Quantitative Criterion for the Evaluation of the Functional Classification of Public Roads

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ABSTRACT

The Florida Department of Transportation is required by law to periodically evaluate the functional classification of public roads. The evaluations are to utilize formally adopted quantitative criteria. A quantification criterion, called the System Attribute Score (SAS), has been developed by the department. The procedure provides score values that indicate the probable functional classification of public roads. Its output is the product of two concurrent assessments. The first measures the satisfaction of threshold levels of certain road attributes such as traffic count, number of trucks, and length of road. The second evaluates the elemental role of a road in a transportation network that connects service end points (e.g., two urbanized areas, rural communities, and collector roads). Separate processes are included in the procedure to address the geosocial transportation differences among rural, urban, and urbanized areas. The SAS procedure provides the department with a quantitative criterion to utilize in the functional classification of public roads. However, functional classification will also consider other factors, including input from public hearings, as required by Florida statutes.

In 1977 the Florida legislature enacted a law that provided for the establishment of the functional classification of public roads in Florida. The law defined the various road classifications, established public road systems based on those classifications, and provided a mechanism for a continuing evaluation of each classified road and road system assignment.

The law also required that functional evaluations performed after 1982 utilize quantitative criteria. The Florida Department of Transportation (FDOT) has developed the required criterion, which is detailed in this paper.

CLASSIFICATION THEORY

The quantitative criterion developed by the department is to be known as the System Attribute Score (SAS). It is based on two system classification theories that augment and complement each other to produce a classification procedure of the highest accuracy. The first classification theory is based on the concept that a road, by itself, has certain inherent attributes that define its functional service. The attributes are physical and operational characteristics that naturally stratify into ranges correlating with functional classification. In its application, an analytical methodology known as Minimum Attribute Presence is used to evaluate (score) each road. The resulting score of qualifying attributes of the evaluated road is then entered into the SAS quantitative formula for functional classification.

The second theory used in SAS is based on the concept that the whole road network is made up of system elements (routes) that interconnect and link together the end points of transportation service. System elements are each defined in terms of their operation within a hierarchical order of service connections. The hierarchy forms a natural stratification that correlates well with functional classification. Consequently, an individual road can be inspected for its typical principal service and matched with its corresponding system element. Each evaluated road is assigned the coefficient value of its system element, which is then entered into the SAS quantitative formula for functional classification.

Quantitatively stated, SAS is expressed by the following mathematical notation:

$$SAS_f = s(\sum A) \qquad (1)$$

where

SAS_f = SAS by functional model (rural arterial, rural collector, urban principal arterial, urban minor arterial, and urban collector),
s = system element coefficient, and
A = qualifying attribute.

In the process of criterion development, it became apparent that no single quantitative criterion could be efficiently designed to evaluate the diversity of public roads in Florida. A criterion calibrated to qualify high-traffic-volume urbanized area arterials would disqualify many rural arterials. Conversely, a criterion calibrated to qualify even moderate-traffic-volume rural arterials would erroneously qualify many urbanized area collectors as arterials. Accordingly, it was determined that Florida's road systems would best be evaluated by differentiating between three system groups: rural roads, roads in small urban areas (5,000 to 50,000 population), and roads in urbanized areas (population in excess of 50,000).

Three criteria sets were developed to model the three system groups. The rural criteria set and the urban area criteria set follow the SAS as introduced in the foregoing discussion. The urbanized area criteria set was developed from the same conceptual base; however, it was designed to draw its data from

the Urban Transportation Planning System (UTPS) models, which were approved and adopted by FHWA, FDOT, and the officials of the respective urbanized areas.

The UTPS models are analytical tools with a massive data base used to predict travel demand in urbanized areas. The models are individually tailored for each urbanized area. In Florida, 15 models (one for each 1970 census urbanized area) are operational. Microcomputer models for the six additional Florida (1980 census) urbanized areas are now under development. Pending the adoption of these six new models, an interim new urbanized area functional model has been developed. Analysis of the UTPS models indicates that they have an inherent relationship to SAS theory. In an oversimplification of the model process, tables of traffic-related data (minimum attributes) are mathematically processed by computer in a program that measures productions and attractions of trips between transportation service end points (system elements). As a consequence, the mathematical notation for the urbanized area SAS is a variation of the general formula and is expressed as follows:

$$SAS_{uf} = \sum A_u \quad (2)$$

where SAS_{uf} is the SAS by urbanized area functional model (urban principal arterial, urban minor arterial, and urban collector) and A_u is the UTPS attribute output.

