Highway Performance Monitoring System: Kentucky's Approach

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The Kentucky Transportation Cabinet (KYTC) participated with great interest in implementing the FHWA's Highway Performance Monitoring System (HPMS) from its inception in 1978. One of FWHA's basic objectives was to gather the most up-to-date necessary information for the biennial report to Congress concerning condition, performance, and needs of the nation's highway system and to justify continued or increased highway funding. This effort by the FHWA was similar to some of the work the KYTC had been performing for legislative requests and for funding justification to the state's General Assembly. The HPMS concept of determining performance in relation to available or anticipated funds with statistical reliability and the overall needs convinced KYTC top level management about its effectiveness and usefulness to the department. Therefore, they provided necessary support to implement and expand this program to include other systems (state primary and federal-aid). Continuing spot-checks, refinements, and other enhancements of critical data items in sample sections by Kentucky officials have provided the desired quality capable of providing management with a remarkably consistent, flexible tool for developing and analyzing alternate programs, different scenarios, and so forth.

HPMS was reviewed in depth by the U.S. General Accounting Office (GAO) at congressional request to determine its usefulness and overall data quality. Kentucky was one of 6 states visited by GAO to evaluate HPMS. After detailed examination and consultation with staff, GAO concluded that the HPMS program and its analytical package was a reasonable tool for analyzing capital investment need estimates, because the models used key engineering elements based on nationally accepted standards. The data collection and quality control procedures were adequate to ensure needed precision levels.

At the statewide level, HPMS takes into account 2,681 samples comprising 3,675 miles of the total state-maintained system (27,289 miles), about a 13.5 percent sample. This sample has been statistically designed and kept up-to-date for analysis and data reporting requirements. Samples were selected separately from individual major urbanized areas for analysis. Kentucky has 100 percent of Interstate system on the HPMS file because of its importance in I-4R apportionment and the periodic need to perform project level analysis. Expected precision levels vary from 90-5 to 80-10. The Traffic Monitoring Guide (TMG) recommendations and SHRP's sites have been integrated with the overall HPMS program for ease in data collection activities and to avoid duplication of efforts.

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ANALYTICAL PACKAGE AND ITS APPLICATION

The HPMS Analytical Package has been designed to respond to questions concerning the determination of investment levels necessary to accomplish alternate objectives. With increasing construction and maintenance costs, and fluctuating revenues from fuel usage, prudent investment of available resources is essential. HPMS is capable of providing information not only on the funding required for ultimate system performance, but also on the effect on future systems performance resulting from insufficient funding. The package also makes it possible to analyze alternative funding levels, minimum acceptable conditions, design standards, and future travel with resulting performance measures.

The analytical package consists of a series of computer models which use HPMS data as primary input. The package consists of (a) needs analysis, (b) investment analysis, (c) impact analysis, (d) deferred cost analysis, and (e) multiple deficiency and composite analysis. The most important feature is the needs analysis model.

Needs Analysis

This model simulates the improvements required to keep the operating conditions of a highway system from falling below prescribed (user flexible) minimum acceptable conditions (MAC) during any preassigned analysis period. Needs are directly related to the MAC. Analysis and use have indicated that lane width, pavement condition, alignment adequacy, and volume-to-service flow ratio are very sensitive parameters that significantly affect needs. The other items that affect needs are travel demand and widening feasibility that is coded on each record. These are not models parameters, but their impact is significant. In order for needs to be reasonable and convincing, the user must make some assumptions concerning the MAC. After considerable analysis, KYTC decided to use the following assumptions with regard to the MAC:

1. No minor widening is performed (i.e., adding 1-ft or 2-ft width per lane to the roadway of an existing facility). In other words, the prevailing lane width of 8 to 10 ft on rural low-volume collectors is considered tolerable with some reduction in service level and safety aspects.
2. The existing curvature and gradient characteristics on the collector system cause some restrictions in the speed limit because of the design speed of curves. Hence, reduction in speed on low volume collectors is tolerable. Actually, it is unsafe on some collectors to travel at the prevailing speed limit.

3. The threshold value of PSI by system for resurfacing is very subjective and depends upon economic considerations and available funding.

