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Chapter 7

Benefits and Costs

7.1 INTRODUCTION

This chapter provides estimates of the benefits and costs that would be expected due to implementation of a intelligent transportation system in the Wichita metropolitan area. The second section of this chapter provides a background of benefits experienced with other ITS implementations in other areas. System benefits due to a freeway management system, discussed in the third section, are presented for the staged implementation of the freeway management system. Costs associated with a freeway management system, discussed in the fourth section, include both capital and operating expenses, and are provided as the summation of the component costs that comprise the system. The benefit-cost ratios for the freeway management system are presented in the fifth section.

7.2 BACKGROUND[1]

The first implementations of some of the user services included in the current ITS structure began appearing in urban areas in the late 1960's. Implementations since then have become more flexible, more capable, and more integrated. For example, incident management programs that began as courtesy patrols and CB monitoring have incorporated new technologies and are increasingly being integrated into transportation management centers.

Implementations of ITS programs have demonstrated benefits to address the national program goals in the areas of safety, productivity, efficiency, and environmental impact. Benefits are derived from a smoother flow of traffic with less delay from signals, incidents, and traffic queues. Most aspects of the implementations contribute to time savings.

Experiences with past ITS program implementations have shown positive results. For example, Incident Management Programs have shown an eight (8) minute decrease in incident clearance time, a 10%-20% decrease in travel time, and a 10% decrease in fatalities in urban areas. According to draft analyses based on data from the Fatal Accident Reporting System, reduction of incident notification times on urban freeways from the current average of 5.2 minutes to 3 minutes would reduce fatalities 10% annually.

Implementations of ITS programs are justified by user benefits and are evaluated against other no-build options. As an approximate comparison, freeway expansion costs $2 million per lane mile while a complete implementation of a traffic management system in an urban corridor costs $500,000 per freeway mile plus the cost of a freeway management center. If the existing freeway has four lanes, installing a traffic management center could add about half the capacity of an additional lane at about 1/8 the cost.

[1] Information on the background of ITS benefits was obtained from *Intelligent Transportation Infrastructure Benefits Expected and Experienced* USDOT, Operation Timesaver, January 1996

7.3 ANTICIPATED BENEFITS

The estimated benefits for the implementation of the freeway management system in Wichita include reductions in travel delay time, fuel consumption and automobile emissions. The benefits were calculated for each phase of the freeway management system implementation. In order to help prioritize areas for improvement, the benefits are also shown on a per mile basis.

The benefits in the short term are based on 1996 AADT values as documented in the KDOT highway database. The long term benefits are based on projected 2020 ADT volumes provided by the MAPD and KDOT. The medium term benefits are based on volumes extrapolated from the 1996 and the projected 2020 volumes. In order to best estimate the benefits of the system in future conditions, the number of accidents is assumed to grow at the same rate as the ADT's over the time frames on all facilities except the Kellogg corridor.

It is assumed in this study that the Kellogg expressway will be completed to the east of Wichita by the start of the medium term. The completion of this expressway is expected to reduce the number of accidents currently being experienced along the at-grade intersections. However, the traffic volume is expected to increase by the medium term, increasing the risk of accidents. For the purposes of this analysis, we are assuming that the number of accidents will remain constant as geometric improvements are made and as the volume increases.

A number of assumptions were necessary to estimate the annual benefits of the freeway management system. While these assumptions affect the absolute magnitude of the benefits, they do not affect the relative magnitude of the benefits. Thus, they are not critical with respect to identifying which segments would be expected to result in the greatest benefit. However, because these assumptions affect the magnitude of the estimated benefit, they do affect the benefit-cost ratios and will impact the recommended time frame for implementation and the extent and kinds of technologies that would appear to be warranted. Additional information regarding the calculation of the benefits, including the assumptions used, is included in Appendix E.

Travel Delay Time

The primary benefits expected to result from the implementation of a freeway management system are travel time savings that would result from a decrease in incident response time. A reduction in the time that elapses before an incident is identified and located would be expected due to the implementation of freeway surveillance equipment, including roadway detectors and closed circuit television (CCTV).

