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Appendix A

A.1 Utility Factors

Utility factors for each evaluation criteria are based on a range from 0 to 10, with 0 indicative of the least utility and 10 indicative of the greatest utility. With the exception of the utility factor for cost, the utility factors were qualitatively determined, as discussed below.

COST

The utility factor representing cost is based on the estimated cost for each alternative, as shown in Tables A-1 through A-3. The cost for each alternative was expressed as a percentage of the greatest cost for the capital, operating and total cost. The utility was calculated by subtracting this percentage from 10.0. The estimated cost for each alternative was calculated based on the following assumptions.

Roadway Surveillance Equipment - Roadway surveillance equipment includes:

- CCTV cameras:
  - $30,000 each site
  - 1 site each 0.5 miles
- Detection:
  - $10,000 each site
  - 1 site each 0.5 miles

Variable Message Signs - Variable message signs include:

- Large fiber optic variable message signs
- 3 rows, 18 characters per row, 18" characters
- $120,000 per sign
- Quantities based on locations identified for deployment (Chapter 7)

Highway Advisory Radio - Highway advisory radio includes:

- Permanent installations
- AM Radio
- $17,000 per transmitter
- $3,000 per sign
- Quantities based on locations identified for deployment (Chapter 7)

Field Processors - Field processors include:

Alternatives A and C:	Non-intelligent Processors, $10,000 per processor (for example, a Type 170 controller) 1 processor per 0.5 miles
Alternative B:	Intelligent Processors, $20,000 per processor 1 processor per 0.5 miles

Table A-1. Estimated Cost for Alternative A

		Level 1	Level 2	Level 3
	Number of miles	48	82	258
Capital Costs				
Freeway Surveillance Equipment				
CCTV	cost per site	$30,000	$30,000	$30,000
	frequency per mile	2.0	2 0	2.0
	total cost	$2,880,000	$4,920,000	$15,480,000
Detection	cost per site	$10,000	$10,000	$10,000
	frequency per mile	2 0	2.0	2.0
	total cost	$960,000	$1,640,000	$5,160,000
Variable Message Signs	cost per sign	$120,000	$120,000	$120,000
	number	35	45	79
	total cost	$4,200,000	$5,400,000	$9,480,000
Highway Advisory Radio	cost per transmitter	$17,000	$17,000	$17,000
	number	6	8	16
	total cost	$102,000	$136,000	$272,000
	cost per sign	$3,000	$3,000	$3,000
	number	22	29	54
	total cost	$66,000	$87,000	$162,000
Power Distribution to System Components				
	cost per mile	$30,000	$30,000	$30,000
	total cost	1440000.0	2460000.0	7740000.0
Communications to ITS Elements				
	cost per mile	$10,000	$10,000	$10,000
	total cost	$480,000	$820,000	$2,580,000
Conduit Installation	cost per foot	$40	$36	$25
	total cost	$10,137,600	$15,523,200	$34,272,229
Field Data Processing Equipment				
Non-intellilgent	cost per processor	$10,000	$10,000	$10,000
	frequency per mile	2	2	2
	total cost	$960,000	$1,640,000	$5,160,000
Intelligent	cost per processor			
	frequency per mile			
	total cost			
Traffic Operations Center	number of centers	1	1	1
	square feet per center	$12,000	$12,000	$12,000
	cost per square foot	$110	$110	$110
	total cost	$1,320,000	$1,320,000	$1,320,000
Central Hardware				
Centralized	base cost	$650,000	$650,000	$650,000
	cost per mile	$3,333	$3,333	$3,333
	total cost	$809,984	$923,306	$1,509,914
Decentralized	base cost			
	cost per mile			
	total cost			
Software and Systems Integration				
Centralized		$750,000	$1,000,000	$1,250,000
Decentralized				
Subtotal for 15 Year Life		$24,105,584	$35,869,506	$84,386,143
Construction and Contingency		$4,821,117	$7,173,901	$16,877,229
Subtotal		28926700.8	43043407.2	101263371 1
Capital Recovery Factor (15 years, 6%)		0 1	0.1	0.1
Subtotal for Annual Cost		$2,978,293	$4,431,749	$10,426,077
Percentage of Greatest		2.7	4.0	9 5
Utility Factor		7.3	6.0	0.5
Annual Operating and Maintenance (O-M) Costs				
Traffic Operations Center Personnel		$350,000	$700,000	$1,750,000
Maintenance Personnel		$250,000	$400,000	$1,100,000
Replacement Parts and Spare Equipment		$1,101,779	$1,677,475	$4,090,807
Subtotal		$1,701,779	$2,777,475	$6,940,807
Percentage of Greatest		2.33	3.81	9 52
Utility Factor		7.67	6.19	0.48
Total Cost per Year		$4,680,072	$7,209,225	$17,366,884
Percentage of Greatest		2.56	3.94	9 49
Utility Factor		7.44	6.06	0.51