TABLE 1 Minimum Attribute Levels for Rural Functional Models

Rural Arterial		Rural Collector	
Attribute	Minimum Qualifying Presence	Attribute	Minimum Qualifying Presence
Traffic factor	3,000	Traffic factor	400
Extent of road	20	Extent of road	2
Trucks	200	Trucks	50
Network factor	15,000	Network factor	1,000
Access factor	150	Access factor	25
Mobility	3	Interchange	4

Note: Rural attribute definitions are as follows: traffic factor = product of ADT and county normalizing coefficient T_{pd}, where $T_{pd} = 5/[\log_{10}$ (county population density x 100)]; extent of road = physical length of the road in miles (not necessarily the same as that of the segment being evaluated); trucks = actual count of trucks in a 24-hr period during the week, or value obtained by utilizing U.S. Department of Transportation estimated truck percentage x ADT; network factor = product of ADT and distance between arterial connections; access factor = ADT divided by number of access points per mile, where access points are road intersections, driveways, etc.; mobility = total number of counties in which the road is located; interchange = number of intersecting or interchanging arterials and collectors along the segment, including beginning and ending termini.

RURAL AND SMALL URBAN AREA CRITERIA SETS

Tables 1 and 2 detail the minimum attribute levels applied in the evaluation of rural and small urban area road segments. Rural segments are awarded a score of 1 for each attribute exhibited in excess of the minimum qualifying presence level. Attributes exhibited below the minimum level are scored zero. Urban segments are scored in the same manner with the exception of average daily traffic (ADT), which is awarded a score of 2 for qualifying presence. System elements and coefficients are detailed in Tables 3 and 4.

The product of the sum of the attribute scores and the system element coefficient is graded in Table 5, which indicates the probable functional classification of the rural or urban road segment being evaluated.

In evaluating rural and urban road segments with SAS, a designated evaluation sequence is mandatory:

1. Rural road segments must be evaluated first, because their extensions into urban areas will influence the urban classifications.
2. All segments must be evaluated in descending order of classification tests, starting with the highest level (rural arterial or urban principal arterial).
3. Evaluations terminate with the first "passing" SAS.
4. If a segment fails the highest-level test, it is then evaluated with the next-lower-level test or tests (rural collector or urban minor arterial and urban collector).
5. If a segment fails a rural collector or urban collector test, it is automatically determined to be a local road.
6. Under no circumstances can an SAS value from a test at a collector level be used to qualify a segment as an arterial.

URBANIZED AREA CRITERIA SET

As noted earlier in the section on classification theory, the urbanized area functional model combines the tandem attribute-element process of the rural and urban models into a single urbanized area system attribute set. By using the data and the UTPS model of the respective urbanized area, a set of five attributes is produced for each link (segment) in the modeled network. The attributes and their definitions are as follows:

1. Volume-trip length (VTL): product of a trip and its total trip length (from origin to destination) summed for total trips on the link over 24-hr period,

TABLE 2 Minimum Attribute Levels for Small Urban Area Functional Models

Urban Principal Arterial		Urban Minor Arterial		Urban Collector	
Attribute	Minimum Qualifying Presence	Attribute	Minimum Qualifying Presence	Attribute	Minimum Qualifying Presence
ADT	10,000	ADT	4,000	ADT	1,000
Speed	45	Speed	35	Speed	35
Traffic signals	4	Traffic signals	3	Traffic signals	1
Street length	5.0	Street length	3.5	Street length	1.5
Lanes	3	Lanes	3	Interchange	10

Note: Urban attribute definitions are as follows: ADT = average daily traffic in vehicles per day; speed = lowest posted speed (ignoring school zones) in miles per hour; traffic signals = number of signalized intersections, including termini; street length = physical length of the continuous segment in miles; lanes = total number of through roadway lanes excluding ramps, speed-change lanes, parking lanes, turn lanes, etc.; interchange = number of intersecting streets along the continuous urban street, including beginning and ending termini.