Incident response would also be facilitated by the provision of information to emergency responders. Information from the CCTV cameras would help emergency responders decide what kind of equipment is needed at the scene. This would decrease vehicle delay by both assuring that the needed equipment arrives quickly and by minimizing the transport of unnecessary, capacity reducing equipment to the scene. Information from the CCTV could also be used to determine the best method of access for emergency responders. Sometimes accidents are best accessed from surface streets that are close to the freeway or from the freeway lanes in the opposite direction. Finally, information on current travel speeds obtained from traffic detectors could be used to help determine the best route for emergency responders.

Benefits also accrue as a result of informing motorists about traffic conditions. Variable message signs, highway advisory radio, and the provision of current and accurate traffic information through commercial radio and television are all valuable mechanisms for communication with the public. Although it is difficult to predict the magnitude of the impact of this information, it does have an impact. In addition to reducing driver frustration, it can also affect travel behavior. In fact, almost half of respondents using a traveler advisory telephone service reported that the information they received had a direct effect on their travel behavior.[2]

Studies completed in other areas have reported a 20-50 percent reduction in incident induced travel delay times resulting from the implementation of freeway management systems. For this analysis a conservative approach was taken to estimating the benefits that may be obtained by implementing a freeway management system. It is assumed that during incidents causing delay, a 25 percent reduction in travel time delay would result from the implementation of a freeway management system. It is also assumed that the average queue length during an incident in the Wichita area is two (2) miles[3] and the average speed in the queue is 10 mph. The percentage of the total traffic that will experience delays due to accidents depends on where the accident occurs and at what time it occurs. For accident sensitive areas (areas highlighted in Figure 2-9), it is assumed that 40 percent of the ADT will encounter 30 percent of the total number of accidents. This is based on the assumption that approximately 10 percent of the ADT occurs during each of the a.m. and p.m. peak hours when accidents are most likely to cause significant delay. It is further assumed that an additional 20 percent of the ADT is likely to encounter delay-causing incidents, primarily during the midday period. Another set of assumptions was made concerning the frequency of accidents and the percentage of accidents that are likely to cause delay. The first assumption was that 40 percent of the recorded accidents occurred during the time that 40 percent of the ADT was on the road. The second assumption was that 75 percent of those accidents would cause delay. Taking 75 percent of the 40 percent of the accidents expected to occur during the heavier traveled periods resulted in 30 percent of the total recorded accidents for each segment being used in the calculation of travel time delay. Similarly, for those areas not highlighted in Figure 2-9, it is assumed that only 10 percent of the ADT is likely to encounter delay causing accidents and that 10 percent of the recorded accidents will cause the delay. Tables 7-1, 7-2, and 7-3 summarize the annual benefits expected from travel delay time savings for the short, medium, and long term implementation plans, respectively.

Table 7-1 Annual Travel Delay Time Savings - Short Term

Roadway	Travel Delay Savings (millions of $)
I-135	$2.22
US 54	$0.45
Total	**$2.67**

[2] Summary of Findings, Massachusetts Highway Department Independent Evaluation of SmarTraveler Operational Test (conducted for the Massachusetts Highway Department and presented in a paper to ITS America)

[3] Assumption based on the observed distance between freeway exits along I-135 in Wichita is about one (1) mile and that the incident related traffic backup would extend to the second exit back from the incident scene

Table 7-2 Annual Travel Delay Time Savings - Medium Term

Roadway	Travel Delay Savings (millions of $)
I-135	$1.92
US 54	$2.18
Total	**$4.10**

Table 7-3 Annual Travel Delay Time Savings - Long Term

Roadway	Travel Delay Savings (millions of $)
I-135	$0.67
I-235	$0.20
US 54	$0.26
K-96	$0.07
K-254	$0.01
Total	**$1.21**

Fuel Use and Emissions

Benefits are also expected to result from a decrease in fuel consumption and related automobile emissions due to the implementation of the freeway management system. These benefits correspond to the travel delay time savings in that they are the direct result of improved incident response and management.

