Simplified Procedures for Determining County Road Project Priorities

JOSEPH L. SHAFFER AND JON D. FRICKER

Although more and more counties are realizing the value of systematic procedures to evaluate the condition of their highway networks and to establish priorities for candidate road projects, many of them are finding that they lack the data, background, and budget to implement a more comprehensive pavement management system (PMS). This paper reports the experiences of a county with a large network and a small budget, and its desire to implement a needs and priority-setting process that is fair, data efficient, and easy for any interested citizen to understand. Three simplified ranking procedures were developed or adopted: the index method, percentile method, and successive-subsetting method. Each method embodied a different combination of strengths and weaknesses, which gave them considerable value when used as a group. There was also remarkable agreement among the three methods when applied to the large, actual database. Not only are the three methods capable of working well with sparse data, they can be and have been used to direct the data collection efforts of a county that lacks up-to-date data. Two more sophisticated multicriteria ranking or optimization techniques were adapted to this problem for comparison with the three simplified methods, but the results did not justify the extra complexity of analysis. Finally, the value of the three simplified methods as steppingstones to multiyear PMS approaches is pointed out.

It is a rare county that has a highway budget large enough to make all the necessary road repairs and maintain its entire road system at desired standards. Most counties must decide which of the many needy roads are most deserving of attention, subject to the limited road funds available. Sometimes, these decisions are made in a black-box fashion (Figure 1), in which the question is, "Which roads should be repaired?" but the way in which the response is determined is known only to a few individuals. Whether the black box takes the form of a smoke-filled room or some consultant's mysterious computerized model, the response does not respect the right of county officials and the public to have a full understanding of the priority-setting process.

Whenever a large number of projects are competing for limited resources and subjective judgments are involved, a clearly defined system for making such decisions has several advantages:

1. It enables highway officials to translate a large amount of data on a variety of factors into a recommended ranking of projects.
2. It helps the decision makers to clearly define and review the explicit bases for their decisions.
3. It enables a high degree of consistency over time and in different locations for making decisions that may involve strong personal opinions.
4. It provides an opportunity for conflicting viewpoints to find a compromise by redefining the problem in terms of specific components, principles, and criteria.
5. It opens up the process to public review, possibly inviting unprecedented criticism, increased public confidence, or both.

Although sophisticated pavement management techniques are being developed, many counties—in terms of their confidence in them, the availability of data to use them, or the budget to afford them—are not ready for them. In this paper, the principal findings of a technology transfer (T^2) project carried out in cooperation with a county in northern Indiana are summarized. The project's primary objective was to acquaint citizens and county officials with the issues involved and the techniques available, should a county wish to implement priority-setting procedures in house or contract with a consultant. Among the principal findings were three priority-setting techniques designed to be acceptable alternatives to a black box. Each method allows incorporation of all important road characteristics in a way that can be understood by any interested official or concerned citizen. Each method could even be carried out using a hand calculator, but to save time and avoid errors, computer programs are used to do the calculations.

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Question ----------> Black Box ----------> Response
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FIGURE 1 Black-box decision making.

Since the completion of the T^2 study, the three simplified methods have been compared to two more sophisticated techniques. These comparisons are included in this paper.

THREE SIMPLIFIED PRIORITY-SETTING METHODS

Consider Table 1, which presents 11 highway segments (Segments A through K) in a hypothetical county. Which of the segments is most deserving of road repair funds? If road condition is the most important criterion, Segments A and J are prime candidates. If the most heavily traveled road deserves immediate attention, then Segment C is the most deserving. If

J. L. Shaffer, Rummel, Klepper and Kahl, 1035 N. Calvert St., Baltimore, Md. 21202. J. D. Fricker, School of Civil Engineering, Purdue University, West Lafayette, Ind. 47907.

