Use of Highway Performance Monitoring System in Reclassifying Rural Highways in Support of National Highway System in Kansas

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Kansas ranks fourth nationally in total miles of streets and highways. Maintaining such a large system is a burden to all levels of government. There are similarities between Kansas and surrounding states, particularly Iowa and Nebraska. This suggests that the conventional functional classification was done properly. It is evident that national averages do not provide appropriate guidelines for attaining a classification that produces an optimal decision making basis for states such as Kansas. The Highway Performance Monitoring System model proved to be a useful tool for demonstrating the benefits of using different criteria to classify Kansas's highways. An estimate of total needs to attain an assumed level of service was not particularly useful. However, a comparison of the higher user costs associated with the existing functional classification system—which attempts to bring all arterials, no matter how minor, up to arterial standards—to the costs associated with the State Transportation Planning classification system, proved convincing to policy makers.

An explanation is provided of the problem Kansas has had with the existing functional classification and of the measures taken to remedy the problem. Even though the mileage in each class fell within acceptable ranges, the large number of miles of rural local roads inherent to the geography of the state contributed to the large number of miles of arterials. Estimates of necessary costs to achieve arterial standards on many miles of arterials in a relatively low density area were unrealistic. Even though the traffic volumes were typically far below capacity, the minimum arterial standards dictated reconstruction and replacement rather than rehabilitation and resurfacing.

The analysis was conducted using FHWA's Highway Performance Monitoring System (HPMS) to support the reclassification by showing how vehicle operation costs were reduced from the escalated levels in the existing classification. By effectively reducing the mileage classified as arterials, more miles of roadway could be improved and better service on the overall system could be achieved with available funding. The smaller system of principal arterials became the basis for the state's recommendation for the National Highway System (NHS) for Kansas.

Reported here are analyses made during a 6-year period. During that time, there were changes in governors, legislative committees, secretaries of transportation, state transportation engineers, and directors of planning and development. Data used in the analysis also changed. The most up-to-date data available were used at each step as the effort progressed. As an example, approximately 50 mi of the Kansas Turnpike were added to the Interstate system after the 65-mph speed limit was allowed on rural Interstates.

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BACKGROUND

The extensive network of transportation facilities in Kansas today is a product of the historical development of the state. Rapid growth in population occurred as a result of the Homestead Act of 1868. Most of the tillable land was homesteaded within the next 20 years with 160-acre (quarter-section) farms. Section-line roads were built throughout the state. During the next decades, as the many farms that resulted from the Homestead Act were incorporated into larger farms, the state's extensive farm population began moving to the cities and even leaving Kansas.

Since all the roads were unsurfaced and the vehicles were horse-drawn, travel beyond the nearest town was very limited. Accessibility to distant markets was provided by rail. Consequently, an extensive rail system developed, along with numerous towns that served both as suppliers for the surrounding community and markets for the crops produced. The rail system served as arterials, and the better roads were, at best, collectors.

Population Trends in Kansas

An analysis of population characteristics and trends is basic to any type of understanding and planning of the state's transportation system. Many counties have lost much of the population since they peaked. Figure 1 shows the losses experienced and the year each county reached its maximum. Correlation between loss of population and the number of farms can be observed by comparing the year of maximum population to the year the maximum number of farms was attained. Although the number of farms has declined, the area farmed has been fairly constant, except for urbanization, resulting in much larger farms and farm equipment.