The average fuel efficiencies are assumed to be 15 miles per gallon when the speeds are under 35 mph. The cost of fuel is estimated to be $1.20 per gallon. The assumptions regarding the average speed, length of queue and percentage of ADT encountering congestion are the same as mentioned for the travel delay time benefits. Tables 7-4, 7-5, and 7-6 summarize the annual benefits expected from fuel use savings for the short, medium, and long term implementation plans, respectively.

Table 7-4 Annual Fuel Use Savings – Short Term

Roadway	Fuel Use Savings (millions of $)
I-135	$0.19
US 54	$0.04
Total	**$0.23**

Table 7-5 Annual Fuel Use Savings – Medium Term

Roadway	Fuel Use Savings (millions of $)
I-135	$0.17
US 54	$0.19
Total	**$0.36**

Table 7-6 Annual Fuel Use Savings – Long Term

Roadway	Travel Delay Savings (millions of $)
I-135	$0.06
I-235	$0.02
US 54	$0.02
K-96	$0.01
K-254	$0.00*
Total	**$0.11**

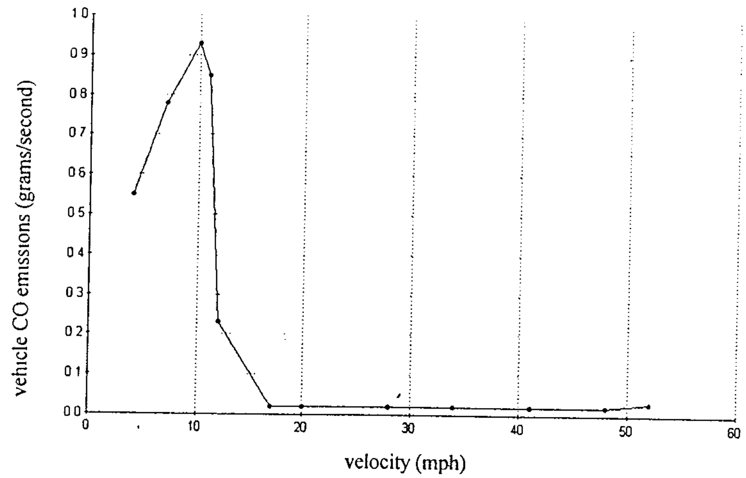
* Actual annual fuel savings is $500.00

Vehicle exhaust emissions can be reduced due to the reduction of incident related congestion. Research that was conducted by Partners for Advanced Transit and Highways (PATH) and the South Coast Air Quality Management District shows that vehicles emit various amounts of CO, HC, and NO_x emissions according to their speed. Figure 7-1 indicates the amounts of emissions versus velocities generated by vehicles on the average. From the graphs, using a speed of 10 mph, the following emission rates were extrapolated:

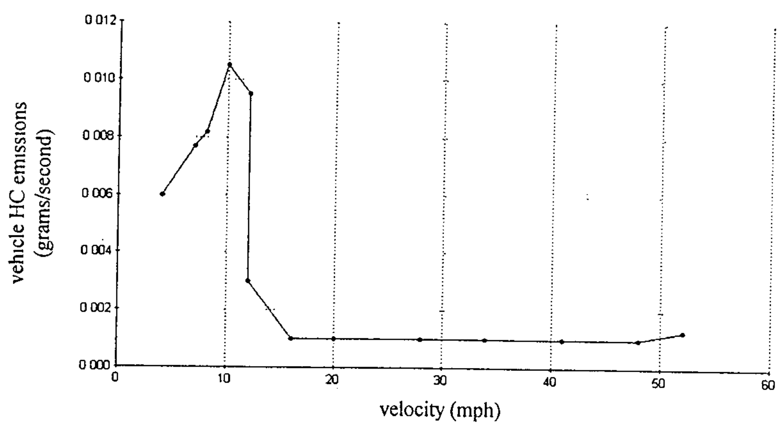
Emission	Emission Rate (g/sec)
CO	0.940
HC	0.012
NO_x	0.009

Tables 7-7, 7-8, and 7-9 show the reductions in these emissions for the short, medium, and long term implementation plans.