In essence, the rationale was that the systems will still have some problems, but none that are currently considered serious enough to justify capital improvements. MAC have been established by a combination of engineering judgment, budgetary demands, and the best acceptable situation for the traveling public. The MAC established for Kentucky adequately safeguard public safety and minimizes long-term capital and improvement costs by making cost effective and timely capital improvements needed over the year of analysis.

Needs are analyzed in four possible scenarios:

- Full needs,
- Constrained full needs,
- Maintaining overall system condition "status quo," and
- Maintain system performance.

Full needs does not mean system perfection. It implies that no roadway section would exhibit physical and operational characteristics that fall below the MAC standards used to identify deficiencies. Because the MAC are significantly below full design standards for new roads, there will be some deficiencies (problems) that are not considered serious enough to require any capital improvement.

Constraint full needs list only those capacity-related improvements that can reasonably be expected to be accomplished particularly in congested urbanized areas where right-of-way is very critical. Operating characteristics are going to decline under the scenario in urbanized areas because of the lack of right-of-way for major widening. The required highway capacity resulting from traffic demand cannot be met because of prohibitive costs.

The third scenario is to maintain the status quo. This option represents the investment required to maintain an overall composite rating. The weakness of this method is that the overall composite index overshadows significant changes in the other components. In other words, on higher functional systems, pavement conditions tend to improve, and performance declines slightly, but the composite index remains essentially the same.

Maintain system performance scenario represents the cost of preventing further service deterioration. It does not exhibit any improvement in the average service level. This strategy shows the cost and investment required to keep the functional system performance the same as it was designed to do or at the same level as now. It permits continuation of overall quality of highway condition, service and safety, and accessibility. It also permits necessary capacity improvements to ensure retention of current service.

Present System Characteristics

As of December 31, 1988, the public road mileage in Kentucky totaled 69,848 miles. It carried 31.5 billion vehicle miles of travel (VMT). This represents about 8,294 VMT per person. Almost 11.2 percent (3.5 billion) was accounted for by trucks. About 90 percent (62,250 miles) of the total mileage is in rural areas with an annual VMT of 18.5 billion. The 10 percent (7,598 miles) of the total mileage is in urban areas with an annual VMT of 13 billion. The VMT split between rural and urban is 59 to 41 percent, respectively. About 27,289 miles of the total road system is maintained by the state and accounts for 27 billion or 86 percent of the total VMT. Approximately 13,820 miles are on the federal-aid system with an annual VMT of 26 billion which is 83 percent of total VMT.

The total statewide capital expenditures by the federal-aid system from 1980 to 1988 have obligations that vary from a minimum of $321 million in 1980 to a maximum of $662 million in 1987. Similarly, the capital expenditures vary from a minimum of $332 million in 1982 to a maximum of $524 in 1988. (See Table 1 and Figure 1.)

The statewide total expenditures by major categories are presented in Figure 2 and Table 2. The expenditures vary from $740 million to $1.04 billion.

Overall federal-aid system performance on a scale of 0 to 100 was about 74 in 1988. It varied substantially by system (Interstate, 66; rural roads, 88; and urban roads, 68). The system condition over the past 7 years has been maintained by an average annual capital overlay expenditure of $427 million that includes about $70 million on non-federal-aid system maintained by the state. There is slight increase in operating speed and decrease in vehicle operating cost on

TABLE 1 CAPITAL EXPENDITURES ON THE FEDERAL AID SYSTEM (IN $MILLIONS)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
INTERSTATE	117	81	73	90	148	124	123	90	100
PRIMARY	252	151	96	122	144	144	196	213	196
URBAN	47	29	34	48	31	20	28	42	56
SECONDARY	49	66	66	45	54	37	54	69	78
NON-FEDERAL	41	35	63	57	39	53	65	88	94
TOTAL	506	362	332	362	416	378	466	502	524

