the appropriate severity prediction formula, compute the predicted accidents or fatal accidents or combined casuality index.

c. Report Printing

Execute the specific report generating procedure depending on the severity measure selected earlier. This procedure prints the following reports:

(1) Listing of grade crossings sorted by rank,
(2) Listing of grade crossings sorted by crossing IDs.

d. Summary Printing

Execute the summary data step which prints the input data as well as run time summary.

The Accident and Severity Prediction subtask is divided into three sections. The first section, calculates the basic number of predicted accidents (H) for a crossing. The program uses one of three different equations to make this calculation. The equation used is dependent on the warning device classification of the current crossing. For warning device classes 1-4 the Crossbucks (passive device) equation is used, classes 5-7 the Flashing Lights equation is used, and for class 8 the Gates equation is used.

The basic accident prediction formula computes the initial predicted accident rate for each crossing on the basis of the crossing's current warning device class. If, during the last 5 years, a change in warning device took place, the formula computes the basic predicted accidents on the basis of the previous warning device class and then makes an adjustment to the predicted accidents using the appropriate effectiveness factor (see Tables 4-7 and 4-8) to account for the influence of the warning device change. For individual crossings, this procedure more accurately determines the short term (less than 5 years) change in the crossing's accident rate than use of the basic formula for the new warning device. For example, if a passive crossing was upgraded to gates in the last 5 years, the passive (Crossbucks) formula would be used and the result would be multiplied by the effectiveness factor for gates (1.0 - the effectiveness of the upgrade to gates) to obtain the initial predicted accidents for the crossing with gates. Similarly, the predicted

Examples of the output of ACPD.NEW program are shown in Figures 5-1 through 5-9. This output represents three separate calculations. Figures 5-1, 5-2, and 5-3 are for predicted accidents, Figures 5-4, 5-5, and 5-6 are for predicted fatal accidents. Figures 5-7, 5-8 and 5-9 are for combined casualty index. The first part of each set of the three outputs define the parameters of the crossings listed. The second part is the ranking by predicted accidents computed on the basis of the desired severity measure. All parameter values used in the computation of predicted accidents and severity prediction are included in the output. The third part presents the list of crossings sorted by crossing ID. This third part enables users to find a crossing on the ranked list (second part) when only the crossing ID is known.

5.2 COMPUTER PROGRAM FOR RESOURCE ALLOCATION MODEL

This section describes the computer program for the resource allocation model discussed in Section 4. The model is run by a SAS computer procedure called RESAL.NEW. The program listing for RESAL.NEW is contained in Appendix B. The program executes a number of data steps to accomplish the following subtasks:

a. <u>Data Subsetting</u>

From the dataset comprising all of the rail-highway crossings, select the set of non-gate crossings for which accident prediction is made and for which the available budget is to be allocated.

b. <u>Accident and Severity Prediction</u>

Compute basic predicted accidents (H) for every selected crossing using the passive or flashing lights formula. Using the appropriate severity formula, compute the predicted accidents or fatal accidents or combined casualty index.

c. <u>Identify the Crossings for Stop Signs</u>

Check eligibility of each crossing for stop signs. If it meets the criteria, assign the "yes" attribute to the crossing.

```
**********************************************************
*        SUMMARY  OF  INPUT   PARAMETERS                 *
*       FOR ACCIDENT AND SEVERITY PREDICTION             *
**********************************************************

         TITLE            :             RR DEMO 1
         STATE            : 99
         COUNTY           : .
         CITY             : .
         RAILROAD         : A
         CROSSING ID      :
          BOTTOM OF RANGE: .
          TOP OF RANGE    : .
         RECORDS TO BE    :
           PRINTED        : 20
         SEVERITY TYPE    : 1    (1) PREDICTED ACCIDENTS
                          :      (2) FATAL ACCIDENT
                          :      (3) COMBIN. CASUALITY INDEX

**********************************************************

               SUM OF PREDICTED ACCIDENTS          :1.633867

               TOTAL NUMBER OF CROSSINGS ANALYZED  :120

               INVENTORY DATE: APRIL 1986

**********************************************************
```