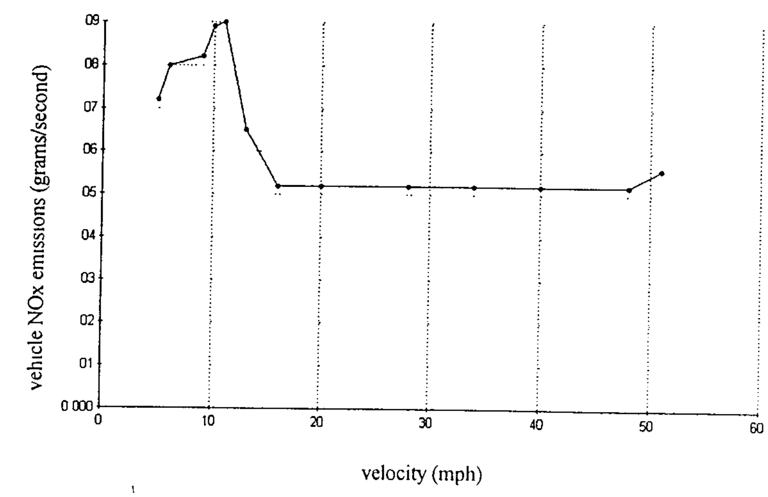
Figure 7-1 Velocity vs. Emission Curves



Vehicle CO



Vehicle HC



Vehicle NOx

SOURCE. University of California, Riverside

Table 7-7 Annual Emissions Reductions – Short Term

Roadway	CO Emission Reduction (Tons/yr.)	HC Emission Reduction (Tons/yr.)	NOx Emission Reduction (Tons/yr.)
I-135	827	9	8
US 54	168	2	2
Total	**995**	**11**	**10**

Table 7-8 Annual Emissions Reductions – Medium Term

Roadway	CO Emission Reduction (Tons/yr.)	HC Emission Reduction (Tons/yr.)	NOx Emission Reduction (Tons/yr.)
I-135	1,929	20	17
US 54	844	9	7
Total	**2,773**	**29**	**24**

Table 7-9 Annual Emissions Reductions – Long Term

Roadway	CO Emission Reduction (Tons/yr.)	HC Emission Reduction (Tons/yr.)	NOx Emission Reduction (Tons/yr.)
I-135	2,023	22	18
I-235	73	1	1
US 54	575	6	5
K-96	28	0	0
K-254	2	0	0
Total	**2,701**	**29**	**24**

Total Benefits

The total annual benefits for each roadway and per each phase are summarized in Table 7-10. Note that the benefits are higher on the highways with higher volumes and accident rates. This is due to the fact that benefits would accrue to a greater number of vehicles where both volumes and incidents are higher. Benefits are highest on I-135.

Table 7-10 Annual Benefits Per Phase

Roadway	Short Term	Medium Term	Long Term	Total Benefit
I-135	$2.41	$2.09	$0.72	$5.22
I-235	-	-	$0.21	$0.21
US 54	$0.49	$2.37	$0.28	$3.14
K-96	-	-	$0.08	$0.08
K-254	-	-	$0.01	$0.01
TOTAL	**$2.90**	**$4.46**	**$1.30**	**$8.66**

All figures in millions of dollars

7.4 ESTIMATE OF PROBABLE COSTS

The cost estimate for the freeway surveillance system includes both capital and annual operating and maintenance costs. Capital costs reflect the need for freeway surveillance equipment, which includes both CCTV and vehicle detection equipment; variable message signs; highway advisory radio, which includes both transmitters and advisory signs with flashing lights; power distribution and communications to system components; field data processing equipment; a traffic operations center; and centralized hardware and software. Appendix F provides a background to the costs indicated for each component indicated in Tables 7-12 through 7-15.

Table 7-11 summarizes the capital costs for the short term arterial and emergency management component implementation. Tables 7-12 through 7-15 summarize the incremental capital cost and the accrued operating and maintenance costs of implementation of the freeway management system for each phase. All costs indicated are in 1998 dollars. Capital costs were converted to equivalent annual costs assuming a 15 year life and an interest rate of 6 percent. The quantities shown in these tables correspond to the quantities indicated in the deployment plan and shown in the figures in Chapter 6. Only selected (priority) locations for each phase are indicated in the deployment plan.