Table A-2. Estimated Cost for Alternative B

		Level 1	Level 2	Level 3
	Number of miles	48	82	258
Capital Costs				
Freeway Surveillance Equipment				
CCTV	cost per site	$30,000	$30,000	$30,000
	frequency per mile	2	2	2
	total cost	$2,880,000	$4,920,000	$15,480,000
Detection	cost per site	$10,000	$10,000	$10,000
	frequency per mile	2	2	2
	total cost	$960,000	$1,640,000	$5,160,000
Variable Message	cost per sign	$120,000	$120,000	$120,000
Signs	number	35	45	79
	total cost	$4,200,000	$5,400,000	$9,480,000
Highway Advisory	cost per transmitter	$17,000	$17,000	$17,000
Radio	number	6	8	16
	total cost	$102,000	$136,000	$272,000
	cost per sign	$3,000	$3,000	$3,000
	number	22	29	54
	total cost	$66,000	$87,000	$162,000
Power Distribution to System Components				
	cost per mile	$30,000	$30,000	$30,000
	total cost	$1,440,000	$2,460,000	$7,740,000
Communications to ITS Elements				
	cost per mile	$10,000	$10,000	$10,000
	total cost	$480,000	$820,000	$2,580,000
Conduit Installation	cost per foot	$40	$36	$25
	total cost	$10,137,600	$15,523,200	$34,272,229
Field Data Processing Equipment				
Non-intelligent	cost per processor			
	frequency per mile			
	total cost			
Intelligent	cost per processor	$20,000	$20,000	$20,000
	frequency per mile	2	2	2
	total cost	$1,920,000	$3,280,000	$10,320,000
Traffic Operations Center	number of centers	2	2	2
	square feet per center	6000	6000	6000
	cost per square foot	$110	$110	$110
	total cost	$1,320,000	$1,320,000	$1,320,000
Central Hardware				
Centralized	base cost			
	cost per mile			
	total cost			
Decentralized	base cost	$440,000	$440,000	$440,000
	cost per mile	$3,333	$3,333	$3,333
	total cost	$599,984	$713,306	$1,299,914
Software and Systems Integration				
Centralized				
Decentralized		$500,000	$750,000	$1,000,000
Subtotal for 15 Year Life		$24,605,584	$37,049,506	$89,086,143
Construction and Contingency		$4,921,117	$7,409,901	$17,817,229
Subtotal		$29,526,701	$44,459,407	$106,903,371
Capital Recovery Factor (15 years, 6%)		0.10296	0 10296	0 10296
Subtotal for Annual Cost		$3,040,069	$4,577,541	$11,006,771
Percentage of Greatest		2.76	4.16	10 00
Utility Factor		7.24	5.84	0.00
Annual Operating and Maintenance (O-M) Costs				
Traffic Operations Center Personnel		$700,000	$700,000	$1,750,000
Maintenance Personnel		$300,000	$450,000	$1,200,000
Replacement Parts and Spare Equipment		$1,139,279	$1,748,975	$4,338,307
Subtotal		$2,139,279	$2,898,975	$7,288,307
Percentage of Greatest		2.94	3.98	10.00
Utility Factor		7.06	6.02	0.00
Total Cost per Year		$5,179,348	$7,476,516	$18,295,078
Percentage of Greatest		2.83	4.09	10.00
Utility Factor		7.17	5.91	0.00