FIGURE 5-1. EXAMPLE OF INPUT PARAMETERS FOR PREDICTED ACCIDENTS PER YEAR

RR DEMO 1 17:01 THURSDAY, JANUARY 29, 1987
PUBLIC RAIL-HIGHWAY CROSSINGS
RANKED BY PREDICTED ACCIDENTS PER YEAR

RANK	PRED ACCDS	XING ID #	ST	RR	--> 81	NUM 82	OF 83	ACC 84	<-- 85	DATE OF CHG	WD CL	TOTL SWIT TRNS	DAY THRU TRNS	TOTL THRU TRNS	TOTL TRKS	MAIN TRKS	TTBL SPD	HWY PVD	HWY LNS	URBN RURL	AADT
1	0.264589	734H		A	0	0	1	1	1		7	2	2	2	1	1	25	YES	2	1	8201
2	0.150495	786A		A	0	0	1	1	0		7	2	0	2	1	1	35	YES	2	0	4325
3	0.136474	773Y		A	0	0	1	0	0		7	4	0	0	5	3	35	YES	2	1	11875
4	0.127626	774F		A	0	0	1	0	0		7	6	0	0	3	2	35	YES	2	1	9170
5	0.116265	724C		A	0	1	0	0	0		7	2	2	2	1	1	35	YES	2	1	7305
6	0.086445	881V		A	0	0	0	0	0		7	12	2	16	10	5	40	YES	2	1	1990
7	0.084143	704R		A	1	0	0	0	0		7	2	0	0	3	2	25	YES	2	1	3791
8	0.081564	735P		A	0	0	1	0	0		4	4	2	2	1	1	20	YES	2	1	530
9	0.071269	769J		A	0	0	0	0	0		7	10	0	0	4	2	10	YES	3	1	12055
10	0.062086	794S		A	0	1	0	0	0		4	0	0	2	1	1	49	YES	2	0	535
11	0.059178	725J		A	1	0	0	0	0		4	2	2	2	1	1	25	YES	2	1	100
12	0.054202	858B		A	0	0	0	0	1		7	0	0	2	1	1	49	YES	2	0	455
13	0.049726	814B		A	0	1	0	0	0		8	0	0	2	1	1	49	YES	2	0	2765
14	0.047646	783E		A	0	0	0	0	0		7	4	0	2	1	1	25	YES	2	0	11510
15	0.045226	713P		A	0	0	0	0	0	84-12	8	6	0	0	1	1	25	YES	4	1	31515
16	0.043566	825N		A	0	0	0	1	0		4	0	0	2	1	1	49	NO	2	0	110
17	0.042530	718Y		A	0	0	0	0	0		8	5	2	2	1	1	25	YES	5	1	15865
18	0.038367	736W		A	0	0	0	0	0		8	6	2	6	1	1	25	YES	4	1	9410
19	0.037319	757P		A	0	0	0	0	0		7	0	0	1	1	1	25	YES	4	0	12995
20	0.035142	775M		A	0	0	0	0	0	84-12	8	6	0	0	2	1	25	YES	4	1	16515

FIGURE 5-2. EXAMPLE OF RANKED LIST OF CROSSINGS FOR PREDICTED ACCIDENTS PER YEAR

DEMO 1 17:01 THURSDAY, JANUARY 29, 1987
PUBLIC RAIL-HIGHWAY CROSSINGS
RANKED BY PREDICTED ACCIDENTS PER YEAR
SORTED BY CROSSING ID

OBS	XING ID #	PRED ACCDS	RANK	ST	COUNTY	CITY	RR	ROAD	RRID	MILEPOST
1	704R	0.084143	7		B	P	A	L		000151
2	713P	0.045226	15		B	P	A			000410
3	718Y	0.042530	17		B	P	A	1		000101
4	724C	0.116265	5		B	P	A	E		000213
5	725J	0.059178	11		B	P	A	E		000214
6	734H	0.264589	1		B	S	A	W		000308
7	735P	0.081564	8		B	S	A	S		000330
8	736W	0.038367	18		B	S	A			000343
9	757P	0.037319	19		B	H	A			000008
10	769J	0.071269	9		B	P	A	6		000020
11	773Y	0.136474	3		B	P	A	1		000103
12	774F	0.127626	4		B	P	A	J		000152
13	775M	0.035142	20		B	P	A	1		000167
14	783E	0.047646	14		B	H	A	E		000440
15	786A	0.150495	2		B	H	A	T		000576
16	794S	0.062096	10		B	P	A	P		001036
17	814B	0.049726	13		B	P	A			002578
18	825N	0.043566	16		B	C	A	S		003303
19	858B	0.054202	12		J	C	A	J		005836
20	881V	0.086445	6		B	S	A	C		000358