Table 7-11 Short Term Arterial and Emergency Management Implementation

Capital Costs			
Item	Quantity	Unit $	Total
Traffic Signal System Upgrade and Expansion Study	L.S.		$ 120,000
Highway Reference Markers*	53 mi.	$750 /mi	$ 39,750
Emergency Vehicle Signal Preemption			
Vehicle Emitters	50 vehicles	$1,800 /veh.	$ 90,000
Signal Components	80 loc.	$6,600 /ea.	$ 528,000
Emergency Vehicle AVL System	400 vehicles	$10,000 /veh.	$ 4,000,000
Railroad Gate Status Information to Emergency Communications	L.S.		$ 200,000
Subtotal			**$ 4,977,750**
Contingency 10%			$ 497,775
Total Capital Cost (Rounded)			**$ 5,480,000**

* "Early Winner" project.

Table 7-12 Short Term Freeway Management System Implementation

Capital Costs			
Item	Quantity	Unit $	Total
CCTV	12 ea.	$ 40,000 /ea.	$ 480,000
Variable Message Signs	14 ea.	$ 200,000 /ea.	$ 2,800,000
Highway Advisory Radio	5 ea.	$ 35,000 /ea.	$ 175,000
HAR Signs	31 ea.	$ 7,000 /ea.	$ 217,000
Fiber Optic Communication	15 mi.	$ 20 /ft.	$ 1,584,000
Incident Detection	7 mi.	$ 10,000 /mi	$ 70,000
Traffic Operations Center	2,000 sq. ft.	$ 150 /sq. ft.	$ 300,000
Central Hardware and Software	L.S.		$ 1,467,000
Subtotal			**$ 7,093,000**
Contingency 10%			$ 709,300
Design and Implementation 10%			$ 709,300
Total Capital Cost			**$ 8,511,600**
Capital Recovery Factor (15 yrs, 6%)			0.103
Annualized Capital Cost (Rounded)			**$ 880,000**

Annual Operating and Maintenance Costs			
Item	Qty.	Annual Cost	Total
Motorist Assistance Patrol* (in addition to existing)	2 patrols	$ 200,000 /yr.	$ 400,000
Leased T-1 Phone Lines	3 lines	$ 15,000 /yr.	$ 45,000
Dial-up Phone Lines	13 lines	$ 900 /yr.	$ 11,700
Staffing (Hybrid System)			
TMC Manager	1 person	$ 66,560 /yr.	$ 66,560
Signal System Operator	1 person	$ 46,800 /yr.	$ 46,800
Incident Mgt. System Operator/ TMS Operator	1 person	$ 46,800 /yr.	$ 46,800
Maintenance Personnel	3 people	$ 32,000 /yr.	$ 96,000
Maintenance			
Factory Repairs (5% of equip $)			$ 128,020
Spare Parts (3% of equip. $)			$ 76,812
Total Annual Operating and Maintenance Costs (Rounded)			**$ 920,000**
Total Annual Capital, Operating and Maintenance Costs (Rounded)			**$ 1,800,000**

* "Early Winner" project.

Table 7-13 Medium Term Freeway Management System Implementation

Capital Costs			
Item	Quantity	Unit $	Total
CCTV	16 ea.	$ 40,000 /ea.	$ 640,000
Variable Message Signs	3 ea.	$ 200,000 /ea.	$ 600,000
Fiber Optic Communication	19 mi.	$ 45 /ft.	$ 4,514,400
Incident Detection	16 mi.	$ 10,000 /mi.	$ 160,000
Subtotal			**$ 5,914,400**
Contingency 10%			$ 591,440
Design and Implementation 10%			$ 591,440
Total Capital Cost			**$ 7,097,280**
Capital Recovery Factor (15 yrs, 6%)			0.103
Annualized Capital Cost (Rounded)			**$ 730,000**
Annual Operating and Maintenance Costs			
Item	Quantity	Annual Cost	Total
Motorist Assistance Patrol	2 patrols	$ 200,000 /yr.	$ 400,000
Staffing (Hybrid Center)			
TMC Manager	1 person	$ 66,560 /yr.	$ 66,560
Signal System Operator	1 person	$ 46,800 /yr.	$ 46,800
Incident Mgt. System Operator/ TMS Operator	1 person	$ 46,800 /yr.	$ 46,800
Maintenance Personnel	3 people	$ 32,000 /yr.	$ 96,000
Maintenance			
Factory Repairs (5% of equip $)			$ 168,820
Spare Parts (3% of equip. $)			$ 101,292
Total Annual Operating and Maintenance Costs (Rounded)			**$ 930,000**
Total Annual Capital, Operating and Maintenance Costs (Rounded)			**$ 1,660,000**