TABLE 1 DATA FOR PRIORITY-SETTING EXAMPLE WITH 11 ROAD SEGMENTS

Segment	PCR	ADT	HAZ	Length	$/MILE
A	1	366	0	2.3	79,000
B	3	448	0	2.5	18,000
C	2	5704	0	6.6	61,000
D	2	106	2	1.2	75,000
E	3	263	1	1.5	31,000
F	5	359	0	2.6	0
G	4	278	0	2.0	11,000
H	2	125	1	1.9	85,000
I	3	119	0	3.2	20,000
J	1	672	0	1.2	65,000
K	2	98	0	0.5	60,000

Segment: Road Segment Identifier

PCR : Pavement Condition Rating (5 = best)

ADT : Average Daily Traffic

HAZ : Index of Safety Hazards (0 = safest)

Length : Road Segment Length in Miles

$/MILE : $/Mile to Remove Segment Deficiency

safety, with its associated liability insurance questions, is of greatest concern, Segments D, E, and H rise to the top of the projects list. If cost effectiveness (least dollars per mile to restore a road to a prespecified standard condition) is the key factor, then perhaps Segments G and B receive the highest rankings. Of course, the best ranking method combines some or all of these criteria (or factors) in a way that reflects the relative importance placed on them by the county officials. Three possible methods to achieve this are presented in this section.

The Index Ranking Method

The index method uses as a ranking method the proportion of distance that a given segment's factor value lies between the best and worst factor values. The total distance between the best and the worst factor values in the needs list is called the "range." A better value is one that would place a segment lower in the priority list than the segment currently under consideration. For example, a better (lower-priority) segment with respect to the factor being evaluated would have a lower ADT, higher pavement condition rating (PCR), lower hazard index, or higher cost per mile to upgrade. This method is shown

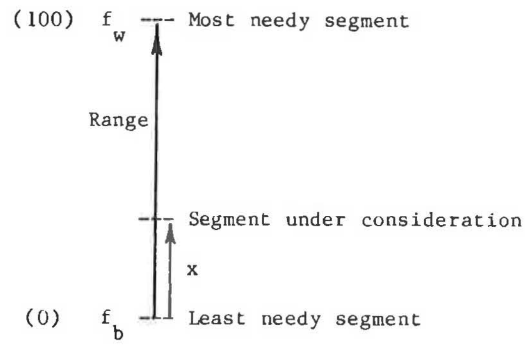

FIGURE 2 Index priority-setting method.

by Figure 2. The equations for the segment indexes are as follows:

$$I_j = (x/R) \times 100 \qquad (1)$$

and

$$IC = \sum_{j=1}^{n} \left[(I_j \times w_j) / \left(\sum_{j=1}^{n} w_j \right) \right] \qquad (2)$$

where

f_w = worst value of factor for segments in needs list;
f_b = best value of factor for segments in needs list;
x = difference between f_b and the factor value;
R = difference between f_b and f_w, the range of values of the factor under consideration;
I_j = segment index value, based on its value for factor j;
n = number of factors in the evaluation $j = 1, \ldots, n$;
IC = composite factor index of the segment under consideration, including all factors; and
w_j = weight for jth factor.

The ADT index value for Segment C, using Equation 1, is

$$I_{ADT}(C) = (5{,}704 - 98)/5{,}606 \times 100 = 100$$

Segment K will receive an index value of 0 because no segment has a less needy traffic factor value than it does. Because of Segment C's very large ADT, the rest of the segments receive low index values, as illustrated in Table 2.

Once all the factors are evaluated individually, a composite index value can be calculated. Each factor index value can be weighted before calculating the total. To keep this introductory example as simple as possible, each factor weight is set at 1. Using Equation 2, the composite index for road Segment C, using the first four factors in the order presented in Table 1, is

$$(75 \times 1 + 100 \times 1 + 0 \times 1 + 28 \times 1)/(1 + 1 + 1 + 1) = 50.8$$

The complete ranked list of segments can be seen in Table 2.