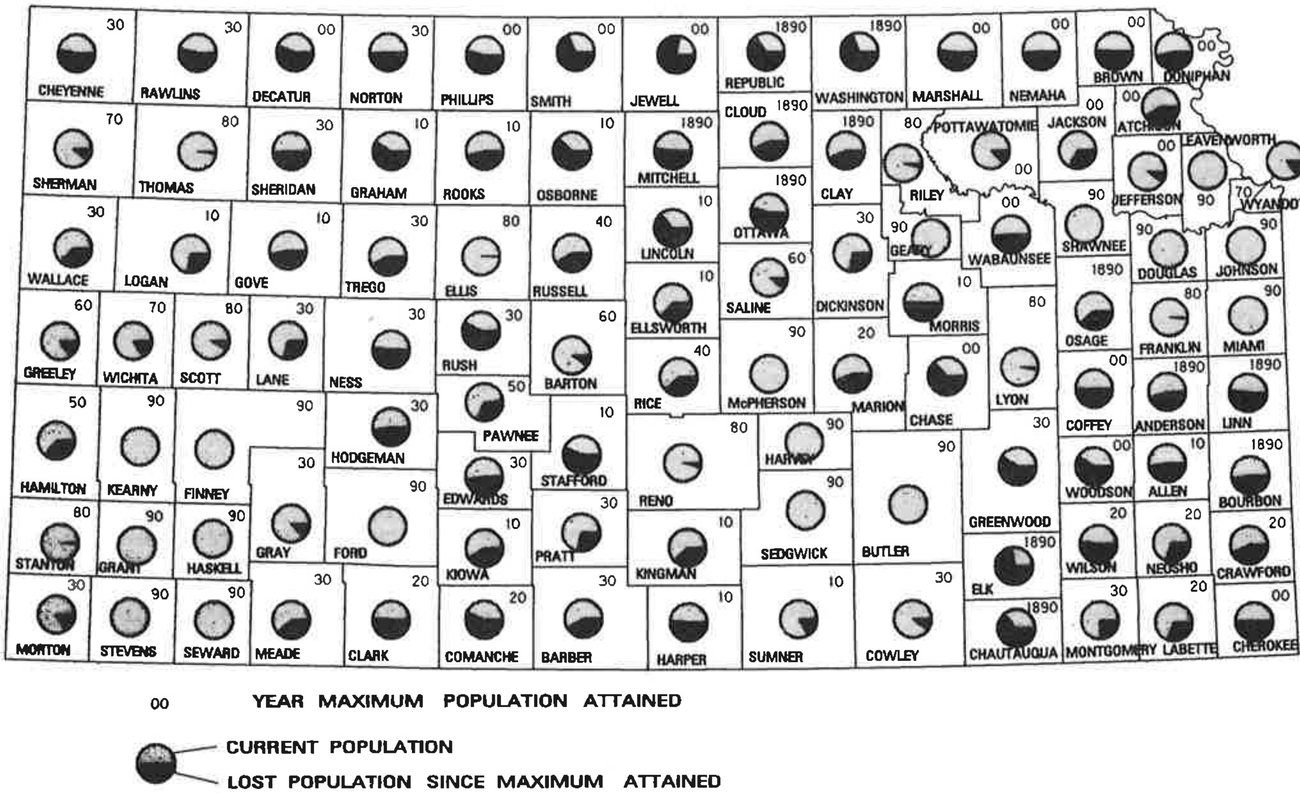

FIGURE 1 Population trends retained and lost.

Terrain

The relatively flat terrain of Kansas contributed to extensive homesteading and to a uniform grid pattern of roads. One road is about as good as any other when so many choices are available on the grid. Another phenomenon of the grid pattern is the large number of bridges. The uniform pattern crosses streams regularly at the point of intersection.

Summary of Existing Classification

Table 1 presents the percentage of miles and vehicle miles by existing federal functional class for all rural roads on the state highway system. The state highway system includes the entire principal and minor arterial system and about 7 percent of the rural major collector system. Only 22 of 9,322 mi (0.2 percent) are minor collectors. No rural local roads are included in the state highway system.

Comparison of Kansas with Surrounding States and Nation

A comparison was made with surrounding states to determine whether the classification was consistent and whether the Great Plains states shared some characteristics. It was recognized at the outset that a state highway system is a political system that varies from state to state.

One of the most important elements facing a transportation agency is that of finances. Funding must be provided to maintain and upgrade the systems for which the agency is responsible. Traditionally, funding has come from fuel tax and vehicle registration. Travel and vehicles owned are both indicators of resources that generate the revenue base that supports the operations of the agency.