Table A-3. Estimated Cost for Alternative C

	Number of miles	Level 1 48	Level 2 82	Level 3 258
Capital Costs				
Freeway Surveillance Equipment				
CCTV	cost per site	$30,000	$30,000	$30,000
	frequency per mile	2	2	2
	total cost	$2,880,000	$4,920,000	$15,480,000
Detection	cost per site	$10,000	$10,000	$10,000
	frequency per mile	2	2	2
	total cost	$960,000	$1,640,000	$5,160,000
Variable Message	cost per sign	$120,000	$120,000	$120,000
Signs	number	35	45	79
	total cost	$4,200,000	$5,400,000	$9,480,000
Highway Advisory	cost per transmitter	$17,000	$17,000	$17,000
Radio	number	6	8	16
	total cost	$102,000	$136,000	$272,000
	cost per sign	$3,000	$3,000	$3,000
	number	22	29	54
	total cost	$66,000	$87,000	$162,000
Power Distribution to System Components				
	cost per mile	$30,000	$30,000	$30,000
	total cost	$1,440,000	$2,460,000	$7,740,000
Communications to ITS Elements				
	cost per mile	$10,000	$10,000	$10,000
	total cost	$480,000	$820,000	$2,580,000
Conduit Installation	cost per foot	$40	$36	$25
	total cost	$10,137,600	$15,523,200	$34,272,229
Field Data Processing Equipment				
Non-intelligent	cost per processor	$10,000	$10,000	$10,000
	frequency per mile	2	2	2
	total cost	$960,000	$1,640,000	$5,160,000
Intelligent	cost per processor			
	frequency per mile			
	total cost			
Traffic Operations Center	number of centers	1	1	1
	square feet per center	$10,000	$10,000	$10,000
	cost per square foot	$110	$110	$110
	total cost	$1,100,000	$1,100,000	$1,100,000
Central Hardware				
Centralized	base cost	$800,000	$800,000	$800,000
	cost per mile	$3,333	$3,333	$3,333
	total cost	$959,984	$1,073,306	$1,659,914
Decentralized	base cost			
	cost per mile			
	total cost			
Software and Systems Integration				
Centralized		$1,000,000	$1,250,000	$1,500,000
Decentralized				
Subtotal for 15 Year Life		$24,285,584	$36,049,506	$84,566,143
Construction and Contingency		$4,857,117	$7,209,901	$16,913,229
Subtotal		$29,142,701	$43,259,407	$101,479,371
Capital Recovery Factor (15 years, 6%)		00 10296	00 10296	00 10296
Subtotal for Annual Cost		$3,000,532	$4,453,989	$10,448,316
Percentage of Greatest		2.73	4 05	9 49
Utility Factor		7.27	5.95	0.51
Annual Operating and Maintenance (O-M) Costs				
Traffic Operations Center Personnel		$350,000	$700,000	$1,750,000
Maintenance Personnel		$250,000	$400,000	$1,100,000
Replacement Parts and Spare Equipment		$1,109,279	$1,684,975	$4,098,307
Subtotal		$1,709,279	$2,784,975	$6,948,307
Percentage of Greatest		2.35	3.82	9.53
Utility Factor		7.65	6.18	0.47
Total Cost per Year		$4,709,812	$7,238,964	$17,396,623
Percentage of Greatest		2.57	3 96	9.51
Utility Factor		7.43	6.04	0.49

Traffic Operations Center (TOC) - TOC consists of:

New facility built on DOT property
Building sized for ultimate system size

Alternative A:	12,000 square foot facility (extra room for emergency management and transit operators) 1 facility
Alternative B:	6,000 square foot facility 2 facilities $110 per square foot
Alternative C:	10,000 square foot facility 1 facility $110 per square foot

Central Hardware - Central hardware includes:

Alternative A, Centralized:

$50,000 per 15 miles of controlled freeway (Console $5,000, 2 video monitors at $5,000, Computer Workstation $10,000, Miscellaneous $25,000).

$650,000 base (Video displays $300,000, Central Computer $250,000, Miscellaneous $100,000).

Alternative B, Decentralized :

$50,000 per 15 miles of controlled freeway (Console $5,000, 2 video monitors at $5,000, Computer Workstation $10,000, Miscellaneous $25,000).

$440,000 base (Video displays $300,000, Central Servers $40,000, Miscellaneous $100,000).

Alternative C, Centralized:

$50,000 per 15 miles of controlled freeway (Console $5,000, 2 video monitors at $5,000, Computer Workstation $10,000, Miscellaneous $25,000).

$800,000 base (Video displays $300,000, Two Servers plus Information Server, $400,000, Miscellaneous $100,000).

Software and Systems Integration - Software and Systems Integration includes:

Alternative A, Centralized:	$750,000 Level 1 $1,000,000 Level 2 $1,250,000 Level 3
Alternative B, Decentralized:	$500,000 Level 1 $750,000 Level 2 $1,000,000 Level 3
Alternative C, Centralized:	$1,000,000 Level 1 $1,250,000 Level 2 $1,500,000 Level 2

Annual Operating and Maintenance Costs - Annual operating and maintenance costs include:

Traffic Operations Personnel for 1 TOC (Alternatives A and C):

Level 1 System - 2 operators/shift
Level 2 System - 4 operators/shift
Level 3 System - 10 operators/shift
3.5 shifts (3 shifts plus 1/2 shift coverage) for 24 hour coverage
$50,000 per year (fully burdened) per operator

Traffic Operations Personnel for 2 TOCs (Alternative B):

Level 1 System - 2 operators/shift at each TOC (4 total)
Level 2 System - 2 operators/shift at each TOC (4 total)
Level 3 System - 5 operators/shift at each TOC (10 total)
3.5 shifts (3 shifts plus 1/2 shift coverage) for 24 hour coverage
$50,000 per year (fully burdened) per operator