FIGURE 5-3. EXAMPLE OF CROSSINGS SORTED BY ID FOR PREDICTED ACCIDENTS PER YEAR

```
**********************************************************
*          SUMMARY  OF  INPUT   PARAMETERS               *
*        FOR ACCIDENT AND SEVERITY PREDICTION            *
**********************************************************

         TITLE            :               RR DEMO 2
         STATE            : 99
         COUNTY           : .
         CITY             : .
         RAILROAD         : A
         CROSSING ID      :
          BOTTOM OF RANGE: .
          TOP OF RANGE    : .
         RECORDS TO BE    :
           PRINTED        : 20
         SEVERITY TYPE    : 2    (1) PREDICTED ACCIDENTS
                          :      (2) FATAL ACCIDENT
                          :      (3) COMBIN. CASUALITY INDEX

**********************************************************

               SUM OF PREDICTED ACCIDENTS          :0.08848205

               TOTAL NUMBER OF CROSSINGS ANALYZED  :120

               INVENTORY DATE: APRIL 1986

**********************************************************
```

FIGURE 5-4. EXAMPLE OF INPUT PARAMETERS FOR PREDICTED FATAL ACCIDENTS PER YEAR

RR DEMO 2 17:02 THURSDAY, JANUARY 29, 1987

PUBLIC RAIL-HIGHWAY CROSSINGS

RANKED BY PREDICTED FATAL ACCIDENTS PER YEAR

RANK	PRED ACCDS	XING ST ID #	RR	--> 81	NUM 82	OF 83	ACC 84	<-- 85	DATE OF CHG	WD CL	TOTL SWIT TRNS	DAY THRU TRNS	TOTL THRU TRNS	TOTL TRKS	MAIN TRKS	TTBL SPD	HWY PVD	HWY LNS	URBN RURL	AADT
1	0.010999	786A	A	0	0	1	1	0		7	2	0	2	1	1	35	YES	2	0	4325
2	0.010037	734H	A	0	0	1	1	1		7	2	2	2	1	1	25	YES	2	1	8201
3	0.006721	794S	A	0	1	0	0	0		4	0	0	2	1	1	49	YES	2	0	535
4	0.006244	773Y	A	0	0	1	0	0		7	4	0	0	5	3	35	YES	2	1	11875
5	0.006079	724C	A	0	1	0	0	0		7	2	2	2	1	1	35	YES	2	1	7305
6	0.005868	858B	A	0	0	0	0	1		7	0	0	2	1	1	49	YES	2	0	455
7	0.005677	774F	A	0	0	1	0	0		7	6	0	0	3	2	35	YES	2	1	9170
8	0.005383	814B	A	0	1	0	0	0		8	0	0	2	1	1	49	YES	2	0	2765
9	0.005240	881V	A	0	0	0	0	0		7	12	2	16	10	5	40	YES	2	1	1990
10	0.004716	825N	A	0	0	0	1	0		4	0	0	2	1	1	49	NO	2	0	110
11	0.002910	704R	A	1	0	0	0	0		7	2	0	0	3	2	25	YES	2	1	3791
12	0.002436	783E	A	0	0	0	0	0		7	4	0	2	1	1	25	YES	2	0	11510
13	0.002389	735P	A	0	0	1	0	0		4	4	2	2	1	1	20	YES	2	1	530
14	0.002245	725J	A	1	0	0	0	0		4	2	2	2	1	1	25	YES	2	1	100
15	0.002108	757P	A	0	0	0	0	0		7	0	0	1	1	1	25	YES	4	0	12995
16	0.001963	758W	A	0	0	0	0	0		7	0	0	1	1	1	55	YES	2	0	3295
17	0.001888	720A	A	0	0	0	0	0		8	2	2	2	1	1	40	YES	2	1	33045
18	0.001876	760X	A	0	0	0	0	0		7	0	0	1	1	1	25	YES	4	0	9120
19	0.001863	793K	A	0	0	0	0	0		7	2	0	0	1	1	49	YES	2	0	2775
20	0.001832	836B	A	0	0	0	0	0		4	0	0	2	1	1	49	YES	2	0	725

