A Step-by-Step Procedure for Roadway Network Improvement Priority Setting

FAZIL T. NAJAFI

This study was initiated as a response to the need of the city of Gainesville, Florida, to develop methods to prioritize the allocation of funds for roadway improvement projects. Because funds are limited, only the highest priority projects can be funded immediately. The uncertainty of federal highway funding programs and change in public attitude toward transportation investment costs are driving factors in forcing decision makers to devise systems for priority setting to allocate limited funds for needy improvement projects. In this paper, the author provides an overview of the traditional allocation mechanisms and then focuses on a step-by-step roadway improvement prioritization procedure that has been devised for the city of Gainesville, Florida. In the step-by-step procedure, (a) roadway network improvement criteria are identified, (b) the city's roadway network system is divided into segments of homogeneous characteristics, (c) numerical point ratings are assigned to each roadway segment based on roadway sufficiency ratings derived from an overall roadway condition, and (d) cost per segment deficiency improvement is calculated for funding allocation. In addition, a simple computerized improvement ranking procedure is developed to rank and identify signalized intersections as candidates for improvement. A similar program is also developed for sidewalks. In general, the models are simple and easily understood by public officials, and they are practical tools ready for implementation by city, county, or state officials. The models are flexible to accommodate variable standards and modifications that are useful to city, county, state, and federal projects.

During the last decade, the transportation investment decision environment has grown steadily more complex. The traditional process for deciding whether or not to build has been complicated by a number of newly important criteria. For example, capital improvement programs must now frequently be evaluated on the basis of issues such as regional equity, efficient use of available funding assistance, statutory constraints, community and environmental impacts, and even general public acceptability. Responding to any of these issues within a short time frame and with limited resources is a difficult task for decision makers. Therefore, analytical models are needed to allocate limited resources to transportation projects that can satisfy essential project needs. The development of a step-by-step procedure for roadway network improvement priority setting was initiated in response to a request from the city of Gainesville, Florida. The project is part of an overall effort on the part of the city to apply a simplified procedure to allocate limited funding on a priority basis to improve roadway networks, sidewalks, and signalized intersections.

Department of Civil Engineering, University of Florida, 345 Weil Hall, Gainesville, Fla. 32611.

The developed procedure for allocating funds to roadway segments is based on deficiency ratings derived from overall roadway conditions.

The city of Gainesville is a medium-size city with a population of 85,000 people located in the north central part of Florida. The city has 772 lane-miles of arterial, collector, and local roads. The funding sources for the improvement of these roadway network systems come from federal, state, and local revenues. In the past, the allocation of funds for roadway improvement was based on the traditional allocation mechanism, which lacked a systematic prioritization procedure.

The following procedure of systematic steps was developed for Gainesville:

1. Criteria are identified through established standards and by the city's experienced public works staff and engineering and planning divisions, relevant to roadway improvement deficiency (e.g., safety, surface condition, base, drainage, pavement width, level of service, and so on).
2. The roadway network system is divided into homogeneous segments.
3. A total deficiency point value is assigned to each roadway segment.
4. Cost estimates are prepared for the improvement of each roadway segment.
5. Tables are prepared for the present and future roadway network improvement program.

The step procedure provides city officials with the benefit of being able to apply the models for the allocation of limited funds into projects in a systematic fashion. The procedure is flexible and could also be implemented by other cities, counties, or states. The computerization of the system enables decision makers to obtain fast results. In general, it is a simple procedure that can be understood and easily followed.

LITERATURE SEARCH

In the past, transportation improvement priority-setting goals were generally centralized, made either by the state's transportation planning or by each of the state's districts with review and approval at the state level. Funds were allocated on the basis of project needs. Needs were defined relevant to project deficiency in level of service, capacity, or structural quality. In others, lists of projects were generated on a more ad hoc basis. Once such a list was generated, adjustments were made to account for anticipated impacts, community opposition, and environmental effects, and for the consideration of political realities of building these projects. The final list of selected projects would then be made public. In the last decade, citizen participation in the earlier stages of the planning became essential to the overall transportation planning process. Typically, the state agency still retains responsibility for overall system planning and developing alternative programs for review and evaluation by the public. The integration of community and environmental impacts and participation and interaction with a wide variety of interest groups are also part of the overall planning and evaluation process.