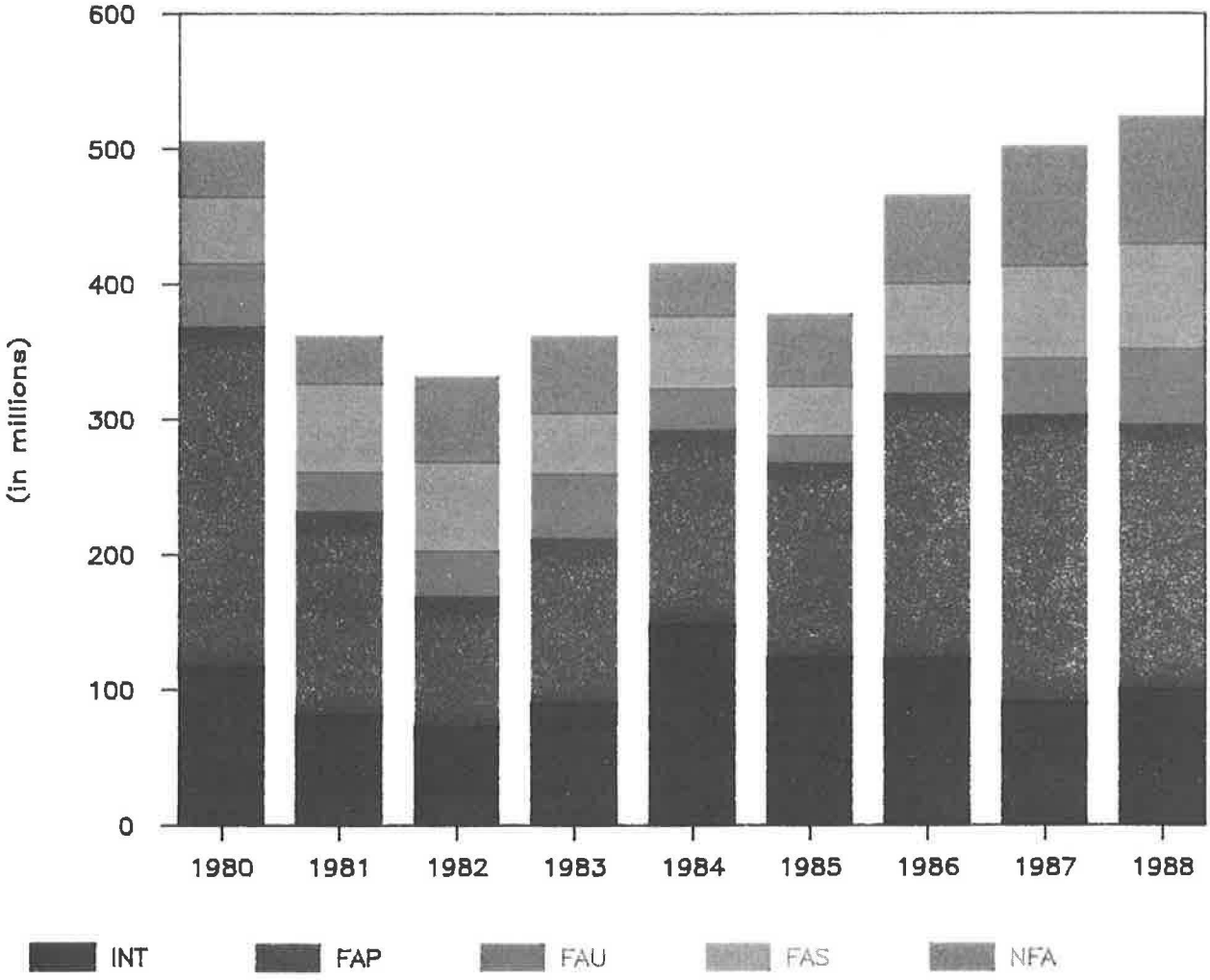

FIGURE 1 Expenditures on the Federal Aid System.

TABLE 2 STATEWIDE TOTAL EXPENDITURES (IN $THOUSANDS)