The first comparison made was average daily traffic (ADT) on all rural federal-aid highway systems for Kansas and the surrounding states, including the national average. Figure 2 shows that the national average is more than 2.5 times that

TABLE 1 Functional Classification Summary, Rural Mileage and Jurisdiction

CLASS	TOTAL MILES	PER CENT	ACCUM %	ST.SYS MILES	PER CENT	ACCUM %	% OF CLS TOT
I-ST	654	0.5	0.5	654	6.5	6.5	100.0
OPA	3307	2.7	3.2	3307	32.8	39.3	100.0
MA	4505	3.6	6.8	4505	44.7	84.0	100.0
MjC	22628	18.3	25.1	1604	15.9	99.9	7.1
MnC	9329	7.5	32.7	7	0.1	100.0	0.1
Loc	83351	67.3	100.0	0	0.0	100.0	0.0
Total	123774	100.0		10077	100.0		8.1

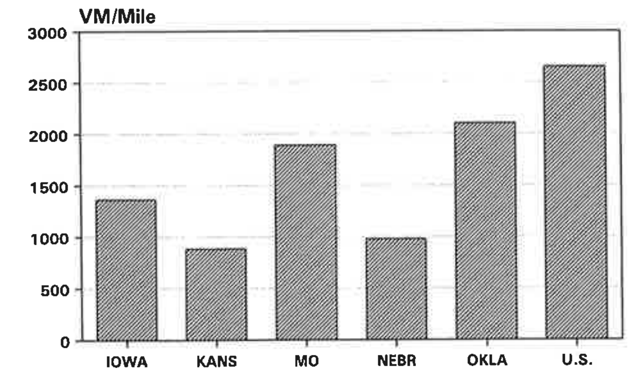

FIGURE 2 Systemwide ADT: rural only, all federal-aid systems.

of either Kansas or Nebraska. This would indicate that it would be more difficult for Kansas, both the state and county governments, to generate enough revenue from highway users to construct federal-aid highways to a national standard.

If only the primary system (not including Interstate) is considered, the conclusion is the same. Figure 3 shows the vehicle miles of travel (VMT) for the rural primary system. On this graph, Iowa falls in the same general range as Kansas and Nebraska; Missouri approaches the national average.

A similar comparison was made in Figure 4 for registered vehicles per mile of road. In Kansas, the vehicle registration

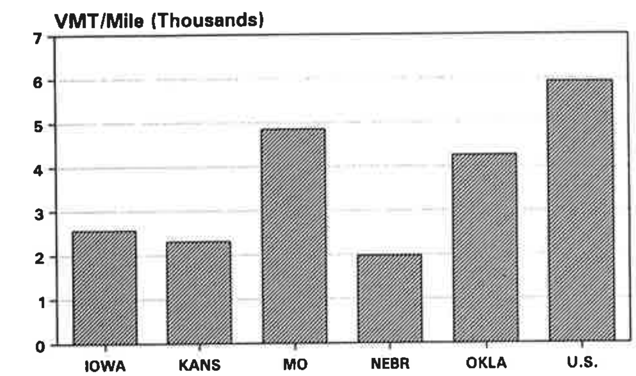

FIGURE 3 Systemwide ADT: primary system, vehicle miles per mile of primary.

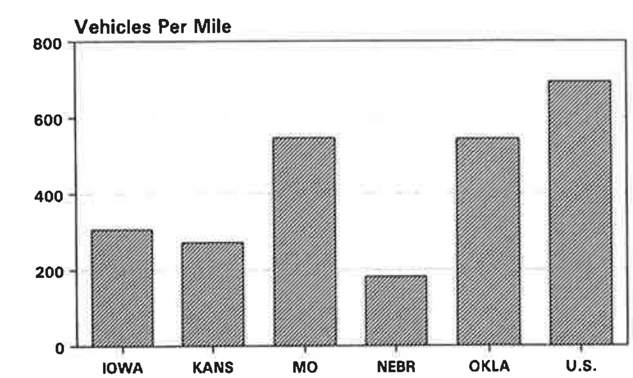

FIGURE 4 State-by-state comparison, registered vehicles per mile of road.