Most evaluation systems in use are patterned after a numerical rating system first developed by the Arizona Highway Department in 1946 (*1–3*) describing the highway's "sufficiency." The sufficiency rating method assigns a point score to each section of road, based on its actual condition and its ability to carry load in a safe and efficient manner.

The U.S. Navy Public Works Center model of a priority scheme for the selection of pavement sections needing major repair used a benefit-cost optimization technique. The center developed a pavement condition technique and numerically ranked roadways as primary, secondary, and tertiary. The parking area and roadway network systems were rated as good, fair, poor, very poor, and failed. The conclusion of the repair-when-needed strategy represented the best in terms of maximizing network benefits and minimizing cost (*4*).

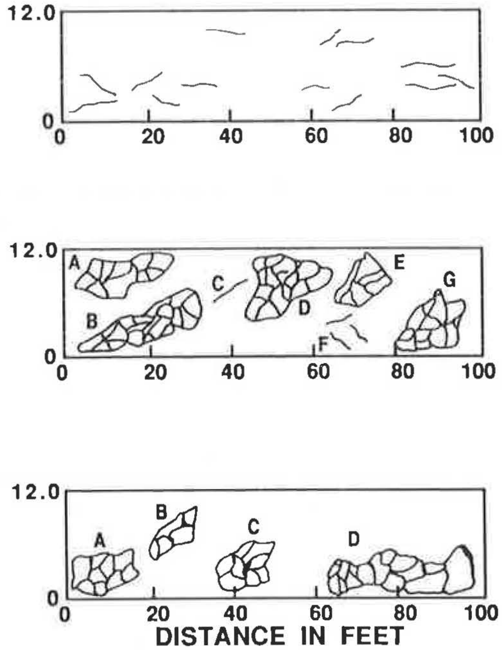
The state of Kentucky used an adequacy rating procedure based on certain fixed-point scales for highway construction projects (*3*). One of the major advantages of this procedure included computerization, which allowed coding of numbers from simplified forms without reference to charts, tables, and graphs.

Bower (*5*) cited that in urban areas, in general, traditional allocation mechanisms were based on population. Safety was among the factors included in improvement priority settings.

A demand-responsive approach to highway maintenance and rehabilitation is used by many states. Table 1 presents

TABLE 1 EQUIPMENT USED TO MEASURE PAVEMENT CONDITION PARAMETERS (*6*)

	ROUGHNESS	DEFLECTION	SKID RESISTANCE	DISTRESS
ALASKA	Mays Ride Meter	Falling Weight Deflectometer		Rutting: Measured Cracking, Patching: Visual
ALBERTA	PCA Car Roadmaster	Benkelman Beam and Dynaflect		Visual
ARIZONA	Mays Ride Meter	Dynaflect	Mu Meter	Visual/ Measured
CALIFORNIA	PCA Car Ridemeter	Dynaflect or Deflectometer	K. J. Law, Inc. Skid Tester	Visual/ Measured
CERL				Visual
DENMARK	Servo-accelero-meter Mounted in car	Falling Weight Deflectometer		
FLORIDA	Mays Ride Meter	Dynaflect	ASTM Skid Trailer	Visual/ Measured



Class 1 Cracking
128 Lin. Ft. x 1' = 128 Sq. Ft. - 1200 Sq. Ft.
= 11% Cracking
Measure Individual Cracks

Class 2 Cracking

Area	Dimensions
A & B	24' x 12' = 408 Sq. Ft.
C	10' x 1' = 10 Sq. Ft.
D	18' x 12' = 216 Sq. Ft.
E	12' x 12' = 144 Sq. Ft.
F	4' x 1' = 4 Sq. Ft.
G	14' x 12' = 168 Sq. Ft.

Total = 950 Sq. Ft. - 1200 Total Sq. Ft.
= 79%

Class 3 Cracking

Area	Dimensions
A	16' x 12' = 192 Sq. Ft.
B	12' x 12' = 144 Sq. Ft.
C	14' x 12' = 168 Sq. Ft.
D	36' x 12' = 432 Sq. Ft.

TOTAL = 936 Sq. Ft. - 12 Total Sq. Ft.
= 78%

FIGURE 1 Florida method for cracking measurements (*6*).