ITEMS	1980	1981	1982	1983	1984	1985	1986	1987	1988
1. CAPITAL OUTLAYS:									
a. State Maintained System	496,350	373,890	334,022	369,629	412,618	367,583	485,648	483,103	520,710
b. Local Road System	36,432	14,126	15,227	19,393	22,657	30,517	41,626	62,517	48,108
2. MAINTENANCE:									
a. State Maintained System	120,434	119,848	122,001	121,152	121,274	126,137	136,541	138,861	141,993
b. Local Road System	8,522	1	29	120	196	323	774	278	274
3. ADMINISTRATION:									
a. State Maintained System	37,318	35,168	33,198	37,891	40,672	51,481	47,288	59,062	33,831
b. Local Road System	2,320	989	1,068	1,366	1,600	2,159	2,966	4,396	3,387
4. DEBT SERVICES:									
a. General Obligation Bonds	18,067	18,064	18,099	18,093	18,060	18,056	18,052	18,064	18,071
b. Toll Roads Lease Rentals	54,826	47,702	58,989	55,167	54,693	40,593	43,787	33,426	31,813
c. Resource Recovery Rentals	35,114	42,105	54,658	46,301	46,219	70,857	20,093	42,503	23,913
d. Economic Development Rentals	--	--	--	--	19,363	35,751	35,710	35,600	13,804
5. REVENUE SHARING GRANTS:									
a. Cities	4,509	13,568	13,433	13,688	13,213	13,089	16,378	24,005	26,317
b. Counties	28,417	31,861	32,133	31,341	36,313	31,403	49,333	57,076	67,308
c. Rural Secondary	37,416	36,872	59,264	46,143	36,579	48,169	46,567	67,575	59,627
6. MASS TRANSPORTATION:	2,331	3,708	4,228	3,084	2,022	4,103	2,805	1,787	828
7. LAW ENFORCEMENT:	3,364	2,301	4,381	4,851	6,302	5,344	7,702	7,880	9,096
TOTAL	885,420	740,203	750,730	768,219	831,781	845,565	955,270	1,036,133	999,080