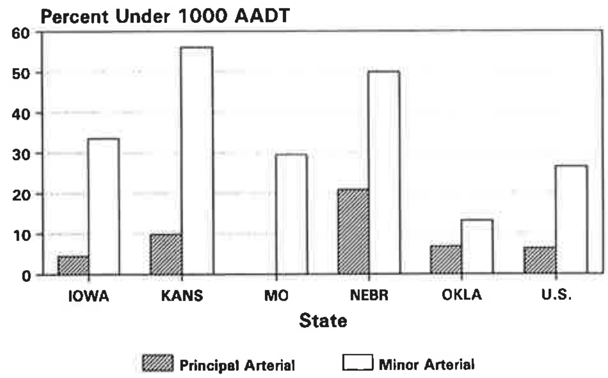

FIGURE 5 State-by-state comparison, AADT under 1,000.

fees are dedicated to the state highways only. Again, Iowa and Nebraska were very close to Kansas. As in the two previous graphs showing vehicle miles, both Missouri and Oklahoma had a substantially better revenue base than the three other states, but they were significantly below the national average.

An additional comparison was made to pinpoint the problem more closely. Figure 5 displays the percentage of miles of principal and minor arterials that carry fewer than 1,000 vehicles a day. The value of 1,000 vehicles a day is an arbitrary round number, but it represents the lower traffic volume that will generate enough revenue to support normal maintenance. This chart vividly indicates that Kansas would have to deal with the large number of minor arterials. More than 50 percent of the minor arterials carry fewer than 1,000 vehicles a day; the national average is less than 25 percent.

The charts provided enough evidence to support the use of different criteria for selecting the highways in Kansas that would receive the greatest attention for upgrading and modernization. The adoption of the 1984 AASHTO Green Book lent an even greater urgency to the task, because the Green Book does not distinguish between principal and minor arterials. Therefore, any geometric improvement made to low-volume minor arterials must be made to full arterial standards (this decision was made before Kansas adopted restoration, rehabilitation, and reconstruction standards).

DESCRIPTION OF A–E CLASSIFICATION

The following is a summary of criteria used in the State Transportation Plan (STP) to stratify the routes.

Class A

Class A routes are those routes designated as the Interstate system.

Class B

Class B routes, along with Class A routes, serve the most important corridors of statewide and interstate travel. The trips on the facilities are very long and carry many out-of-state vehicles. Traffic volumes remain relatively constant along major segments of the route. The corridors are spaced widely enough to serve distinctly different trip movements.

Class C

Class C is a part of the statewide arterial system and is integrated with Class A and B routes to provide service to all areas of the state. Major cities not on Class A and B routes are connected by Class C routes. Continuity and long average trip lengths are important, but greater attention is given to coverage of areas not served by other routes.

Class D

Class D contains routes serving a combined role of intercounty movement and access to the arterial routes for county seats and other small urban areas not on a Class A, B, or C route. Through truck traffic should be discouraged, but there may be a large number of trucks serving local industries.

Class E

Class E is made up of stubs and routes whose service is limited almost exclusively to local service. Few nonlocal license plates are observed unless the route serves a well-known park or tourist attraction. The trip lengths are very short: the same people often travel over the same roads several times a day, day after day.

Defining the System

The rural state highway system is made up of facilities displaying a wide variety of characteristics. One of the very important factors to consider in planning a system that will efficiently carry statewide travel is that of route continuity. Corridors should provide a fairly consistent level of service throughout their length so as not to surprise the traveler with unexpected design changes.

As a general rule, the routes carrying the most traffic are those serving the long intercity and interstate trips. However, the classification cannot be based on traffic volume alone. A route with short average trip lengths may also carry high volumes of traffic. Examples of these are commuter routes radiating from the metropolitan areas. Traffic volumes may be some of the highest rural volumes, but the traffic on these routes drops off rapidly beyond the commuting range for the area. Routes serving primarily local trips are not affected by the condition of segments elsewhere along the route. A good test for determining if a corridor serves many very long trips occurs when roads are closed during snowstorms. The function of a route, such as an Interstate system route, can be affected by actions or conditions several hundred miles away in other states.

The reclassification was done from the top down to ensure continuity and integration within each class and with those previously listed. To minimize confusion with FHWA functional classifications and with preconceived notions about what certain words mean, the most generic terms were used. Five classes were defined, with Class A being comparable to the Interstate system and Class E being stubs and other local service routes that should probably not be on the state highway system. County roads and city streets were not included in the reclassification.