The Percentile Ranking Method

For a single factor, a road segment can be ranked as being in worse condition or more needy than a certain percentage of the

TABLE 2 RESULTS OF INDEX PRIORITY-SETTING METHOD

SEG #	PCR Index	ADT Index	HAZ Index	$/MILE Index	Composite Index*	Final Rank
A	100	7.4	0	7	28.6	9th
B	50	6.2	0	79	33.8	4th
C	75	100	0	28	50.8	1st
D	75	0.1	100	12	46.8	2nd
E	50	2.9	50	64	41.7	3rd
F	0	4.7	0	100	26.2	10th
G	25	3.2	0	87	28.8	8th
H	75	0.5	50	0	31.4	7th
I	50	0.4	0	76	31.6	6th
J	100	10.2	0	24	33.6	5th
K	75	0	0	29	26	11th

* All factor weights set to 1

segments being considered in the information set. Each segment competes with the other segments on the needs list to see how much justification there is for allocating road funds to it. The segment's percentile ranking represents that proportion of the other segments in the needs list that fail to be as deserving of road funds as measured by the value of the factor under consideration. For a single factor,

$$P = [B/(B + W)] \times 100 \quad (3)$$

where

P = percentile rank of the segment,
B = number of segments with better values, and
W = number of segments with worse values.

As in the index method, a better value is one that would place a segment lower in the priority list than the segment currently under consideration. For simplicity, those segments having the same factor value as the segment being ranked are excluded from the counts of B and W. In the rare but possible case in which all segments have the same factor value, P is set to 50 arbitrarily.

This percentile ranking is done separately for each factor, then combined into a weighted sum π for each segment. The weighted sum π is then divided by the sum of the weights $\sum w_j$ to produce the composite percentile PC.

$$\pi = \sum_j w_j \times P_j \quad (4)$$

with w_j = weight of jth factor, and

$$PC = \pi / \sum_j w_j \quad (5)$$

Using Equation 3, the PCR values for Segments B, E, and I are translated into the following percentile:

$$P_B = P_E = P_I = [2/(2 + 6)] \times 100 = 25$$

Note that segments with the same factor value were excluded from the counts of B and W in Equation 3. Segment F, with a PCR of 5, receives a percentile of 0, as no segments have a better factor value than Segment F does. The same procedure is then followed for the remaining factors.

For this example, each factor will be considered equally important. Thus the weights w_j assigned to each factor are set to 1. For Segment C, using Equations 3, 4, and 5 to determine PC, the composite percentile follows:

$$P_{PCR} = [5/(5 + 2)] \times 100 = 71$$

$$P_{ADT} = [11/(11 + 0)] \times 100 = 100$$

$$P_{HAZ} = [0/(0 + 3)] \times 100 = 0$$

$$P_{\$/MILE} = [4/(4 + 6)] \times 100 = 40$$

$$\pi_c = (1 \times 71) + (1 \times 100) + (1 \times 0) + (1 \times 40) = 211$$

$$PC = 211/(1 + 1 + 1 + 1) = 52.8$$

Segment C's composite percentile is 52.8. The composite percentile is then computed for each remaining segment. A list of project ranks is then compiled and printed. Table 3 presents the results.

TABLE 3 RESULTS OF PERCENTILE PRIORITY-SETTING METHOD

Seg. #	PCR P'tile	ADT P'tile	HAZ P'tile	$/MILE P'tile	Composite P'tile*	Final Rank
A	100	70	0	10	45	7th
B	25	80	0	80	46.3	6th
C	71	100	0	40	52.8	3rd
D	71	10	100	20	50.3	4th
E	25	40	89	60	53.5	2nd
F	0	60	0	100	40	8th
G	10	50	0	90	37.5	9th
H	71	30	89	0	47.5	5th
I	25	20	0	70	28.8	11th
J	71	90	0	30	55	1st
K	71	0	0	50	30.3	10th

* All factor weights set to 1

The Successive Subsetting Ranking Method *(1)*

Because much of the road segment information is collected on a subjective or approximate basis, problems with accuracy of particular factor values or consistency among the opinions of individual investigators can occur. Weights assigned to the index and percentile methods are subjective in nature, and might imply a greater precision than is possible with the existing information. A feature of the successive subsetting method is that the sensitivity is controlled by the order in which factors are chosen for subsetting. There is no need for the determination of specific weights that might be difficult for a number of decision makers to agree upon.