2. Free flow speed: average speed that vehicles travel on the link when there is no congestion,

3. Daily load: number of vehicles that use the link on an average weekday 24-hr period during peak season,

4. Capacity: theoretical maximum number of vehicles that may pass over the link during a 24-hr period, and

5. Number of lanes (code): 1 = five or more lanes; 2 = four lanes; 3 = two or three lanes; 4 = one lane.

Operation of this functional evaluation process is substantially computer-internal. The UTPS model program accesses the data base, computes attribute values, sums the values, and stratifies the streets in classification order. This process does not allow the "hands-on" scoring of individual roads that is permitted in the other models. The following short description of the UTPS model is provided for those who have not yet been exposed to it.

The model is driven by two data files: the Traffic Analysis Zone (TAZ) data base and the network data base. The TAZ data base contains demographic, socioeconomic, and land use data for each of the hundreds of zones included in the urbanized area. This yields a set of vehicle trips between all TAZs. The set is filed in matrix form and is known as a trip table.

The network data base is a file of street-related information including street width, length, number of lanes, operating speed, and so on. This yields a file of network characteristics for individual street segments. A mathematical manipulation of the network and trip table files then produces a computed traffic volume for every street on the urban network. At that point the computed traffic volumes are measured against actual traffic counts. Adjustments are made until the traffic is balanced. The UTPS model is then said to be calibrated.

The calibrated UTPS model data will then provide all of the attributes listed previously for every segment in the urbanized area street network. Other routines are programmed to score the attribute values for each segment, sum the segment scores, and assign the segment its probable functional classification. A computer graphics program is then applied to automatically plot the street network with color-coded ink to differentiate the assigned classifications.

TABLE 3 Rural System Elements, Definitions, Typical Functions, and Coefficients

System Element	Definition	Typical Function	Coefficient
Urbanized-to-urbanized with arterial termini	Most direct route(s) beginning at one urbanized area boundary and ending at another urbanized area boundary; route may involve a number of different roads and may pass through a number of urban areas and communities; if the distance between urbanized areas is 75 mi or less, one or two additional routes of this system element category may be designated	Principal arterial	15
Bypass with principal arterial termini	Road that serves as a bypass or circumferential route around an urbanized area, urban area, or community; must have principal arterial termini	Principal arterial	15
Alternative urbanized-to-urbanized with arterial termini	A second-most-direct route beginning at one urbanized area boundary and ending at another urbanized area boundary over 75 mi away; route may involve a number of different roads and may pass through a number of small urban areas and communities	Minor arterial	10
Bypass with arterial termini	Bypass or circumferential route around an urbanized community	Minor arterial	10
Urbanized-to-urban with arterial termini	Most direct route(s) beginning at an urbanized area boundary and ending at a small urban area boundary; route may involve no more than two different roads and may pass through a number of communities with <5,000 population; if urbanized area is oblong in shape, two or three such routes serving its greatest dimension may be designated	Minor arterial	10
Urban-to-urban with arterial termini	Most direct route beginning at one urban area boundary and ending at another urban area boundary; route may involve no more than two different roads and may pass through a number of communities with <5,000 population	Minor arterial	10
Urbanized/urban-to-multiple communities with arterial termini	Most direct route connecting one urbanized or urban area with two or more communities; communities must have a combined population of at least 5,000; route may involve no more than two different roads and each road must connect at least two communities	Minor arterial	10
Connection from rural Interstate/rural principal arterial to large municipality within urbanized area with arterial termini	Road that extends from an interchange/intersection with an Interstate/principal arterial and runs parallel to and outside the boundary of an oblong urbanized area to a municipality with a population of 25,000 or greater within that urbanized area; rural portion of the road may not exceed 5 mi in length; urban extension of the road must cross the municipality's boundary and have an arterial terminus within the urbanized area	Minor arterial	10
County seat to arterial/Interstate/county seat/urban area, county population <25,000	Road that extends from a county seat and fulfills at least one of the following conditions: (a) is over 40 mi long and connects to an arterial, (b) connects with an Interstate highway, or (c) connects to adjacent county seat or urban area in the same or adjacent county; applies only to county seats in counties where population is <25,000	Minor arterial	10
Community-to-community or to urbanized/urban area	Most direct route connecting one community with another community or with an urbanized or urban area; route may involve no more than two different roads	Major collector	5
Arterial-to-arterial, serves only one urbanized or urban area or community	Route beginning at one arterial intersection and ending at another arterial; serves only one urbanized or urban area or community at one route end; route is confined to one road	Major collector	5
Arterial-to-arterial, no communities or urban areas connected	Route beginning at one arterial intersection and ending at another arterial but not serving any urbanized or urban area or community; route is confined to one road	Major collector	5
Rural-to-urbanized or urban area or community, no arterial termini	Route beginning in rural area at one end and serving one urbanized area or community at another end; route is confined to one road and does not connect two arterial highways	Minor collector	2
Collector-to-collector or arterial, no urban areas or communities served	Route beginning at one collector intersection and ending at another collector or arterial intersection; route is confined to one road and does not serve urbanized or urban area or community	Minor collector	2
Same arterial at both ends, no bypass, no arterials or collectors served	Road that begins and ends by intersecting with the same arterial; road must not serve as a bypass around urbanized or urban area or community or intersect with other collectors or arterials	Minor collector	2
No special traffic generators	Road that does not provide service between arterials and collectors or collectors and collectors; road must not provide service to any urbanized or urban area or community	Local	1
Within community	Road that remains entirely within the boundary of community with 1,000-4,999 population	Local	1