FIGURE 5-5. EXAMPLE OF RANKED LIST OF CROSSINGS FOR PREDICTED FATAL ACCIDENTS PER YEAR

RR DEMO 2
PUBLIC RAIL-HIGHWAY CROSSINGS
RANKED BY PREDICTED FATAL ACCIDENTS PER YEAR
SORTED BY CROSSING ID

17:02 THURSDAY, JANUARY 29, 1987

OBS	XING ID #	PRED ACCDS	RANK	ST	COUNTY	CITY	RR	ROAD	RRID	MILEPOST
1	704R	0.002910	11		B	P	A	L		000151
2	720A	0.001888	17		B	P	A	C		000150
3	724C	0.006079	5		B	P	A	E		000213
4	725J	0.002245	14		B	P	A	E		000214
5	734H	0.010037	2		B	S	A	W		000308
6	735P	0.002389	13		B	S	A	S		000330
7	757P	0.002198	15		B	H	A			000008
8	758W	0.001963	16		B	H	A	C		000067
9	760X	0.001876	18		B	L	A	D		000243
10	773Y	0.006244	4		B	P	A	1		000103
11	774F	0.005677	7		B	P	A	J		000152
12	783E	0.002436	12		B	H	A	E		000440
13	786A	0.010999	1		B	H	A	T		000576
14	793K	0.001863	19		B	P	A	C		000967
15	794S	0.006721	3		B	P	A	P		001036
16	814B	0.005383	8		B	P	A			002578
17	825N	0.004716	10		B	C	A	S		003303
18	836B	0.001832	20		J	A	A	3		004418
19	858B	0.005868	6		J	C	A	J		005836
20	881V	0.005240	9		B	S	A	C		000358

FIGURE 5-6. EXAMPLE OF CROSSINGS SORTED BY ID FOR PREDICTED FATAL ACCIDENTS PER YEAR

```
**********************************************************
*         SUMMARY  OF  INPUT   PARAMETERS                *
*        FOR ACCIDENT AND SEVERITY PREDICTION            *
**********************************************************

        TITLE          :              RR DEMO 3
        STATE          : 99
        COUNTY         : .
        CITY           : .
        RAILROAD       : A
        CROSSING ID    :
         BOTTOM OF RANGE: .
         TOP OF RANGE  : .
        RECORDS TO BE  :
          PRINTED      : 20
        SEVERITY TYPE  : 3   (1) PREDICTED ACCIDENTS
                       :     (2) FATAL ACCIDENT
                       :     (3) COMBIN. CASUALITY INDEX
        FATALITY FACTJR : 50

**********************************************************

              SUM OF PREDICTED ACCIDENTS          :4.832302

              TOTAL NUMBER OF CROSSINGS ANALYZED  :120

              INVENTORY DATE: APRIL 1986

**********************************************************
```

FIGURE 5-7. EXAMPLE OF INPUT PARAMETERS FOR COMBINED CASUALTY INDEX

RR DEMO 3 17:02 THURSDAY, JANUARY 29, 1987

PUBLIC RAIL-HIGHWAY CROSSINGS

RANKED BY PREDICTED COMBINED CASUALTY INDEX (CCI)