The successive subsetting method assumes that projects can be only roughly lumped into subsets according to a given factor. The members of each factor subset should have approximately the same value for the factor under consideration. Each one of these smaller sets can then be further subdivided using subsequent evaluation criteria. In Figure 3, four ADT subsets are distinguishable. The first subset contains only Segment C, with an ADT of 5,704 vpd that is much larger than the second greatest ADT value. The second subset contains only Segment J, with an ADT of 672 vpd. Segments A, B, E, F, and G fall into another subset of similar ADT values, from 263 to 448 vpd. The final subset, Segments D, H, I, and K, consists of segments with low ADT values, from 98 to 125 vpd.

The next factor to be considered is the PCR. (Any method of characterizing pavement condition is acceptable. In this example, a subjective rating of the pavement surface is used, with 1 = worst and 5 = best.) Segments C and J remain at the top of the list, because they are the only segments in their respective subsets. The third initial subset can be divided into four new subsets. Segment A, with the lowest PCR value of 1 will form an individual subset, because no other segments in the initial subset have as needy a PCR value. The second new PCR subset contains Segments B and E, with PCR values of 3. The PCR of Segments B and E makes them less needy than Segment A, so they are ranked below Segment A. Segments G and F, with PCR values of 4 and 5, respectively, form the final two least needy subsets from the third initial subset. Segment I forms a new subset ranked below the fourth original subset, because segment I has a less needy PCR value than Segments D, H, and K.

The hazard rating HAZ further divides the six subsets. Three segments, D, E, and H, have hazard ratings greater than zero, and form new individual subsets. Segment K forms an individual subset, ranked below the subset containing Segment H.

The final factor to be used for subsetting is the cost per mile ($/MILE) to correct the segments' deficiencies. Because the segments are already in individual subsets, the $/MILE factor is not needed for further subsetting. If $/MILE is used, a segment with a lower cost per mile would be ranked above a segment with a higher cost per mile.

All road segments are now ranked in individual subsets, according to the order of priorities ADT, PCR, HAZ, and $/MILE. The most needy road segments could be selected for funding.

Using the successive subsetting method, a large number of road segments can be ranked in a small number of steps from information that need not be precise. Because only a limited amount of information has to be collected, savings in acquisition costs result.

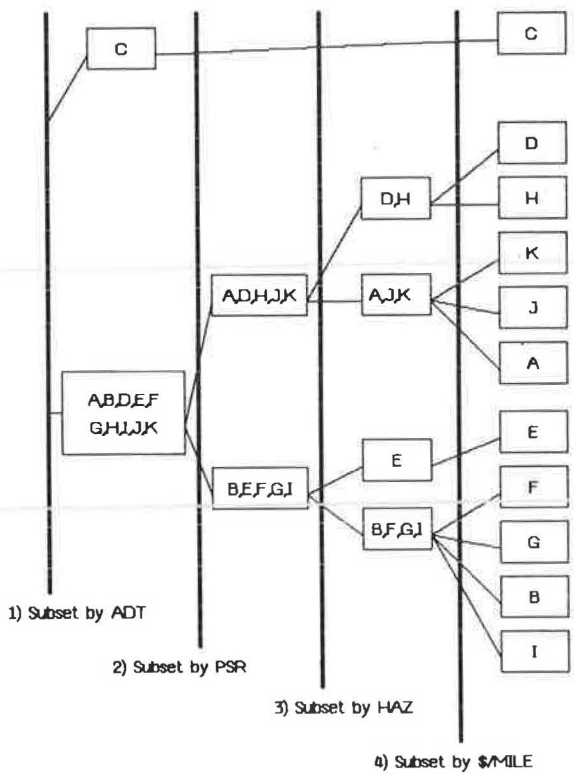

FIGURE 3 Use of successive-subsetting method.