Table 7-14 Long Term Freeway Management System Implementation

Capital Costs			
Item	Quantity	Unit Cost	Total
CCTV	20 ea.	$ 40,000 /ea.	$ 800,000
Variable Message Signs	2 ea.	$ 200,000 /ea.	$ 400,000
Fiber Optic Communication	30 mi.	$ 30 /ft.	$ 5,544,000
Incident Detection	30 mi.	$ 10,000 /mi.	$ 300,000
Subtotal			**$ 7,044,000**
Contingency 10%			$ 704,400
Design and Implementation 10%			$ 704,400
Total Capital Cost			**$ 8,452,800**
Capital Recovery Factor (15 yrs, 6%)			0.103
Annualized Capital Cost (Rounded)			**$ 870,000**
Annual Operating and Maintenance Costs			
Item	Quantity	Annual Cost	Total
Motorist Assistance Patrol	2 patrols	$ 200,000 /yr.	$ 400,000
Staffing			
TMC Manager	1 person	$ 66,560 /yr.	$ 66,560
Assistant TMC Manager	1 person	$ 50,000 /yr.	$ 50,000
Signal System Operator	1 person	$ 46,800 /yr.	$ 46,800
Incident Mgt. System Operator/ TMS Operator	3 people	$ 46,800 /yr.	$ 140,400
Secretary/Clerical	0.5 person	$ 32,000 /yr.	$ 16,000
Maintenance Personnel	4 people	$ 32,000 /yr.	$ 128,000
Maintenance			
Factory Repairs (5% of equip $)			$ 222,420
Spare Parts (3% of equip. $)			$ 133,452
Total Annual Operating and Maintenance Costs (Rounded)			**$ 1,210,000**
Total Annual Capital, Operating and Maintenance Costs (Rounded)			**$ 2,080,000**

Table 7-15 Freeway Management System Annual Costs Per Phase

Phase	Short Term	Medium Term	Long Term
Annual Cost (in millions)			
Capital	$0.88	$0.73	$0.87
Operating and Maintenance	$0.92	$0.93	$1.21
Total	**$1.80**	**$1.66**	**$2.08**

7.5 COST ALLOCATION AND FUNDING OPTIONS

The specifics of how the recommendations included in this report may be funded and the cost sharing among each of the jurisdictions is a major issue that must be addressed and agreed upon subsequent to the completion of this study. Section 6.5 of this report provided an overview of the various funding sources that may be used for ITS projects. The major federal funding categories that are possible candidates to provide funding for the Wichita ITS recommendations include; National Highway System (NHS), Surface Transportation Program (STP), Congestion Mitigation and Air Quality Improvement Program (CMAQ), and the Intelligent Transportation System Integration Program (also referred to as "Deployment Incentives Program). The FY 1999 apportionment to Kansas for each of the categories is:

NHS	$71.8 million
STP	$90.4 million
CMAQ	$6.8 million

Money for the Deployment Incentives Program is being used to cover the earmarked ITS projects that were included in FY 1999 DOT Appropriations Act. It is most likely that little money, if any, will be available from this category for the next couple years since it is being used to cover the earmarked projects. In theory, this money was to have been competed for and awarded by FHWA on the basis of the project's merits, however the extensive amount of earmarking has circumvented that process. Lobbying of Kansas' congressional delegation for earmarked funds in future appropriation bills is another possibility for obtaining funding.