RANK	PRED ACCDS	XING ST ID #	RR	--> 81	NUM 82	OF 83	ACC 84	<-- 85	DATE OF CHG	WD CL	TOTL SWIT TRNS	DAY THRU TRNS	TOTL THRU TRNS	TOTL TRKS	MAIN TRKS	TTBL SPD	HWY PVD	HWY LNS	URBN RURL	AADT
1	0.599508	786A	A	0	0	1	1	0		7	2	0	2	1	1	35	YES	2	0	4325
2	0.573475	734H	A	0	0	1	1	1		7	2	2	2	1	1	25	YES	2	1	8201
3	0.356085	794S	A	0	1	0	0	0		4	0	0	2	1	1	49	YES	2	0	535
4	0.338709	773Y	A	0	0	1	0	0		7	4	0	0	5	3	35	YES	2	1	11875
5	0.336666	724C	A	0	1	0	0	0		7	2	2	2	1	1	35	YES	2	1	7305
6	0.314528	774F	A	0	0	1	0	0		7	6	0	0	3	2	35	YES	2	1	9170
7	0.310868	958B	A	0	0	0	0	1		7	0	0	2	1	1	49	YES	2	0	455
8	0.285196	814B	A	0	1	0	0	0		8	0	0	2	1	1	49	YES	2	0	2765
9	0.270301	881V	A	0	0	0	0	0		7	12	2	16	10	5	40	YES	2	1	1990
10	0.249870	825N	A	0	0	0	1	0		4	0	0	2	1	1	49	NO	2	0	110
11	0.164631	704R	A	1	0	0	0	0		7	2	0	0	3	2	25	YES	2	1	3791
12	0.140955	735P	A	0	0	1	0	0		4	4	2	2	1	1	20	YES	2	1	530
13	0.137270	783E	A	0	0	0	0	0		7	4	0	2	1	1	25	YES	2	0	11510
14	0.128263	725J	A	1	0	0	0	0		4	2	2	2	1	1	25	YES	2	1	100
15	0.117287	757P	A	0	0	0	0	0		7	0	0	1	1	1	25	YES	4	0	12995
16	0.104382	760X	A	0	0	0	0	0		7	0	0	1	1	1	25	YES	4	0	9120
17	0.103628	758W	A	0	0	0	0	0		7	0	0	1	1	1	55	YES	2	0	3295
18	0.103467	720A	A	0	0	0	0	0		8	2	2	2	1	1	40	YES	2	1	33045
19	0.100138	793K	A	0	0	0	0	0		7	2	0	0	1	1	49	YES	2	0	2775
20	0.097065	836B	A	0	0	0	0	0		4	0	0	2	1	1	49	YES	2	0	725

FIGURE 5-8. EXAMPLE OF RANKED LIST OF CROSSINGS FOR COMBINED CASUALTY INDEX

RR DEMO 3 17:02 THURSDAY, JANUARY 29, 1987
PUBLIC RAIL-HIGHWAY CROSSINGS
RANKED BY PREDICTED COMBINED CASUALTY INDEX (CCI)
SORTED BY CROSSING ID

OBS	XING ID #	PRED ACCDS	RANK	ST	COUNTY	CITY	RR	ROAD	RRID	MILEPOST
1	704R	0.164631	11		B	P	A	L		000151
2	720A	0.103467	18		B	P	A	C		000150
3	724C	0.336666	5		B	P	A	E		000213
4	725J	0.128263	14		B	P	A	E		000214
5	734H	0.573475	2		B	S	A	W		000308
6	735P	0.140955	12		B	S	A	S		000330
7	757P	0.117287	15		B	H	A			000008
8	758W	0.103628	17		B	H	A	C		000067
9	760X	0.104382	16		B	L	A	O		000243
10	773Y	0.338709	4		B	P	A	1		000103
11	774F	0.314528	6		B	P	A	J		000152
12	783E	0.137270	13		B	H	A	E		000440
13	786A	0.599508	1		B	H	A	T		000576
14	793K	0.100138	19		B	P	A	C		000967
15	794S	0.356085	3		B	P	A	P		001036
16	814B	0.285196	8		B	P	A			002578
17	825N	0.249870	10		B	C	A	S		003303
18	836B	0.097065	20		J	A	A	3		004418
19	858B	0.310868	7		J	C	A	J		005836
20	881V	0.270301	9		B	S	A	C		000358

FIGURE 5-9. EXAMPLE OF CROSSINGS SORTED BY ID FOR COMBINED CASUALTY INDEX

d. Accident Reduction to Cost Ratio

Compute accident or severity reduction to cost ratio and, using this as the key value, sort the set in descending order.

e. Resource Allocation

Execute the resource allocation data step, and allocate the new class to all candidate crossings. Compute benefit/cost ratio, cumulative cost, cumulative accident benefit, and decision criteria.

f. Report Writing

Execute one of the three report writing procedures to print a report, depending on the selected severity measure. Each procedure prints the following report in three or four parts:

1. List of crossings and associated data items sorted by accident reduction to cost ratio. (See Figure 5-10).

2. Set of crossings as listed above along with subset parameters sorted by crossing IDs. (See Figure 5-11).

3. List of crossings eligible for stop signs. (See Figure 5-12).

4. Summary Report (See Figure 5-13).

g. Summary Printing

Execute the summary data step which prints the input data as well as number of crossings analyzed. (See Figure 5-13).