For the successive subsetting method to be effective, however, decision makers must clearly understand their priorities. In fact, this method requires that the factors be ranked in order of importance; equal weighting of factors as used in the index and percentile examples is not possible. Because the first subsetting step has the greatest effect on the final ranking, the most important factor must be chosen with great care.

Summary of Priority Ranks

The results of the three small examples are instructive. There is a certain amount of agreement between the index and percentile methods—Segments C, D, and E rank near the top and Segments F, G, and K near the bottom in both cases—but there are also noticeable differences. For example, Segment I is ranked 6th by the index method and 11th out of 11 by the percentile method. Of course, because the subsetting rankings are based on unequal factor weights, they cannot be compared directly with the index and percentile results. The choice of ranking method can be based on whichever ones the decision makers feel comfortable with, but some rules of thumb are

1. If factor values are accurate and up-to-date, the index method offers the best combination of precision and simultaneous consideration of the factors.
2. If the factors are approximate or subjective, but the simultaneous consideration feature is retained, the percentile method is a good choice.
3. If factor values are approximate or subjective, and simultaneous consideration of multiple factors is not important, the successive subsetting method is appropriate. In fact, preliminary results *(2)* indicate that this method most closely duplicates the rankings made intuitively by individuals. It involves a sequential rather than a simultaneous consideration of the factors, from most important to least important.

However, the best strategy would be to use all three methods and look for results that reinforce one other, because no method is inherently better than the others and all three are so easy to implement.

Advice on Weights

Equations 2, 4, and 5 have involved the use of the weights w_j. A common tendency is to select such a large w_j value for the most important factor that the least important factors have no influence and could have been excluded, except to break ties. If this happens, the ability to incorporate all chosen factors into the ranking has been lost. Experience to date *(2)* indicates that the ratio of the highest to lowest w_j values should not exceed the following values:

Rating	*Index Method*	*Percentile Method*
PCR	2	3
ADT	3	3
HAZ	2	3

A good procedure is to set the lowest $w_j = 1$, set the highest w_j to a value within the bounds shown in the preceding table, and set any remaining w_j to values between the high and the low. Noninteger values (e.g., 1.5, 1.67, etc.) are acceptable.

ALTERNATIVE PRIORITY-SETTING METHODS

More sophisticated priority-setting methods are examined to determine what is being sacrificed for the sake of simplicity before proceeding to a large-scale problem. Two such methods have been carefully considered for their compatibility with the objectives of the county-level project. The strengths and weaknesses of each method are introduced briefly in this section, followed by a comment as to their usefulness for county rankings.

The Analytic Hierarchy Technique

The analytic hierarchy (AH) technique was developed by Saaty *(3)* as a scaling procedure for measuring priorities "in complex situations in which an implicit objective criterion is multidimensional and perhaps only vaguely realized." Although this method has the potential to capture the detail and subtleties—and reconcile the inconsistencies—inherent in an individual's or a group's ranking process (according to a paper by M. Saito in this Record), there are drawbacks. The principal disadvantage is that the input requirements are more extensive and less intuitive than the three simplified methods. Furthermore, several of its computational procedures cannot be easily replicated by hand. A computer is a necessity for even small cases.

Goal Programming

Goal programming (GP) *(4)* is not strictly a priority-setting or ranking technique, but it can generate the optimal bundle of segments that maximizes benefits or minimizes penalties, subject to multiple goals, weights, penalties, and budget constraints established by the user. Although it is somewhat more straightforward to use than the analytic hierarchy method, there are still sufficient difficulties in problem formulation and refinement that keep GP from being considered a simplified method. In GP, there must be a budget constraint, and this requires knowledge of all $/MILE values in the segment list. In a county with hundreds of segments, these values would be very tedious to determine. It is also the most elusive factor value, because $/MILE estimates depend on the type of project and site-specific characteristics. In the priority-setting methods previously introduced, the inclusion of a particular factor is left to the user, not dictated by the method.