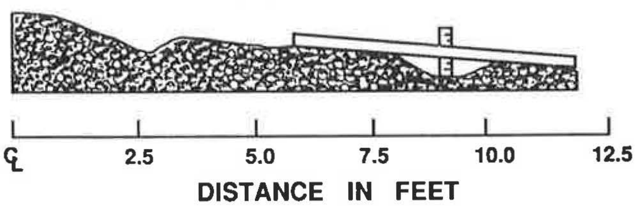


FIGURE 2 Florida method for rutting measurements (*6*).

equipment used to measure pavement condition parameters (*6*). Figures 1 and 2 present the Florida Department of Transportation methods for cracking and rutting measurements (*6*).

In 10 of the 13 states consulted in an NCHRP project (*7*, *8*), the determination of transportation priorities was identified as a major concern.

GAINESVILLE ROADWAY NETWORK SYSTEM'S MODEL FOR PRIORITIZATION OF CAPITAL IMPROVEMENT

To obtain the greatest benefits from the allocation of limited funds to roadway improvement projects, a systematic and simple model for each element of the system is needed. Formulation of models is time-consuming and costly. A model must accurately reflect the structure or behavior of a real-life counterpart. There should be a close correlation between the model and its corresponding reality.

In the model formulation process, the analyst's main concern is how accurately the model fits the problem at hand, including considerations of physical, economic, political, social, and governmental objectives, as well as community goals. The model must be simple and understandable because lay elected decision makers are reluctant to rely on more sophisticated models that they do not understand. Simple models with a reasonable degree of accuracy are generally acceptable for application. In selecting a model related to roadway improvement priority settings, one needs to establish evaluation criteria such as

- Theoretical soundness;
- Rationale for priority settings;
- Multiyear constraint capability;
- Sensitivity and assumptions;
- Multimodel capability;
- Demonstrated use and ability to be convincing;
- Simplicity;
- Accuracy;
- Quality of ideas;
- Cost;
- Time period required;
- Data requirements;
- Individual knowledge needed; and
- Group knowledge needed.

In some instances decision makers are seeking a quick response to a difficult question. Then, time becomes an important factor in selecting a model to generate results in the most cost-effective manner.

As a result of reviewing the city's budgetary constraints and the growing demand for roadway improvement projects, a simplified practical procedure is developed to rank and prioritize projects on the basis of established needs. The city's roadway network system is divided into homogeneous segments, categorized and ranked on the basis of improvement criteria established for the allocation of funding. For the deficiency rating assignments, AASHTO and *Highway Capacity Manual* (HCM) standards are used along with the professional judgments of the city's experienced staff from public works and the planning and traffic divisions. For instance, roadways carrying heavier traffic volume require higher standards of construction and rehabilitation as compared to roadways carrying less traffic volume. Qualifying deficiency points are accordingly assigned to each identified roadway segment (Table 2).

Safety

The first rating category is related to "safety" (Table 2). In this category, rated items are (a) accident rate, (b) hazards, (c) stopping sight distance, (d) passing sight distance, (e) traffic control, and (f) horizontal alignment.

In Table 2, the first item under safety is accident rate. Assignment of relative weights to each accident occurring on a roadway segment over the past 5 years varies according to severity of the accident. Property damage accidents result in one deficiency point, whereas personal injury accidents are four and fatal accidents are six deficiency points. Mercier and Stoner (*9*) cited that the score for a given road segment uses the following relationships:

$$\text{Rating} = 11 - (N/L)$$

where,

N = sum of all deficiencies,
L = length of the road segment in miles,
11 = maximum score, and
0 = minimum score (negative scores are recorded as 0).

The second item rated under safety is the roadway segment hazards (Table 2). Deficiency points are assessed for each

TABLE 2 ROADWAY NETWORK SUFFICIENCY RATING CRITERIA

Rating Category	Item Rated	Max. Point
1. Safety (45 points)	a. Accident Rate	11
	b. Hazards	9
	c. Stopping Sight Distance	8
	d. Passing Sight Distance	5
	e. Traffic Control	6
	f. Horizontal Alignment	6
	Sub Total	45
2. Roadway Segment Conditions (26 points)	a. Base	9
	b. Wearing Surface	9
	c. Drainage	8
	Sub Total	26
3. Service (20) points	a. Level of Service (HCM65) volume capacity on a roadway segment	6
	b. Pavement Width	9
	c. Shoulder Width	5
	Sub Total	20

hazard not included in any other rating element. They are

- Narrow structures (less than 20 ft);
- Structure with poor approach alignment;
- Railroad crossing at grade without automatic signals;
- Abrupt or severe grade changes; and
- Other fixed structures extending into the traveled way.