The calculation of the accident or severity reduction/cost ratio for each crossing depends on the crossing's current warning device and the number of tracks at the crossing. If the crossing already has gates (warning device class 8), it is deleted from consideration.

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RAIL-HIGHWAY CROSSING RESOURCE ALLOCATION RESULTS
BASED ON PREDICTED ACCIDENTS PER YEAR

OBS	XING ID #	PREDICTED ACCIDENTS PER YEAR	BEN/COST RATIO	RECOMMD WARNING DEVICE	PRESENT WARNING DEVICE	TOTAL TRACKS	TOTAL TRAINS PER DAY	CUMULATIVE COST	CUMULATIVE REDUCED ACCIDENTS	DC1	DC2	DC3	DC4	STOP SIGN REQMNT
1	284H	0.306321	3.60071	GATE	FLASH	1	18	58700	0.211361	.	.	.	0.294	NO
2	636R	0.194600	2.68208	GATE	PASS	1	10	124000	0.386501	0.318	0.780	.	.	NO
3	368H	0.172432	2.61439	GATE	FLASH	1	4	182700	0.539966	.	.	.	0.405	NO
4	365M	0.172333	2.61289	GATE	FLASH	1	4	241400	0.693342	.	.	.	0.405	NO
5	358C	0.160792	2.43791	GATE	FLASH	1	4	300100	0.836448	.	.	.	0.434	NO
6	639L	0.113824	1.94905	FLASH	PASS	1	10	343900	0.921816	0.543	1.334	.	.	NO
7	249Y	0.110546	1.89293	FLASH	PASS	1	8	387700	1.004726	0.559	1.374	.	.	NO
8	377G	0.095405	1.44653	GATE	FLASH	1	2	446400	1.089638	.	.	.	0.732	NO
9	382D	0.094880	1.43857	GATE	FLASH	1	2	505100	1.174081	.	.	.	0.736	NO
10	175X	0.105484	1.38923	GATE	PASS	2	0	570400	1.264798	.	.	0.762	.	NO
11	337J	0.082409	1.24948	GATE	FLASH	1	4	629100	1.338143	.	.	.	0.848	NO
12	158G	0.070495	1.20711	FLASH	PASS	1	0	672900	1.391014	0.878	2.154	.	.	NO
13	164K	0.070495	1.20711	FLASH	PASS	1	0	716700	1.443885	0.878	2.154	.	.	NO
14	651T	0.086557	1.20548	FLASH	PASS	1	30	760500	1.496686	0.879	1.385	.	.	YES
15	631G	0.086557	1.20548	FLASH	PASS	1	30	804300	1.549486	0.879	1.385	.	.	YES
16	389B	0.068887	1.17959	FLASH	PASS	1	10	848100	1.601152	0.898	2.205	.	.	NO
17	640F	0.065503	1.12163	FLASH	PASS	1	10	891900	1.650279	0.944	2.319	.	.	NO
18	370J	0.069902	1.05985	GATE	FLASH	1	4	950600	1.712492	.	.	.	1.000	NO

FIGURE 5-10. EXAMPLE OF CROSSINGS SELECTED FOR UPGRADE

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PUBLIC RAIL-HIGHWAY CROSSINGS RESOURCE ALLOCATION RESULTS

BASED ON PREDICTED ACCIDENTS PER YEAR (SORTED BY CRSSING IDs)