There is also the problem of scaling the factor values. If a GP formulation of the 11-segment problem is not properly modified, a unit of improvement in HAZ is considered equal to one extra vehicle per day of ADT. This situation leads to severely distorted solutions, but it is not clear what a proper modification is. After a reasonable modification was tried, the GP method produced a list of eight segments that represented the best use of available county road funds. But which of these eight projects was most deserving of implementation? An optimization procedure such as GP cannot answer directly. Furthermore, the GP solution is valid for only one budget level. A major change in the budget changes how far down the ranked list a county can afford to go and necessitates a completely new GP solution.

It should also be pointed out that the GP method gets considerably more cumbersome as problem size in number of road segments grows. Whereas the 11-segment example in this paper would have only 11 X variables (1 per segment) in each goal equation, typical counties have hundreds of segments—meaning hundreds of X variables in each goal equation. A separate computer program could be written to transform the segment data files into input files with the proper format for the GP package to use, but the process lacks the desired simplicity.

Comments on the Alternatives

It was hoped that using these alternative methods to rank the 11 segments might produce a pattern or other insight indicating a superior method. Instead, the most that can be said is that the GP method is responsible for the greatest departure from any semblance of consensus in the rankings. What is clear, however, is that the AH and GP methods do not justify their considerable extra complexity and effort in the context of this study. What remains to be done is to evaluate the performance of the three simplified methods for a county-size network database.

PRIORITY SETTING ON A LARGE DATASET

LaPorte County has 1,025 mi of county roads, making it the sixth largest network among Indiana's 92 counties. However, 12 counties have more vehicle registrations and 11 counties have higher populations, making LaPorte County's resources proportionally low. At the time the simplified priority-setting techniques were applied to the county's road list, it contained 668 segments. Of these, 220 were in good enough condition to move to a routine maintenance list. The remaining road list contained ADT values from 19 to 3,786 vpd, some roads with subjectively assessed hazardous conditions, and pavement condition rating values of $1 \leq \text{PCR} < 4$. The three simplified techniques were applied using the following factor weights w_j: 2.0 for HAZ, 1.5 for PCR, and 1.0 for ADT. Members of the citizens task force involved in the project requested that these weights be reversed in the second run: 2.0 for ADT, 1.5 for PCR, and 1.0 for HAZ. The top 20 (most needy) segments resulting from the use of the percentile ranking method and the second factor weighting scheme are listed in Table 4. This is actually the top portion of one of the full segment priority listings provided to LaPorte County.

Table 5 provides a summary of the rankings from the three runs for each weighting scheme. What is remarkable about these rankings is the degree of consistency among them. It was expected that the high number of segments would mean that any slight change in factor values or ranking method would cause large differences in a segment's rank. Instead, even with a reversal of the weighting scheme, a number of segments ramained near the very top of the list of 448 road segments. Thirty-six different segments appear in the six columns of Table 5. Three segments appear in all six columns, 10 appear in five columns, and 6 more in four columns. All of the 8 segments that appear in only one column do so in either Column 3 or 6—the columns produced by the subsetting technique.

It is normally not good practice to compare results obtained from different weighting schemes, but some conclusions are interesting. The degree of consistency observed in Table 5 isn't because the ratio of factor weights (2:1) is too low *(2)*. The worst roads in a list of 448 segments have such a bad combination of factor values that they remain at the top for any reasonable weight ratios. This conclusion is verified by the appearance of many segments in at least one subset column and in other columns with implied ratios that are much larger than those of other segments.