Rating scores are based on the average number of hazards per mile of roadway using the following formula:

$$\text{Rating} = 9 - 2\,(N/L)$$

where,

N = number of hazards encountered,
L = length of road segment in miles, and
2 = perceived weighted severity index of the effect of the hazards on driving safety (maximum score is 9 and minimum is 0 with negatives recorded as 0).

Other items rated under the safety category are (a) stopping sight distance, (b) passing sight distance, (c) traffic control, and (d) horizontal alignment. These items were rated on the basis of existing established standards and engineering judgments. The item with a maximum point value as given in Table 2 is an indication of no defect, whereas a defective item is assigned a point value of 0.

Roadway Segment Conditions

The second rating category is "roadway segment conditions," which includes base, wearing surface, and drainage (Table 2). The identified roadway segment base was rated as follows:

Excellent	8 to 9	No evidence of base failure
Good	6 to 7	Minor base failures, which are correctable by spot repairs
Fair	5	Frequent base failure, which causes reduction in traffic speeds and should be considered for reconstruction
Poor	1 to 4	Severe base failure, which makes reconstruction necessary

In the evaluation of the city's roadway surface condition and drainage problems, the Laser Road Surface Tester (LRST) is used. The LRST uses a combination of 11 laser cameras in conjunction with on-board computers to record various elements of a surface condition. The 11 lasers are mounted on the front of a van capable of collecting roadway surface data (e.g., rut depth, crack, distance, speed, and so on) with an accuracy of ±0.1 of measuring range. The LRST data are analyzed, evaluated, and then incorporated into "roadway segment conditions" for improvement priority consideration.

The city of Gainesville hired the owner of the LRST, a consultant named Infrastructure Management Services (IMS) from Arlington Heights, Illinois. The consultant used LRST with a four-man crew including one from Gainesville for a period of 3 months at a cost of $137 per lane-mile. It took the city about 3 months to collect and incorporate the data into the city's roadway network improvement priority program.

Service

A third general type of scale is represented under the "service" category. For instance, capacity of a segment was based on the criteria established in the 1965 *Highway Capacity Manual* (*10*) having six levels of service from A to F. Furthermore, where the segment included signalized intersections, the improvement was weighed on the basis of 1985 HCM (*11*) criteria (Table 3).

Under the service category related to pavement width, the following design guide was used:

Excellent	9	Width of pavement that meets or exceeds the width specified in the appropriate design standards
Good	6 to 7	Width of pavement that is within 2 ft less than the design standard
Fair	5	A "tolerable" width of pavement, which is 2 to 4 ft less than the design standard
Poor	1 to 4	A not tolerable width of pavement, which falls short of design standard by 4 ft or more

Table 4 presents an example of a summary of each roadway sufficiency rating, segment length, and improving cost and a final priority rank. A candidate with a minimum point value is selected first for improvement. For instance, in Table 4, the first candidate for improvement is roadway segment C. The maximum total roadway sufficiency rating for this segment is 61 points. The total points are calculated on the basis of information given in Table 2. A similar table is prepared for roadway Segment C and a maximum point value is cal-

TABLE 3 LEVEL OF SERVICE IN RELATION TO STOPPED DELAY PER VEHICLE AT SIGNALIZED INTERSECTION (*11*)

Level of Service (HCM 85)	Stopped Delay per Vehicle (s)
A	< 5.0 (sec.)
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	< 60.0

TABLE 4 AN EXAMPLE OF ROADWAY NETWORK SUFFICIENCY RATING AND ROADWAY SEGMENT'S FINAL RANK FOR IMPROVEMENT

Segment at	RNSR	Length (mile)	$/length	Final Rank*
A	89	1.3	56,622	9th
B	75	1.2	159,571	4th
C	61	1.5	77,211	1st
D	65	1.0	102,949	2nd
E	72	1.4	123,539	3rd
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Segment: Road Segment Identifier

RNSR: Roadway Network Sufficiency Rating

Length: Road Segment Length in Miles

$/Length $/mile to Remove Segment Deficiency

* The final ranking was based on the criteria set in Table 2 (Roadway Network Sufficiency Rating Criteria). A total point value was calculated for each roadway segment. A segment with a minimum point was the first candidate for improvement. The cost/length is only calculated as an indication of how much it would cost to improve a candidate segment.

culated for each of the items shown in Table 2. The subtotal of each rating category (safety, roadway segment conditions, and service) is added and a maximum of 61 points is obtained for this segment. Tables similar to Table 2 are prepared for each roadway segment and a total maximum point value is calculated.