Within each of the funding categories there are restrictions that further reduce the amount of eligible funding that could be awarded. Under the STP funds there are sub-allocations for mandatory safety programs, mandatory transportation enhancements, improvements in urbanized, urban and rural areas (i.e. areas with populations over 200,000, under 200,000, and under 5,000), and improvements for any area. The CMAQ funding is split approximately in half between air quality beneficial projects in non-attainment and maintenance areas (Kansas City) and general STP eligible projects in the remainder of Kansas (including Wichita).

One of the major outcomes of the TEA-21 legislation is the clarification that ITS projects are eligible for the Federal-aid funding categories described above. Nearly all of the recommendations would qualify as eligible projects for Kansas' share of the federal allocation, and generally at up to a 100 percent federal participation level, the projects will have to compete with other projects for the funding that is available.

Another major concern regarding funding is for the continued operations and maintenance of the recommended systems. TEA-21 reconfirmed language which had been included in the 1995 National Highway System legislation which allowed for the continuous use of federal funds to cover operations and management of systems and was defined to include the "labor costs, administrative costs, cost of utilities and rent, and other costs associated with the continuous operation of traffic control, such as integrated traffic control systems, incident management programs, and traffic control centers". As with the capital costs for implementation, the operating expenses would have to compete for the limited Federal-aid funding provided to Kansas. Any split between KDOT, the City of Wichita, and Sedgwick County would have to be negotiated and agreed upon prior to initiating system design and implementation.

7.6 BENEFIT-COST RATIOS - FREEWAY MANAGEMENT SYSTEM

Table 7-16 shows the cumulative benefit-cost ratio for each phase of the project. Benefit-cost ratios must be greater than one in order for the project to be justified. The benefits calculated in Section 7.3 are derived from the implementation of the traffic management system along the freeways. Therefore, the costs from the Short Term Arterial and Emergency Management Implementation, which would benefit the arterial signal system and the emergency responders and their operations more than the freeway users, are not included in this analysis.

If the whole freeway traffic management system were to be installed immediately, the complete system would have a benefit-cost ratio of 3.40. This indicates that the complete system is justified for implementation. Note that the benefits for the phased deployments increase between implementation time frames. This is due to the anticipated increase in traffic and accidents experienced in the areas where traffic management equipment has been deployed. This also reflects areas that are not currently sensitive to incidents, but are expected to become sensitive in the medium and/or long term.

In order to quantify the true impact of the phased implementation expenditures, Table 7-17 shows the incremental benefit-cost ratio for each phase. This indicates the anticipated amount of benefits from each individual phase. Based on this analysis, the short and medium term plans are justified, however the long term plan is not justified for implementation based on forecasted conditions. If the future growth in Wichita is more than the forecasted growth, it is likely that the benefit-cost ratio will increase and will justify implementation within the long term time frame. Therefore, this plan should be reevaluated in the future.

Table 7-16 Cumulative Benefit-Cost Ratio for Each Phase

Phase	Short Term	Medium Term	Long Term
Annual Benefits (in millions)			
First Phase Equipment Deployment	$2.90	$6.51	$9.92
Second Phase Equipment Deployment		$4.46	$7.63
Third Phase Equipment Deployment			$1.29
Total Annual Benefit	**$2.90**	**$10.97**	**$18.84**
Annual Cost (in millions)			
Capital	$0.88	$1.61	$2.48
Operating and Maintenance	$0.92	$1.85	$3.06
Total Annual Cost	**$1.80**	**$3.46**	**$5.54**
Benefit-Cost Ratio	**1.61**	**3.17**	**3.40**

All costs in millions

Table 7-17 Incremental Benefit-Cost Ratio for Each Phase

Phase	Short Term	Medium Term	Long Term
Annual Benefits (in millions)	$2.90	$4.46	$1.29
Annual Cost (in millions)			
Capital	$0.88	$0.73	$0.87
Operating and Maintenance	$0.92	$0.93	$1.21
Total	$1.80	$1.66	$2.08
Benefit-Cost Ratio	**1.61**	**2.69**	**0.62**

All costs in millions