Most of the few inconsistencies in a segment's placing involve the subsetting technique, when an otherwise needy segment gets caught on the wrong side of an early subset and cannot rise above a certain level thereafter. A good example is Segment 178. It ranks in the top nine in five columns of Table 5 because of its low PCR value (2.0) and relatively high HAZ value (1.0). However, its low ADT of 268 vpd puts it on the wrong side of the first subset when ADT is the first priority, and its ultimate ranking in Column 6 is 139th. However, the subsetting method's simplicity, ability to handle vague data, close similarity to human ranking methods *(2)*, and general consistency with the other two methods make it worthy of retention.

The full output on which Tables 4 and 5 are based was made available to the citizens task force and county officials for inspection. First, with roads identified only by a number that had no meaning to the inspectors, the validity of any road's rank, given its particular set of factor values, was confirmed. Then, with the road segments' real identities revealed to the inspectors, the data factor values were checked for correctness. Most important, there was no dispute over the road segments that were ranked as most needy and those that appeared lower on the list. With an issue that is typically intensely emotional

TABLE 4 PROJECT RANKS BY WEIGHTED-AVERAGE PERCENTILE METHOD

SEG#	PCR	ADT	HAZ	COST	AVGpct	$CUMUL
347.	1.00	811.00	1.00	-7.00	96.03	-7.00
169.	2.00	606.00	1.00	-7.00	84.23	-16.80
612.	1.00	4249.00	0.	-7.00	77.49	46.20
348.	2.00	381.00	1.00	-7.00	75.69	7.70
20.	1.00	927.00	0.	-7.00	74.40	-4.90
163.	1.00	788.00	0.	-7.00	73.61	-92.40
155.	1.00	782.00	0.	-7.00	73.51	-116.90
648.	1.00	637.00	0.	-7.00	72.71	-120.40
178.	2.00	286.00	1.00	-7.00	72.64	-127.40
93.	1.00	524.00	0.	-7.00	72.22	-157.50
154.	1.00	521.00	0.	-7.00	72.12	-161.00
527.	1.00	444.00	0.	-7.00	70.73	-178.50
283.	2.00	187.00	1.00	-7.00	68.04	-182.00
565.	2.00	5704.00	0.	-7.00	66.99	-228.20
42.	2.00	3312.00	0.	-7.00	66.69	-253.40
208.	2.00	2515.25	0.	-7.00	66.39	-261.80
58.	2.00	2117.00	0.	-7.00	65.80	-268.80
148.	2.00	1501.00	0.	-7.00	65.30	-275.80
656.	1.00	416.00	0.	-7.00	65.06	-279.30
620.	2.00	1404.00	0.	-7.00	65.00	-286.30

NOTES: The next 428 segments are not shown in this table. The factor weights are as follows:

Factor	*Input Weight*	*Norm Weight*
PCR	1.5	33.3
ADT	2.0	44.4
HAZ	1.0	22.2
COST	0.0	0.0

TABLE 5 COMPARISON OF PROJECT RANKS, BY METHOD AND FACTOR WEIGHTING

PRIORITY RANK	INDEX	P'TILE	SUBSET	INDEX	P'TILE	SUBSET
1	347.	347.	347.	347.	347.	347.
2	169.	169.	169.	662.	169.	169.
3	348.	348.	348.	612.	612.	348.
4	178.	178.	178.	565.	348.	163.
5	283.	283.	283.	169.	20.	155.
6	528.	528.	528.	348.	163.	648.
7	346.	346.	657.	178.	155.	93.
8	476.	657.	346.	283.	648.	154.
9	612.	612.	565.	476.	178.	527.
10	657.	20.	612.	528.	93.	656.
11	565.	163.	42.	346.	154.	603.
12	662.	155.	208.	42.	527.	500.
13	20.	648.	58.	20.	283.	626.
14	163.	93.	148.	163.	565.	223.
15	155.	154.	620.	155.	42.	267.
16	648.	527.	129.	648.	208.	42.
17	93.	656.	303.	93.	58.	208.
18	154.	603.	171.	154.	148.	58.
19	527.	500.	72.	527.	656.	89.
20	656.	331.	20.	208.	620.	265.