IMPROVEMENT PRIORITIZATION AND RANKING PROCEDURE AT SIGNALIZED INTERSECTIONS

Gainesville also suffers from the lack of funds to improve the city's signalized intersections.

The city's intersections were evaluated and ranked on the basis of consideration for both severity rate and level of service (Tables 5 and 6). A simple computer software program was developed by K. Green of the city's traffic division and the following data were incorporated:

- Number of accidents per intersection;
- Number of fatalities per intersection;
- Number of injuries per intersection;
- Number of property-damage accidents per intersection;
- Property damage total in dollars per intersection; and
- Level of service based on stopped delay per vehicle.

From the raw data, two rates are calculated. These are

$$\text{accident rate} = (tot * 1{,}000{,}000)/(365 * adt)$$

$$\text{severity rate} = [(5.8 * fat) + (2 * per) + (prop)] * 1{,}000{,}000/(365 * adt)$$

where,

tot = total number of accidents for the intersection per year,
adt = average daily traffic (24-hr period),
fat = number of fatalities for the intersection per year,
per = number of personal injuries for the intersection per year, and
prop = number of property accidents for the intersection per year.

The 1985 HCM level-of-service criteria for the average

TABLE 5 AN EXAMPLE OF RANKING THE SIGNALIZED INTERSECTIONS FOR IMPROVEMENT IN GAINESVILLE, FLORIDA

ACCIDENT RATE			SEVERITY RATE			ACCIDENTS			PROPERTY DAMAGE			LEVEL OF SERVICE	
SIG*	RATE	RANK	SIG	RATE	RANK	SIG	NO.	RANK	SIG	$	RANK	SIG	POINT
412	2.908	1	415	3.857	1	121	35	1	128	58,935	1	412	2
411	2.611	2	305	3.727	2	610	33	2	415	54,600	2	415	2
415	2.282	3	411	3.481	3	127	29	3	130	46,000	3	411	4
610	2.264	4	412	3.356	4	336	25	4	106	45,450	4	610	3
306	2.130	5	610	2.676	5	117	24	5	113	43,700	5	117	3
336	1.890	6	336	2.495	6	122	23	6	336	42,220	6	121	4
127	1.825	7	508	2.413	7	628	23	6	612	37,425	7	628	4
117	1.768	8	127	2.390	8	612	21	7	619	35,580	8	508	4
122	1.726	9	117	2.210	9	415	20	8	117	35,395	9	127	2
628	1.717	10	123	2.202	10	123	20	8	628	31,950	10	723	5
121	1.651	11	122	2.177	11	619	20	8	610	30,400	11	130	4
123	1.631	12	324	2.167	12	326	19	9	123	29,170	12	319	3
324	1.589	13	628	2.090	13	130	19	9	412	27,800	13	336	3
335	1.539	14	612	2.001	14	329	18	10	121	25,195	14	324	4
508	1.508	15	625	1.942	15	113	17	11	215	24,625	15	335	5
319	1.412	16	121	1.887	16	410	16	12	335	24,100	16	113	4
410	1.409	17	224	1.847	17	108	16	12	329	22,925	17	612	3
340	1.390	18	517	1.758	18	133	15	13	325	22,955	19	619	4
507	1.366	19	106	1.716	19	213	14	14	324	21,960	19	122	5
612	1.356	20	507	1.706	20	412	13	15	327	21,775	20	106	4

* SIG (Signal) - For identification purpose each intersection is being designated with a number.

stopped delay per vehicle was also incorporated (Table 3). Each intersection is then ranked in five separate categories and given a number for its position in that category. The five ranking categories are accident rate, severity rate, total number of accidents, property damage in dollars, and level of service based on stopped delay per vehicle (Table 5).

The final ranking is based on the total points an intersection received when the five-category rankings were totaled. The lower the ranking total, the higher the candidate's chances for improvements (Table 6). For instance, in Table 5 signal number 412 has the ranking description shown in Table 7.

In Table 6, signal Number 412 is ranked fifth as a candidate for improvement. Other signalized intersections are ranked accordingly.