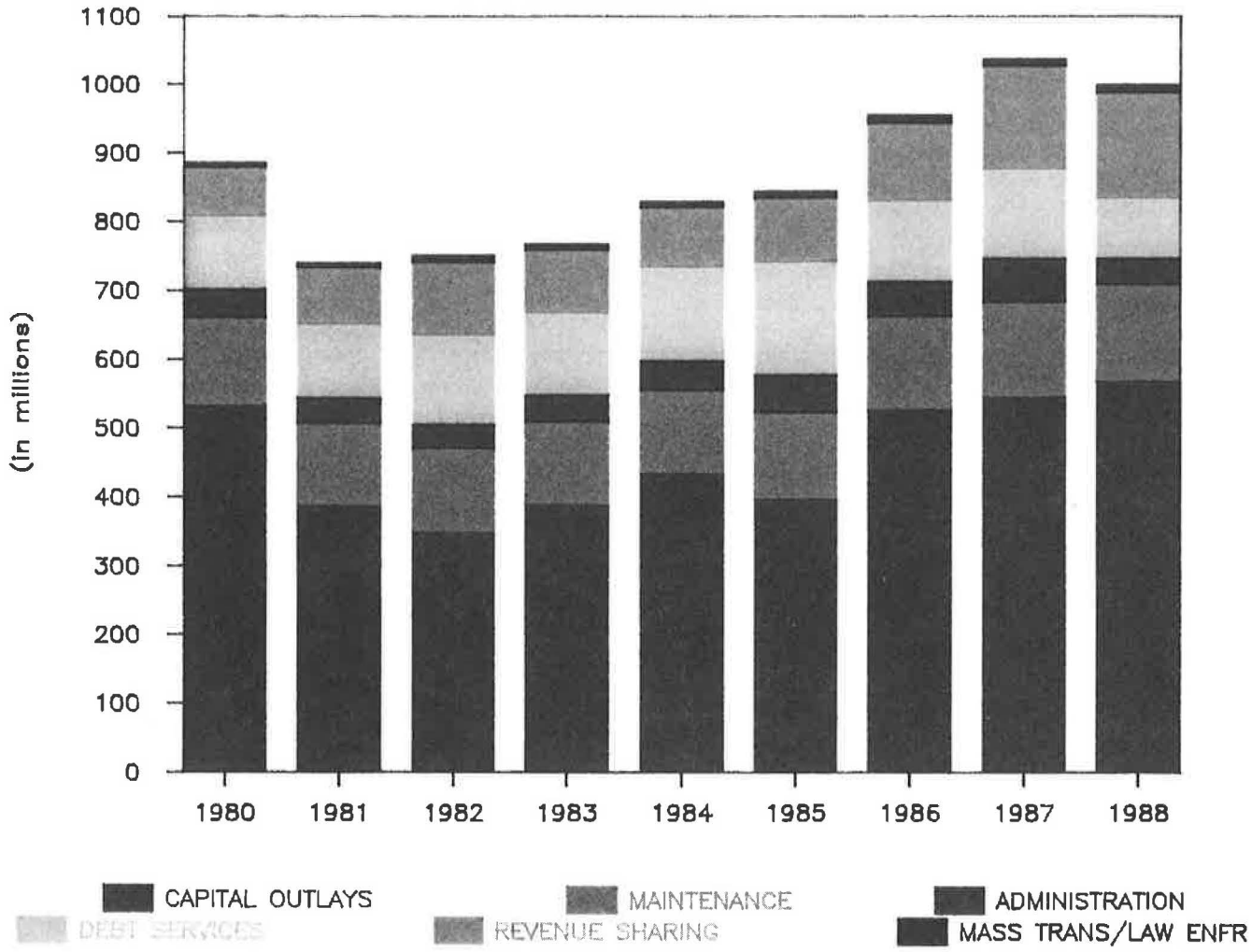

FIGURE 2 Statewide total expenditures.

rural and urban roads. But on the Interstate system, there is some reduction in operating speed and increase in operating cost. This illustrates that past expenditures on the Interstate system were insufficient to accommodate increased travel demand.

NEEDS

Full Constrained Needs

The needs analysis shows that the funds required for the cabinet to accomplish full constrained needs for the next 22 years is $11.1 billion or an average of $504.5 million per year.

Assuming anticipated federal-aid with state match of $178.2 million per year and the continued availability of state funds from the 210 account of about $100 million per year, an additional $226.3 million per year is required to correct the deficiencies.

Maintain Current Highway System Integrity (status quo)

Under this scheme, it would cost $9.2 billion for 22 years or an average of $419 million per year to maintain the overall highway system condition.

Maintain Current System Performance

Under this scenario, an investment of $10.4 billion for 22 years or an average of $471 million per year is required to maintain current system performance.

Expected Federal Funds–System Performance

Expected federal funds with appropriate state match by category is used to determine system performance during the 22-year analysis period. The resulting system performance under this scenario is shown in Table 3 and Figure 3. It is clear from