A wide variety of tools and resources was used to stratify the rural state system into classes. They include

- Traffic counts,
- Classification counts (breakdown of trucks by type),
- Truck weight surveys,
- Roadside origin-destination surveys,
- Census data,
- Plans of adjacent states,
- Statewide traffic assignment models,
- Highway data base,
- Plans for urban areas,
- Revenue forecasts,
- Uniform design standards, and
- State and federal statutes.

MILEAGE AND TRAVEL SUMMARIES

Table 1 presents summaries of miles, vehicle miles, and percentages for total and heavy-truck traffic for each of the five classes. The Class A routes make up only 7.4 percent of the state's rural mileage but carry a fourth of the total rural travel and a third of all rural heavy-truck travel. Classes A through C encompass half of the mileage and carry 75 percent of total travel and more than 80 percent of heavy-truck travel. This is particularly significant because the remaining half of the system does not generate enough revenue from usage to provide adequate maintenance, let alone to provide for limited modernization.

Figure 6 shows graphically the accumulative values of Table 2. The shape of the curve is typical of those found in functional classification manuals. The lower right-hand curve depicts the percentage of accumulative mileage and total vehicle miles for each class, and the upper left-hand curve depicts the percentage mileage and heavy-truck miles for each class. Although more than half (54.7 percent) of total travel occurs

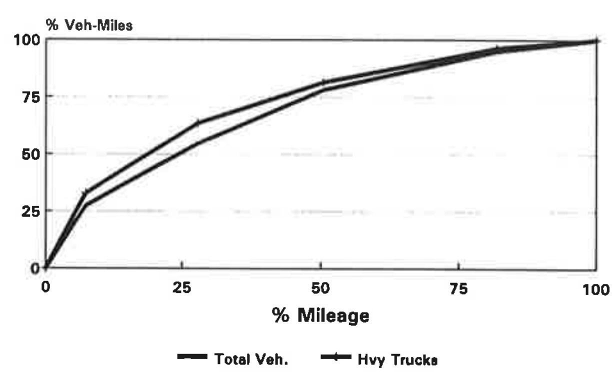

FIGURE 6 STP classification summary of mileage and travel, rural systems only.

TABLE 2 STP A–E Classification Summary, Rural Mileage and Travel

CLASS	MILES	PER CENT	ACCUM %	TOTAL VEH-MI	PER CENT	ACCUM %	TOTAL AVE.*	TRUCK VEH-MI	PER CENT	ACCUM %	TRUCK AVE.#
A	725	7.4	7.4	5480	27.3	27.3	7560	1080	32.8	32.8	1490
B	2021	20.5	27.9	5522	27.4	54.7	2730	1020	30.8	63.6	500
C	2217	22.5	50.4	4699	23.4	78.1	2120	590	17.8	81.4	270
D	3134	31.6	82.0	3428	17.0	95.1	1090	490	15.0	96.4	160
E	1771	18.0	100.0	994	4.9	100.0	560	120	3.6	100.0	70
	9848	100.0		20123	100.0		2040	3300	100.0		330

Vehicle Miles in 1000's per day
1987 Mileage and Travel
* Average Vehicle-Miles per Mile - All vehicles
# Average Vehicle-Miles per Mile - Heavy Trucks

on Class A and B routes, these routes carry 63.6 percent of the heavy-truck travel. The steeper slope of the heavy-truck curve reflects a higher percentage of heavy trucks on a small portion of the system.

A comparison of heavy-truck travel on the Class B and C routes demonstrates one important difference between the two classes: whereas the total traffic is only slightly greater on the Class B routes than on the Class C routes, the heavy-truck traffic on Class B routes is almost twice that on Class C routes.

The STP classification and associated standards were adopted by the agency in 1988. The priority formula used to select candidate projects for the Comprehensive Highway Program was also changed to recognize the A–E standards. A weighting factor incorporated into the formula uses the classification to assign a weight to each section of road.

Obtaining STP Classification Data from Existing HPMS Submittal

The HPMS analytical model was used to compare the existing federal functional classification with the STP classification. Comparisons were made for the agency and for the user. Unmet highway needs were estimated if the available funds were used for projects using the existing federal classification and if the classes in the HPMS model were redefined to the STP standards as

	Class
Interstate (I-St)	A
Other principal arterials (OPA)	B
Minor arterials (MnA)	C
Major collectors (MjC)	D
Minor collectors (MnC)	E

Preparation of Data

Factoring by Classification and Volume Group

The HPMS analytical model uses data compiled from sample sections collected for submittal to FHWA. Because the data are sampled by functional class and factored to the respective classes' total mileage, the sample sections must be refactored to the new STP class totals. The reclassification is complicated slightly because each class is further stratified by volume group. The matrix in Table 3 indicates which functional class and volume groups were involved.