There are many methods that can be used objectively to improve a low-ranking intersection. Among these techniques are

- Adding exclusive turn lanes (left and right turn lanes); and
- Applying signal timing optimization software (e.g., HCM 65, Circular 212, HCM 85, Signal Optimization Analysis Package "SOAP 84," Traffic Network Study Tool 7-version "TRANSYT-7F," PASSER II-87, PASSER III-88, Highway Capacity Software (HCS) version 1.4, and so on).

Installation of the new timing plans in Gainesville produced by TRANSYT-7F enhanced the average total time improvements of an intersection by 10 percent meaning an estimated annual benefit per intersection of about $23,935. The safety results of those improved intersections will be the subject of future investigations.

SIDEWALK IMPROVEMENT PRIORITIZATION AND RANKING PROCEDURE

Gainesville has a large number of existing streets that have either inadequate or nonexistent sidewalk facilities. The cost to construct sidewalks on all of these streets far exceeds the city's current funding capability. A new sidewalk installation work plan, including budget priority and ranking procedure, is established on the basis of (a) pedestrian service demand factor, and (b) pedestrian environmental demand factors.

Pedestrian Service Demand

Because the pedestrian service demand information is qualitative, determination of a numeric value for pedestrian service demand for a given street section is based on weighted

TABLE 6 AN EXAMPLE OF THE FINAL RANKING OF THE SIGNALIZED INTERSECTIONS FOR IMPROVEMENTS

FINAL RANK	SIG. NO.	DESCRIPTION	RANK TOTAL*
1	415	NE 39 Ave/Waldo Rd	16
2	127	W Univ Ave/NW 34 St	21
3	610	SW 2 Ave SW 13 St	25
3	336	Mall Ent/NW 13 St	25
4	117	W Univ Ave/NW 6 St	34
5	412	NE 23 Ave/NE 15 St	35
6	628	SW 16 Ave/SW 13 St	43
7	121	W Univ Ave/NW 13 St	46
7	123	W Univ Ave/NW 18 St	47
8	612	SW 2 Ave/SW 34 St	51
9	324	NW 16 Ave/NW 2 St	65
10	335	NW 23 Ave/NW 16 Terr	70
11	113	Univ Ave/Main St	70
12	619	SW 8 Ave/SW 13 St	71
12	122	W Univ Ave/NW 17 St	72
13	130	Newberry Rd/NW 8 Ave	72
13	411	NE 12 Ave/NE 9 St	72
14	319	NW 8 Ave/NW 43 St	78
15	106	E Univ Ave/SE 15 St	85
16	340	NW 39 Ave/NW 34 St	82
17	329	NW 16 Ave/NW 34 St	89
18	625	Archer Rd/Center Dr	91
19	410	NE 16 Ave/Waldo Rd	99
20	208	SE 4 Ave/S Main St	100

* The lowest total number ranking candidate is selected first for improvement.

TABLE 7 RANKING DESCRIPTION OF SIGNAL NUMBER 412

Signal Number 412	Variable	Rank
Accident rate	2.908	1
Severity rate	3.356	4
Number of accidents	13	13
Dollar value of property damage	$27,800	15
Level of service	—	2
	Subtotal	35[a]

[a]See Table 6.

TABLE 8 WEIGHTED FACTORS FOR PEDESTRIAN SERVICE DEMAND VARIABLES

Variable	Weight Factor
Regional transit service route (RTS)	3
School bus route (SCH BUS RT)	5
School bus stop (SCH BUS ST)	4
Shopping centers (SHP CR)	2
Recreational and park areas (REC & PRK)	5
Public buildings (PUB BLDG)	2
Connection to major arterial system (CAS)	4

factors. The weighted factors used by the city engineering department for each applicable pedestrian service demand variable are given in Table 8.

The determination of the weight factor assigned to each variable is based on the anticipated number of pedestrian traffic. For example, the weight factor for Variable 5, recreational and park areas, is higher than Variable 1, RTS route, because of the higher anticipated pedestrian traffic associated with the recreational and park areas as compared to an RTS route and because the percentage of children in the pedestrian traffic is expected to be higher for recreation and park areas than RTS routes.

The numeric value for pedestrian service demand is the summation of the applicable weighted factors for the given street section. If a street section is close to a park (weight factor is 5), close to a shopping area (weight factor is 2), and connected to a major arterial (weight factor is 4), then the pedestrian service demand value is 11, which results from the summation of these three weight factors.