OBS	CROSSING ID	BEN/COST RATIO	STATE	COUNTY	CITY	RAILROAD	ROAD	RRID	MILEPOST
1	249Y	1.89293		SE	W	T	6		020334
2	284M	3.60071		SE	W	T	M		021441
3	337J	1.24948		SE	W	T	T		000049
4	358C	2.43791		SE	W	T	8		000067
5	365M	2.61289		SE	W	T	M		000121
6	368H	2.61439		SE	W	T	S		000167
7	370J	1.05985		SE	W	T	M		000280
8	377G	1.44653		SE	W	T			000008
9	382D	1.43857		SE	W	T			000005
10	389B	1.17959		SE	D	T			022121
11	631G	1.20548		SE	R	T			021415
12	636R	2.68208		SE	M	T			021631
13	639L	1.94905		SE	M	T			021769
14	640F	1.12153		SE	M	T			021804
15	651T	1.20548		SE	M	T			X21850
16	158G	1.20711		SE	W	T	G		000236
17	164K	1.20711		SE	W	T	H		000291
18	175X	1.38923		SE	W	T	T		000655

FIGURE 5-11. EXAMPLE OF SELECTED CROSSINGS SORTED BY ID

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RAIL-HIGHWAY CROSSING RESOURCE ALLOCATION RESULTS
POSSIBLE CANDIDATE CROSSINGS FOR STANDARD HIGHWAY STOP SIGNS
(SEE NOTE AT THE END OF SUMMARY PAGE)

OBS	XING ID #	PREDICTED ACCIDENTS PER YEAR	PRESENT WARNING DEVICE	TOTAL TRAINS PER DAY	AADT	CROSSING LOCATION URBAN/RURAL
1	651T	0.0865577	4	30	85	RURAL
2	631G	0.0865577	4	30	85	RURAL

FIGURE 5-12. EXAMPLE OF CANDIDATE CROSSINGS FOR STOP SIGNS

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************************************************************
*          SUMMARY  OF  INPUT   PARAMETERS                 *
*        FOR RESOURCE ALLOCATION PROCEDURE                 *
************************************************************

TITLE                     :                    DEMO 4
STATE                     : 99
COUNTY                    : 17
CITY                      : .
RAILROAD                  : .
CROSSING ID               :
    -BOTTOM OF RANGE      : .
    -TOP OF RANGE         : .
SEVERITY TYPE             : 1   (1) PREDICTED ACCIDENTS
                          :     (2) FATAL ACCIDENT
                          :     (3) COMBIN. CASUALITY INDEX
EFFECTIVENESS             : 2  (1)  STANDARD
CHOICE                    :    (2)  EXTENDED
                          :
EXTENDED EFF. VALUES      :
                              TRAINS <=10        TRAINS >=11
                           SINGLE    MULTI    SINGLE     MULTI
                            TRACK    TRACK     TRACK     TRACK
    PASSIVE TO FLASHING   : 0.75     0.65      0.61      0.57
    PASSIVE TO GATES      : 0.9      0.86      0.8       0.78
    FLASHING TO GATES     : 0.89     0.65      0.69      0.63
                          :
UPGRADE COSTS-            :
   PASSIVE TO FLASHING    :  $43,800.00
   PASSIVE TO GATES       :  $65,300.00
   FLASHING TO GATES      :  $58,700.00
                          :
AVAILABLE BUDGET          :   $1,000,000.00

************************************************************

             TOTAL NUMBER OF CROSSINGS ANALYZED  :176

ALL CANDIDATE CROSSINGS FOR STANDARD HIGHWAY STOP SIGNS
ARE SINGLE TRACK, LOCAL CROSSINGS. REFER TO PARAGRAPH
8B-9 OF THE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES
FOR FACTORS TO BE CONSIDERED PRIOR TO MAKING STOP
SIGN INSTALLATION DECISIONS.

             INVENTORY DATE: APRIL 1986

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FIGURE 5-13. EXAMPLE OF INPUT PARAMETERS FOR RESOURCE ALLOCATON REPORT PROGRAM

If the crossing has flashing lights or other active devices (warning device classes 5, 6 and 7), an accident or severity reduction/cost ratio (ACR/C) for upgrading to gates is calculated according to the equation:

$$ACR/C = AC\ (EFFECT_3/COST_3)$$

where AC is either the number of predicted accidents, the number of fatal accidents, or the combined casualty index for the crossing from the accident and severity prediction formulas, and $COST_3$ and $EFFECT_3$ are the cost and effectiveness of the upgrade, as discussed in Section 4. It is important to note here that, if the user has chosen to implement standard effectiveness values throughout the resource allocation model, $EFFECT_j$ simply represents the single effectiveness value for a crossing upgrade. However, if extended effectiveness values are in use, $EFFECT_j$ can have one of four values depending on the crossing's number of trains and tracks (see Section 4.2.5 on extended effectiveness values).