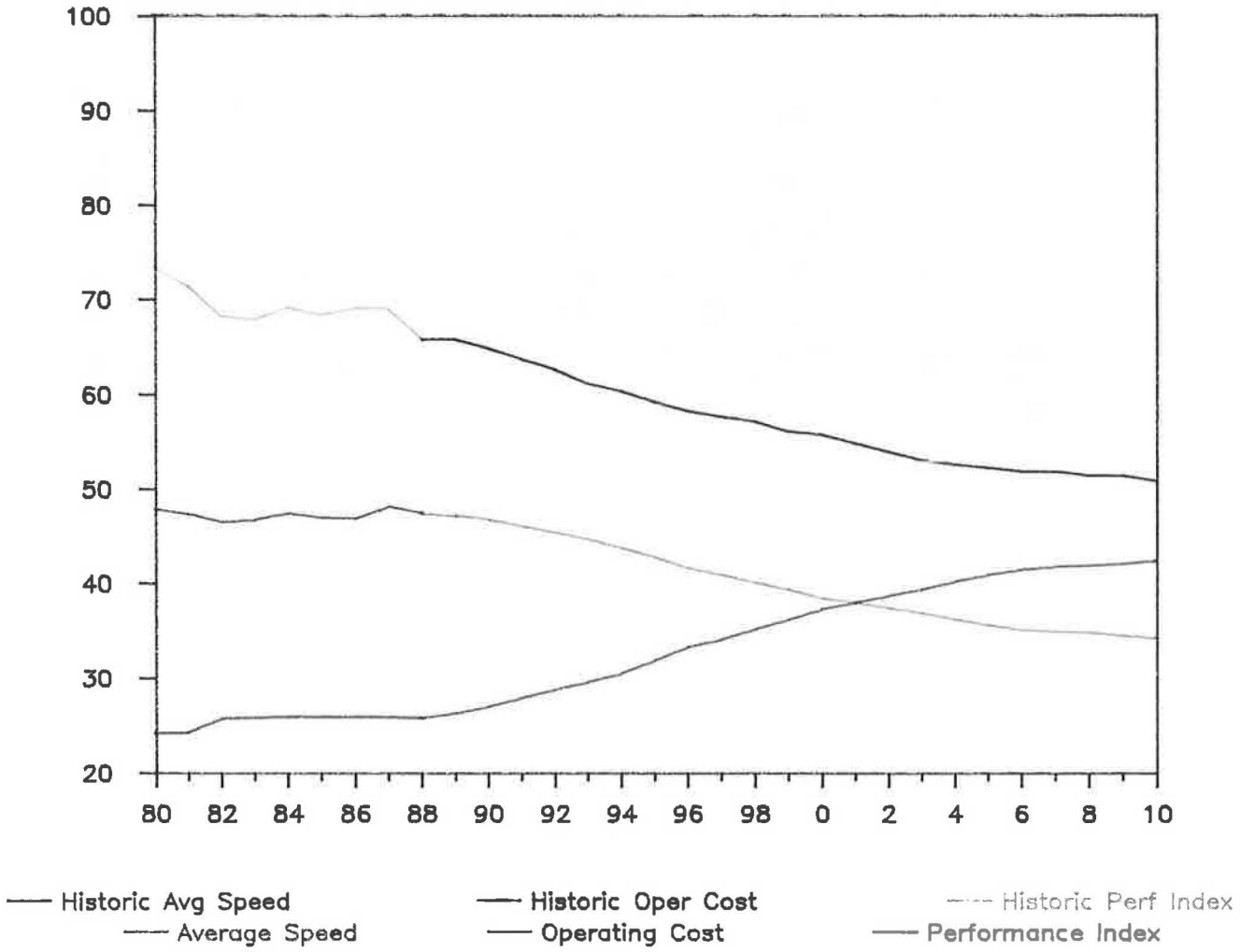

FIGURE 3 Performance measures for expected funds on Interstates.

TABLE 3 EXPECTED FUNDING

YEAR	INTERSTATE AVERAGE SPEED		INTERSTATE OPERATING COST		INTERSTATE PERFORMANCE INDEX	
80	48.0		24.2		73.5	
81	47.4		24.3		71.5	
82	46.5		25.8		68.3	
83	46.8		25.9		67.9	
84	47.5		26.0		69.3	
85	47.0		26.0		68.4	
86	46.9		26.0		69.2	
87	48.2		25.9		69.2	
88	47.5	47.5	25.8	25.8	65.9	65.9
89		47.2		26.4		65.9
90		46.8		27.1		64.9
91		46.1		28.0		63.8
92		45.4		28.9		62.7
93		44.7		29.7		61.2
94		43.8		30.6		60.4
95		42.8		32.0		59.3
96		41.7		33.4		58.3
97		40.9		34.2		57.7
98		40.1		35.3		57.2
99		39.4		36.3		56.1
0		38.4		37.4		55.8
1		38.0		38.1		54.9
2		37.4		38.8		54.0
3		36.9		39.5		53.1
4		36.2		40.3		52.6
5		35.6		41.0		52.3
6		35.1		41.6		51.9
7		34.9		41.9		51.9
8		34.8		42.0		51.5
9		34.5		42.2		51.5
10		34.2		42.6		50.9

Figure 3 that the performance index declines significantly affecting overall quality of mobility in terms of decreased operating speed and increased vehicle operating cost and congestion in urban areas.

Other Uses

- Interstate needs (short- and long-range);
- Truck miles of travel by system to estimate the expected revenue before passage of the "weight-distance tax";
- As justification to the Transportation Subcommittee about the validity of truck VMT;
- Provision of VMT, percent trucks, vehicle occupancy, operating speed, cost and pollutants to the MPOs, Cabinet for Natural Resources and Environmental Protection, State Police, and so forth; and
- Optimization of available financial resources in order to yield maximum attainable system performances.

These are just a few of the many uses being made of the HPMS program in Kentucky. New uses are continually being found as various problems and issues (particularly funding shortfalls) face the highway program.