Statistical Tests

Statistical reliability tests were originally used to establish the number of samples that were needed within each class and volume group. The significance of the Interstate and other higher type facilities resulted in a higher confidence level; consequently, a higher sample rate was chosen for these facilities. Fortunately, the reclassification amounted to a downgrading of many of the routes from minor arterials to major collectors. Therefore, it was possible to maintain the necessary statistical reliability without having to collect any additional field data.

Comparison of STP Classification to Existing Classification

As is shown in Figure 7, there has been a shift to the right in the height of the bars from the conventional functional classification to the STP classification. With a few exceptions, all of the minor collectors on the state system were reclassified as Class E routes. As will be shown later, the greatest impact on the system resulted from a large number of minor arterials' becoming Class D routes. Again it must be remembered that this reclassification, to date, has not involved nearly 30,000 mi of nonlocal rural roads that are the responsibility of counties and townships, nor does it include connections of highways through cities and other city streets.

Benefits of STP Classification

The benefit of the reclassification can be seen from the results of runs made using the HPMS analytical model. The model was run using only the rural sections, both using the conventional functional classification and the refactored STP class totals. As can be seen in Figure 8, the 10-year roadway needs have been reduced by more than three times from a previously run in-house needs analysis (HI SCOPE), using the STP classification. The in-house (LO SCOPE) was also nearly twice that of the STP classification. The HI SCOPE and LO SCOPE needs estimates were made using a needs model developed within the agency, and the STP SCOPE was obtained from the HPMS model using the investment-level option. This comparison by itself means little since this is the obvious result of converting a big part of the system to a lower classification with lower standards.

TABLE 3 Expanding HPMS Samples to STP Mileage Totals

STP Class	Volume Group	Functional Classification I-St Miles	OPA Miles	Min A Miles	Maj C Miles	Min C Miles	Local Miles
A	1	X	X				
	2	X					
	3						
	4						
	5						
B	1		X	X			
	2		X	X			
	3		X				
	4		X				
	5		X				
C	1		X	X			
	2		X	X			
	3		X	X			
	4		X				
	5						
D	1		X	X			
	2		X	X	X		
	3			X			
	4			X			
	5						
E	1		X	X	X	X	
	2			X	X	X	
	3			X	X		
	4						
	5						

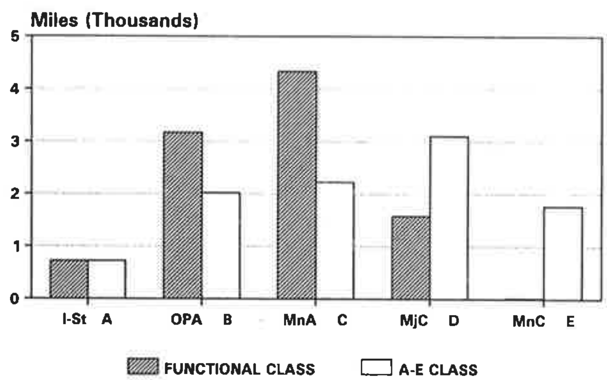

FIGURE 7 Comparison of STP class changes.

A more important comparison is shown in Figure 9. This chart shows the road user cost from the HPMS model at 5-year intervals for both classifications using the fund period analysis option. The funding available in 1987 to finance the 5-year highway construction program was used for each analysis made with the model. The funding was assumed to be level in constant dollars over the remaining three fund periods. The chart shows that user costs more than double over the 20-year period for the conventional functional classification. Part of this increase can be attributed to increased travel over that period. However, during this same period, and with the same funding level, the road user costs increased only slightly when the funds were allocated and used according to the STP classification and standards.