TABLE 4 Small Urban Area System Elements and Coefficients

System Element	Coefficient
Arterial to arterial	15
Arterial to collector	10
Arterial to local	5
Collector to collector	5
Collector to local	2
Local to local	1
Arterial to dead end	1
Collector to dead end	1
Local to dead end	1

Note: These system elements and coefficients are also to be used on an interim basis for new urbanized areas.

TABLE 5 Classification Evaluation of Rural and Small Urban Area Roads

SAS Value	Probable Functional Classification
Rural arterial test	
75 or greater	Rural principal arterial
30-60	Rural minor arterial
Below 30	Fails rural arterial test (evaluate with rural collector test)
Rural collector test	
15 or greater	Rural major collector
4-12	Rural minor collector
Below 4	Fails rural collector test (automatically determined to be rural local road)
Urban principal arterial test	
60 or greater	Urban principal arterial
Below 60	Fails urban principal arterial test (evaluate with urban minor arterial test)
Urban minor arterial test	
30 or greater	Urban minor arterial
Below 30	Fails urban minor arterial test (evaluate with urban collector test)
Urban collector test	
15 or greater	Urban collector
Below 15	Fails urban collector test (automatically determined to be urban local road)

Note: This table is also to be used on an interim basis for new urbanized areas.

Inspection of the plotted network permits the identification of classification anomalies, such as the intrusion of a short segment of one classification in the midst of an otherwise continuous route of another classification. An analysis of the anomalies is made and, if warranted, their classifications may be changed. The resulting smoothed network yields the recommended functional classification of the urbanized area streets.

The attribute scoring routine requires an additional note. The range in Florida of urbanized area public road mileage (500 mi in Gainesville to 5,000 mi in Miami) precludes the use of a single set of functional classification cutoff scores for minimum attribute qualification. Consequently, a relative scoring routine was developed by using a family of regression analysis formulas that quantitatively determines functional classification gross lane mileages for each urbanized area. The analysis is based on two variables (population and square miles inside the urbanized boundary) and produces quantitative determinations of exceptional strength for urban principal arterials, combined principal and minor arterials, and combined arterials and collectors (R = .93, .96, and .99, respectively). The determined lane miles, by functional classification, are then used to set the attribute score cutoffs.

An assignment of probable functional classification for each urbanized area road segment is made by the following procedure. A quantitative model, which regresses urbanized population and urbanized area square miles as independent variables, is used to determine lane miles per functional classification. Segments are listed in descending VTL attribute value order with cumulative lane miles indicated. All segment miles falling within the determined principal arterial lane miles are awarded a score of 1. Subsequent segment miles falling within the determined minor arterial lane miles are awarded a score of 2. The segment miles for collectors are awarded a score of 3, and the remaining local miles are awarded a score of 4.

The scoring procedure is continued for each of the other four attributes. The five attribute scores for each segment are then summed and listed in ascending score order (theoretical range, 5 to 20) with cumulative lane miles indicated. By using the quantitatively determined lane miles per functional classification again, the probable functional classification for each segment is prescribed. With the aid of graphical rectification, the recommended classifications are then assigned.