If the crossing is passive (warning device classes 1-4) but has multiple tracks, an accident or severity reduction/cost ratio for upgrading to gates is calculated according to equation:

$$ACR/C = AC\ (EFFECT_2/COST_2)$$

This forces gates to be installed at multiple track passive crossings in accordance with Federal guidelines. If the crossing is passive but has only one track, an accident or casualty reduction/cost ratio is calculated for upgrading to flashing lights according to the equation:

$$ACR/C = AC\ (EFFECT_1/COST_1)$$

The incremental accident or severity reduction/cost ratio equation for installing a gate at the passive crossing is shown below and is calculated in the Resource Allocation Subtask:

$$ACR/C = AC\ (EFFECT_2-EFFECT_1)/(COST_2-COST_1)$$

In the case where $EFFECT_2/COST_2$ is greater than $EFFECT_1/COST_1$, the program calculates a ratio given by the equation:

$$ACR/C = AC\ (EFFECT_2/COST_2).$$

This applies to all passive crossings, regardless of the number of tracks. In this case, the installation of gates is always more cost-effective than installation of flashing lights. The program does not calculate the incremental accident or casualty reduction/cost ratio in this case. For convenience of storage, all accident or casualty reduction/cost ratios are multiplied by 10^6; i.e., they are expressed in accidents per year per million dollars.

In addition to calculating the accident or severity reduction/cost ratio for each crossing, RESAL.NEW also determines if a crossing is a possible candidate for standard stop signs. For a crossing to qualify for consideration for standard stop signs, it must meet the following criteria:

1. Total trains per day greater than 10
2. No existing standard stop signs
3. Present warning device class less than 5
4. Crossing must be single track
5. For rural area crossings, the annual average daily traffic must be less than 400
6. For urban area crossings, the annual average daily traffic must be less than 1500
7. Crossing must be local highway type.

The set of crossing for which the incremental values of accident or severity reduction/cost ratios were calculated and stored separately are now appended with all the other crossings being analyzed and are sorted with respect to accident or severity reduction/cost ratio in descending order. From this set, only the top few crossings which can be upgraded within the given budget value are retained.

This new, expanded set may have some duplicate crossings. This is due to the fact that some passive crossings which were initially upgraded to flashing lights have now qualified to be considered for upgrade to gates. For all such crossings, the new values of upgrade cost, accident or severity reduction/cost ratio, and accident benefit are computed by adding the incremental values of the parameters to their earlier values computed as upgrade to flashing lights. These crossings are assigned the new upgrade category of gates. The new set of crossings are once again sorted by accident or severity reduction/cost ratio in descending order.

Finally, the Resource Allocation subtask calculates the decision criteria and generates the output in a report format. The decision criteria, DC_1, DC_2, DC_3, and DC_4, are calculated from equations (12), (13), (14), and (15), respectively, described in Section 4.2.6. If the crossing being considered is passive, single-track, the program calculates DC_1 and DC_2. If the crossing is passive, multiple-track, DC_3 is calculated. If the crossing has flashing lights, DC_4 is calculated.

The report generating procedures produce the following four reports for the selected severity measure:

- Resource allocation report sorted by accident and severity reduction/cost ratio.
- Resource allocation report sorted by crossing ID.
- Report for crossings that qualify for standard stop signs.
- Summary report for the run.

An example of the output from the resource allocation procedure is shown in Figures 5-10 through 5-13. The principal results of the program are given in Figure 5-10. This list is sorted by benefit/cost ratio (fourth column from left) and the recommended new warning device is given in the fifth colunm. Figure 5-11 gives the crossings sorted by crossing ID and also shows other Inventory data. Figure 5-12 lists the (two) crossings that meet the criteria for standard stop signs. These two crossings contained "YES" in the right-most column in Figure 5-10. The input parameters to the program are given in Figure 5-13.