NOTE: Factor weights for the first method are HAZ = 2.0, PCR = 1.5, and ADT = 1.0; for the second method, HAZ = 1.0, PCR = 1.5, and ADT = 2.0.

and political, the endorsement given the results by the task force and county officials is a strong vindication of the philosophy followed in this project based on simplicity, openness, and ease of inspection.

A STEP-BY-STEP OVERVIEW

The three simplified ranking methods having been described and advice on selecting values of the factor weights w_j having been offered, the suggested sequence of steps that make up the overall needs-priority process may be described:

1. Identify the factors to be used to describe the highway segments. Examples are measurements of safety, pavement condition, traffic volume, and cost to repair. Select as many as necessary to fully distinguish one road segment from another, but remember that the costs of acquiring, maintaining, and manipulating the data increase with each new factor added.
2. Create a complete list of the highway segments in your jurisdiction. Each segment should be homogeneous, that is, have similar characteristics along its length. If pavement condition or traffic volumes within a segment change significantly, that segment should be broken up into two or more homogeneous segments.
3. Determine factor values for each segment. If these values are not immediately available and new data collection is not practical within the available time or budget, some estimates can be used temporarily. One example is to use synthetic traffic volumes on segments that do not have valid or current volume counts *(5)*. To do this, assign each road in the jurisdiction to one of three volume levels—high, medium, or low—using best judgment. Find the average of the actual traffic volumes for those roads in each level that have valid counts. Assign the high-level average to each road segment believed to have a high volume for all roads in each level that lack a current count.
4. Put road segments that are in good condition (e.g., PCR ≥ 4 and HAZ = 0) into a routine maintenance list. This reduces the number of segments that enter into the priority-setting calculations for road repair work as needy segments.
5. Apply one or more of the available ranking methods—index, percentile, subsetting, and any others that may develop—to the needy segments.
6. Check the results for road segments that appear to have an illogically high or low ranking. This can be evidence of errors in data entry. If any such errors are found, correct them and repeat Step 5.
7. Estimate how many of the top-ranked projects could be undertaken, given the available budget. If any of these segments have synthetic traffic volume values (see Step 3) or other temporary approximate factor values, obtain actual volume counts and more precise values for the other factors. This procedure focuses the often-costly or time-consuming data collection efforts on those segments that are the most likely candidates for road repair. Data collection to replace the temporary values determines whether the segments really are deserving of their high ranking. Then repeat Step 5. If all the top-ranked projects have valid actual factor values, proceed to Step 8.
8. If cost-effectiveness is desired as an additional criterion, develop improved cost estimates for each road project ranked highly after Step 7. Lower-ranking road segments could receive rough estimates of $/MILE values (perhaps based on a function of PCR, HAZ, and ADT) as a temporary factor value, much like the synthetic traffic volumes in Step 3. Return to Step 5, unless the priority list at least as far down as the budget limits contains only segments with valid actual factor values. In this case, proceed to Step 9.
9. Use the rankings as the starting point for developing the road repair work plan for the next planning period. Efficient use of personnel and equipment and equity among the various regions of the county are examples of considerations that may justify minor modifications to the rankings.

It must be emphasized that these methods are intended to be a key ingredient in the county highway priority-setting process, but not a replacement for good management decisions. The rankings produced by these methods should be carefully reviewed for logic, accuracy of input data, and practicality of implementation. Correctly used, the methods constitute a valuable starting point and frame of reference for decisions that are better informed and easier to justify. There are two additional benefits: (a) the county becomes accustomed to collecting and updating data on a regular basis because the data are needed to implement the priority-setting methods; (b) this procedure in turn prepares the county for the next step—implementation of a PMS. Counties that, primarily due to lack of data and a systematic way to apply them, operate in a black-box fashion can make better decisions. These decisions will extend beyond the ranking of next year's projects. Evaluation of consultants' services for data collection and priority setting, acquisition of microcomputer hardware and software, and adoption of more sophisticated PMS techniques are natural sequels to the first step, the use of simplified priority-setting procedures.

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