SPECIAL INTERIM CRITERIA SET FOR NEW URBANIZED AREAS

In the 1980 census six additional Florida population centers qualified as urbanized areas. These new areas (Ft. Pierce, Ft. Walton Beach, Naples, Ocala, Panama City, and West Pasco) will ultimately utilize microcomputer analytical models similar to the UTPS functional models of the other 15 Florida urbanized areas. Development of these models for each of the new areas is under way. Pending completion and adoption of the models, a procedure similar to that for the small urban areas is to be used. Special interim minimum attribute levels are detailed in Table 6. Evaluated segments are awarded a score of 1 for each attribute exhibited in excess of the minimum qualifying presence level. Attributes exhibited below the minimum level are scored zero. System elements and coefficients utilized for new urbanized areas are the same as those for small urban areas and are detailed in Table 4. Quantitative functional evaluation is determined from Table 5.

TABLE 6 Special Interim Minimum Attribute Levels for New Urbanized Area Functional Models

Urban Principal Arterial		Urban Minor Arterial		Urban Collector	
Attribute	Minimum Qualifying Presence	Attribute	Minimum Qualifying Presence	Attribute	Minimum Qualifying Presence
ADT	20,000	ADT	14,000	ADT	4,000
Speed	45	Speed	45	Speed	35
Traffic signals	4	Traffic signals	3	Traffic signals	2
Street length	5.0	Street length	3.5	Street length	1.5
Lanes	3	Lanes	3	Interchange	10

Note: For attribute definitions, see Table 2.

CLASSIFICATION DETERMINATIONS

The quantitative values produced by SAS evaluate the functional classification of public roads with apparent high accuracy. When calibrated against the current official qualitatively determined classification, the SAS rural model replicates rural functional classifications at a better than 90 percent match. The apparent accuracies of the SAS urban and urbanized models are also very fine, although slightly lower. However, the issue of accuracy is not easily addressed.

If a quantitative evaluation model fails to perfectly simulate a qualitative evaluation, any apparent inaccuracies may be due to an error in either of the evaluations. That is, the original qualitative classification may have been incorrect or the quantitative model may have been incorrectly designed and be insensitive to the true classification. The likelihood of absolute perfection in either type of evaluation is improbable. Thus Florida law mitigates against errors of evaluation by requiring a forum for resolution. The paragraph of Florida law that requires that classification evaluations by the department "shall utilize quantitative criteria" also requires that "the Department shall hold a full public hearing . . . as an integral part of its evaluation procedures in order to receive public input prior to making any determination of classification."

Taking into account both statutory evaluation requirements, the department intends to utilize the SAS quantitative criteria as its principal functional classification tool. It will, however, preserve the responsibility to consider other significant data as is necessary to assure that correct classification determinations are made.

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The Development of Transportation Cost Functions for Three Intercity Corridors of Costa Rica

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ABSTRACT

The findings of a cooperative University of California-University of Costa Rica study of the cost characteristics of transportation technology alternatives in three principal corridors of Costa Rica are summarized. The cost functions developed quantify the total fixed and variable costs of moving freight in each corridor as well as the corresponding energy consumption and the cost breakdown between domestic and foreign expenditures. Conclusions are drawn regarding the implications of these findings for the future development of intercity transportation in Costa Rica.

Selected results are presented of a study on alternative transportation technologies applied to interregional transportation needs in Costa Rica (1). The economic and physical consequences of several alternative rail and highway systems, including several systems currently in place, were estimated in order to provide a quantitative basis for future transportation investment decisions. The analysis was based on the particular transportation requirements and resource constraints of concern to Costa Rica.

The results of the study are cost and resource use relationships that can be used to compare different transportation improvements in light of the quantities of goods to be transported now or in the future. It is expected that the quantitative relationships from this study will be used with alternative planning scenarios concerning the future economic structure of Costa Rica in order to help define a comprehensive long-term program for orderly national development.

In order to concentrate on a limited number of issues of practical significance to Costa Rica, attention focused on the costs and physical consequences of alternative transportation technologies in three important transportation corridors of Costa Rica (Figure 1):

1. San José-Puerto Limón (from the national capital to the major Atlantic coast port); this mountainous corridor is now served by both rail and highway;
2. San José-Puerto Caldera (from the capital to the major Pacific coast port); this mountainous corridor is also now served by both rail and highway; and
3. Puerto Caldera-Liberia (parallel to the Pa-