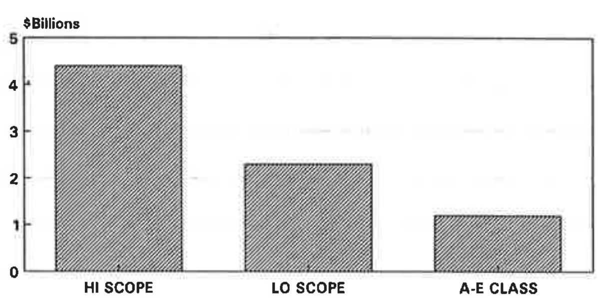

FIGURE 8 Comparison of needs, rural state system (roadway only).

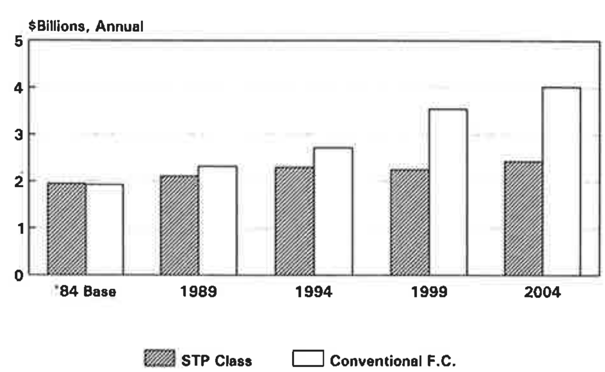

FIGURE 9 Comparison of user costs, rural state system.

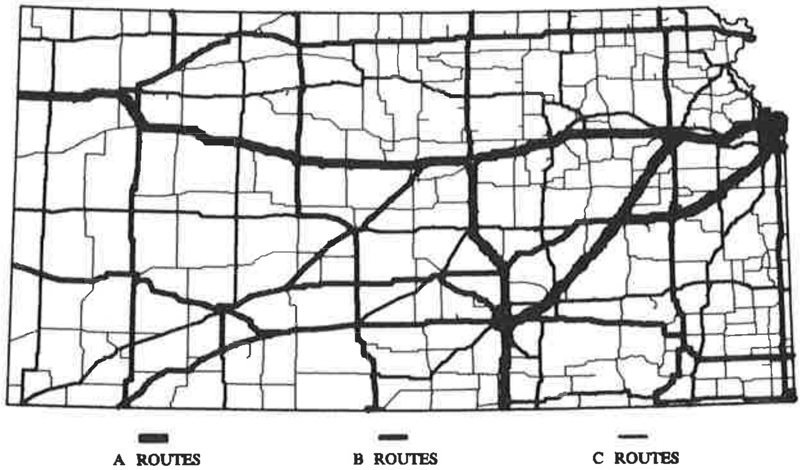

FIGURE 10 Comparison between STP classifications, Class A, B, and C routes.

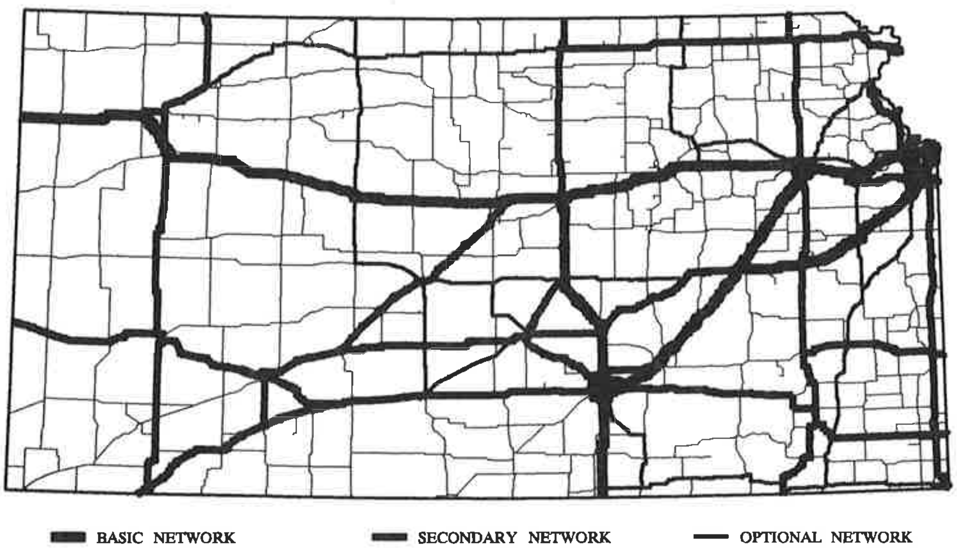

FIGURE 11 Proposed NHS basic and secondary networks.