Pedestrian Environmental Demand

Unlike the pedestrian service demand value, the derivation of the pedestrian environmental demand value involves the quantitative interaction of the two variables.

The value for a given street section is computed by initially checking the existence of sidewalks. This information is evaluated over the entire length of the street section.

Next, the average daily traffic (ADT) volume information is factored into the calculations to yield a final environmental value. The threshold limit for sidewalk consideration is an ADT of 1,000 or greater. ADT of 1,000 is defined by the city ordinance as the ADT value that separates a residential street classification and a minor collector street classification. A given street section must have an ADT of at least 1,000 in order to obtain an environmental value.

Total Sidewalk Demand

The total sidewalk demand for a given street section is a summation of the pedestrian service demand value and the pedestrian environmental demand value.

As stated earlier, a significant portion of the sidewalk needs assessment data base was derived from the roadway pavement management data base. The roadway pavement management program divided the city into six study areas. The sidewalk needs assessment study is likewise divided into six areas.

TABLE 10 WEIGHTED FACTORS FOR TOTAL SIDEWALK DEMAND

Variable	Weight Factor
School bus route (SCH BUS RT)	5
Regional transit service route (RTS)	3
School bus stop (SCH BUS ST)	4
Shopping centers (SHP CR)	2
Recreational and park areas (REC & PRK)	–[a]
Public buildings (PUB BLDG)	2
Connection to major arterial system (CAS)	4
(See Table 9, Row 1, Column 12) Subtotal	20

[a]Factor not present.

The result of the analyses is a priority listing of the street sections to be considered for new sidewalks (Table 9). For instance, in Table 9 the pedestrian service demand need total of 20 (Row 1, Column 12) is calculated as follows: The streets from West University Avenue to Northwest 7th Avenue have the characteristics given in Table 10 (starting from Column 5, Table 9, the value of 1 signifies the presence of the respective factor, and the value of 0 indicates that the factor is not present).

The pedestrian environmental demand total is calculated by giving quantitative values to the existence of sidewalks over the entire length of the street section. The ADT is another consideration over each particular roadway segment. As a result of consideration of these two factors over the entire section of this roadway segment, a total of 71 points are calculated for pedestrian environmental demand value. A total of 91 points (Row 1, Column 15, Table 9) results from adding both pedestrian service demand and environmental demand values. The remaining items in Table 9 are calculated accordingly.

TABLE 9 AN EXAMPLE OF TARGET STREETS FOR NEW SIDEWALK CONSTRUCTION

STREETS FROM	STREETS TO	WDTH (FT)	DIST (FT)	SCH BUS RT	RTS BUS RT	SCH BUS ST	SHP CR	REC & PRK	PUB BLDG	CAS	NEED TTL	NEED RANK	ADT	TTL	RANK
W Univ Ave	NW 7 Ave	31	1,946	1	1	1	1	0	1	1	20	60	11,000	91†	1
W Univ Ave	NW 8 Ave	28	2,683	1	1	1	1	0	1	1	20	61	11,000	78	2
SE 15 St	SE 17 St	22	925	1	1	1	0	0	0	1	16	265	6,600	72	3
S Main St	SW 11 St	20	3,468	0	1	1	0	1	0	1	18	108	5,666	65	4
SE 12 St	SE 15 St	18	1,456	1	1	1	0	0	0	1	16	266	5,600	62	5
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

NOTES: * The value of "1" in columns 5 to 11 signifies the presence of the respective factor and the value of "0" in columns 5 to 11 signifies the factor is not present.

† The higher the total (column 15), the better the chances are for improvement

SCH BUS RT - School Bus Route
RTS BUS RT - Regional Transit Bus Route
SCH BUS ST - School Bus Stop
SHP CR - Shopping Centers
REC & PRK - Recreational & Park
PUB BLDG - Public Building
CAS - Connection to Major Arterial System
ADT - Average Daily Traffic

Evaluation of the results of the analyses indicated that the priority listing for sidewalks, both in a given study section and on a citywide basis, fairly accurately reflect the relative needs of the community.

CONCLUSIONS AND RECOMMENDATIONS

In determining the improvement deficiency of the city's roadway network system, the following general steps were developed:

1. Based on AASHTO and HCM standards and the engineering judgments of the city staff, certain criteria were identified to evaluate the overall improvement conditions (e.g., Table 2).
2. Based on the criteria in Step 1, the city's roadway network system was divided into homogeneous segments. If a level of service or a segment pavement's condition changed significantly, it was broken down into two or more homogeneous segments.
3. A total point value was calculated for each segment in order to examine and rank a segment's candidacy for improvement.
4. Dollar per segment was calculated to remove the segment's deficiency.
5. A careful check was made for locating errors in judging a segment's weight and ranking. An estimate of the top-ranked projects was made, to be undertaken given the available budget.
6. A significant usage of the rankings was established as the starting point for developing a road repair work plan for the next planning period.

Often a decision maker looks for a simple and numerical method to rank several projects to see how many can fit into a limited budget for improvement during a specified planning horizon.

Roadway improvement priority consideration is relevant to the end results of a comprehensive study and analysis of a project's components for establishing order of needs for final selection of each project for improvement. The heuristic presentation of a project's need should help agencies to allocate the available limited funds to those projects identified on a priority basis, particularly when requests for additional funds are made to the state or the federal government. Such an approach should also be helpful in convincing the funding agencies to provide the necessary funding.

It is proper for agencies (city, county, district, state, and federal) to allocate limited funds to projects on the basis of project priority. The priority model developed for Gainesville, Florida, is a starting point for developing roadway repair work plans, sidewalk improvement, traffic improvement, safety and signal improvements, new construction, restoration, and rehabilitation. The benefit derived from this ranking procedure enables the city to identify those critical projects that need improvements. It is a simple and practical approach to rank a project on a priority basis. The developed step-by-step overview should work well if the criteria are identified with accurate data. The quality of subjective assignment of values could also be enhanced by the accuracy of data and consideration of the judgment of experienced city staff. In addition, the quality of the evaluation matrix can be further enhanced by incorporating community goals, preference, impact criteria, and so on. Additional research is needed to establish more systematic scoring criteria with input from community groups and local, state, and federal governments. Similar investigation in other states should provide researchers with information on allocation schemes as a basis for comparing and improving existing methods.

REFERENCES

1. K. Moscowitz. Numerical Ratings for Highway Sections as a Basis for Construction Programs. *Bulletin 17*, HRB, National Research Council, Washington, D.C., 1948, pp. 28–39.
2. W. E. Willey. Arizona's Experience with Sufficiency Ratings. *Bulletin 53*, HRB, National Research Council, Washington, D.C., 1952, pp. 3–7.
3. C. V. Zegeer and R. L. Rizenbergs. Priority Programming for Highway Reconstruction. In *Transportation Research Record 698*, TRB, National Research Council, Washington, D.C., 1979, pp. 15–23.
4. D. R. Uzarski and M. I. Darter. Comparing Different Strategies from Selecting Pavement Sections for Major Repair. In *Transportation Research Record 1060*, TRB, National Research Council, Washington, D.C., 1986, pp. 61–69.
5. D. Bower. Statewide Systems Level Allocation of Highway Resources: Case Study of Colorado. Presented at 67th Annual Meeting of Transportation Research Board, Washington, D.C., 1988.
6. *Demand-Responsive Approach to Highway Maintenance and Rehabilitation, Volume 2: Optimal Investment Policies for Maintenance and Rehabilitation of Highway Pavements.* Report DOT/OST/P-34/87/054. University Research Program, U.S. Department of Transportation, June 1985.
7. T. F. Humphrey. Evaluation Criteria and Priority Setting for State Highway Programs. *NCHRP Synthesis of Highway Practice 84*: TRB, National Research Council, Washington, D.C., Nov. 1981, 32 pp.
8. J. A. Swanson. General Comments on Sufficiency Rating Procedures. *Bulletin 53*, HRB, National Research Council, Washington, D.C., 1952, pp. 7–11.
9. C. Mercier and J. Stoner. Sufficiency Ratings for Secondary Roads: An Aid for Allocation of Funds? Presented at 67th Annual Meeting of the Transportation Research Board, Washington, D.C., 1988.
10. *Special Report 87: Highway Capacity Manual—1965.* HRB, National Research Council, Washington, D.C., 1965, p. 397.
11. *Special Report 209: Highway Capacity Manual.* TRB, National Research Council, Washington, D.C., 1985.

Publication of this paper sponsored by Committee on Transportation, Planning, and Systems Evaluation.