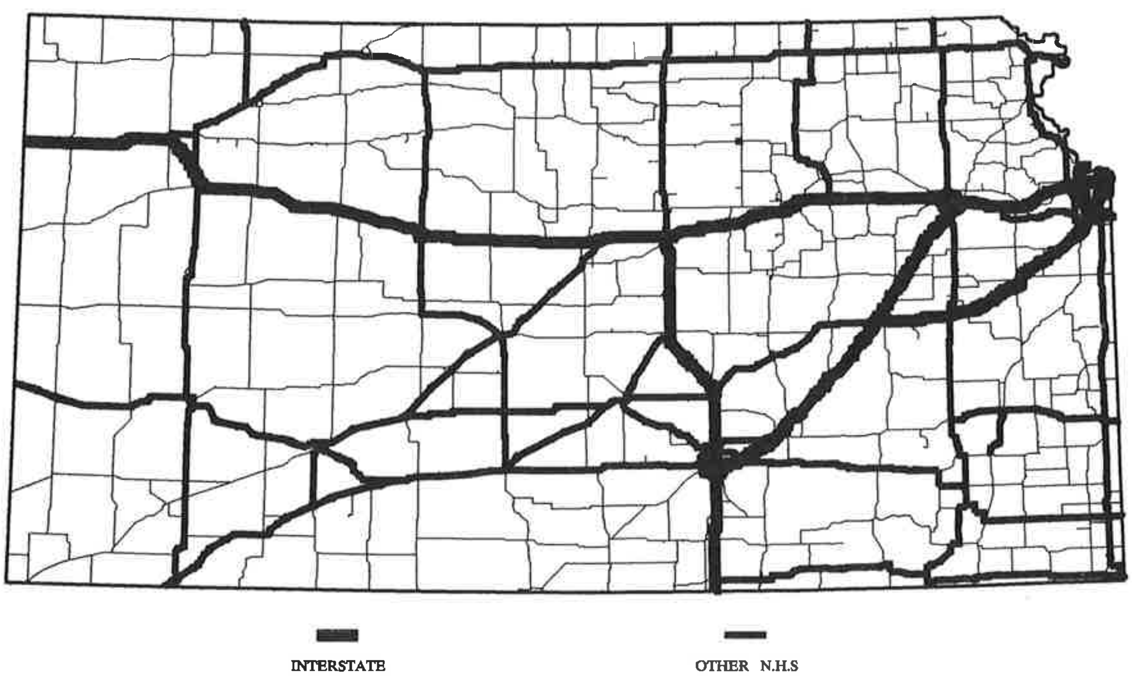

FIGURE 12 Illustrative NHS network prepared by FHWA.

National Highway System Submittal

At the request of FHWA in September 1990, states submitted maps showing highways that should be considered as candidates for the NHS. The NHS was a key element in FHWA's proposed federal reauthorization legislation. Shown in the figures are the comparison between the STP-classified Class A, B, and C routes (Figure 10), the proposed NHS basic and secondary network (Figure 11), and the illustrative NHS network prepared by FHWA (Figure 12).

SUMMARY AND CONCLUSIONS

Kansas ranks fourth nationally in total miles of streets and highways. Maintaining such a large system is a burden to all levels of government. Kansas and surrounding states—particularly Iowa and Nebraska—have some similarities, suggesting that the conventional functional classification was done properly. It is evident that national averages do not provide appropriate guidelines for attaining a classification that produces an optimal decision-making basis for states such as Kansas.

The HPMS model proved to be a useful tool for demonstrating the benefits of using different criteria to classify Kansas highways. An estimate of total needs to attain an assumed level of service was not particularly useful. However, a comparison of the higher user costs associated with the existing functional classification system (which attempts to bring all arterials, no matter how minor, up to arterial standards) to the costs associated with the STP classification system proved convincing to policy makers.

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