Maintenance Personnel for 1 TOC (Alternatives A and C)
Level 1 System - 5 maintenance people /shift
(4 Field maintainers and 1 TOC maintainer)
Level 2 System - 8 maintenance people/shift
(7 Field maintainers and 1 TOC maintainer)
Level 3 System - 22 maintenance people/shift
(20 Field maintainers and 2 TOC maintainers)
1 shift
$50,000 per year (fully burdened) per maintainer

Maintenance Personnel for 2 TOCs (Alternative B)
Level 1 System - 6 maintenance people/shift
(4 Field maintainers and 2 TOC maintainers)
Level 2 System - 9 maintenance people/shift
(7 Field maintainers and 2 TOC maintainers)
Level 3 System - 24 maintenance people/shift
(20 Field maintainers and 4 TOC maintainers)
1 shift
$50,000 per year (fully burdened) per maintainer

Replacement Parts and Spare Equipment:
Approximately 5 percent of Hardware Costs (all capital costs except the software cost and cost for TOC)

RELIABILITY

The utility factor representing reliability varies depending on the control logic, the data processing, the number of traffic operations centers (TOCs) and the geographic extent of the system (interim or ultimate). Multiple server control logic and multiple TOCs are considered more reliable, because if one server or traffic operation center goes down, the remaining server or TOC might be able to assume some of the functions of the server or TOC that is unavailable. Even if this redundancy does not exist, only the portion of the system that relied on the single server or TOC would be down, rather than the entire system. With respect to data processing, decentralized data processing is considered more reliable since field data processing can continue to some extent even when central processing capabilities are restricted. Finally, with respect to the geographic extent of the system, the ultimate system would be more reliable because the loop configuration of the fiber optic cable would provide more possible routes for information flow which would provide additional redundancy and minimize the impact of an equipment malfunction or break in the fiber.

FLEXIBILITY

The utility factor representing flexibility varies depending on the data processing (which impacts the capability to operate the field equipment independently of the central server), and the level of centralization (which impacts each state's ability to proceed independently). The level of centralization is defined not only by the number of activities and agencies included in the TOC (transit, emergency responders, etc.), but also by the number of TOCs and the control logic.

EXPANDABILITY

The utility factor representing expandability is affected by the capacity of central control, as well as the communications network and the data processing. Because all alternatives have fiber optics as the basis for communications, and assuming all systems have similar available capacity with respect to central control, decentralized data processing would facilitate expandability because data processing capacity can be added as needed when additional field equipment is implemented.

STAGED DEPLOYMENT

The utility representing staged deployment varies depending on the degree of centralization and the data processing. A more centralized system would be more difficult to deploy in stages, due to the fact that a larger number of agencies would have to be coordinated. Decentralized data processing is more conducive to staged deployment because data processing equipment can be installed concurrent with the staged expansion.

ARTERIAL DIVERSION

The utility representing the ease with which arterial diversion could be implemented is based on the extent to which arterial signal systems on major alternate routes are controlled by the TOC.

INSTITUTIONAL CONSIDERATIONS

The utility representing the feasibility of each architecture with respect to institutional considerations is affected by the level of centralization, the number of TOCs, and the control logic. With respect to the level of centralization, it is assumed that the fewer agencies involved in the deployment and operation of the TOC, the fewer institutional barriers there will be. Similarly, if multiple TOCs and servers are implemented, then presumably fewer agencies will need to cooperate, and fewer institutional barriers will result.

A.2 Weighting Factors

Table A-4 shows the weighting factors recommended by the Steering Committee members.

Table A-4. Steering Committee Recommendations for Weighting of Evaluation Criteria

Criteria		Response								
		1	2	3	4	5	6	7	8	9
k_1	Cost	25	20	25	20	10	15	20	15	20
k_2	Reliability	15	15	25	15	20	15	20	10	40
k_3	Flexibility	10	15	15	10	20	20	15	15	5
k_4	Expandability	20	20	15	20	15	10	15	10	15
k_5	Staged Deployment	10	10	15	20	5	15	15	20	10
k_6	Arterial Diversion	10	5	3	5	10	10	5	10	5
k_7	Institutional Considerations	10	15	2	10	20	15	10	20	5
Total		100	100	100	100	100	100	100	100	100

Appendix B

B.1 Calculation of Benefits

This appendix documents the calculation of the benefits that would be expected to result due to the deployment of a freeway management system. Benefits calculated reflect the value of time saved due to a reduction in incident detection and clearance time.

ASSUMPTIONS

A number of assumptions were necessary for the calculation of the benefits. The assumptions are as follows:

- Peak hour traffic is 10 percent of average daily traffic.
- The directional distribution is 60 percent in the peak direction, and 40 percent in the off-peak direction.
- The number of accidents in the peak hour is based on the accident rate and the volume on the segment. Thus, as is implied by the previous two assumptions, 10 percent of the accidents each day occur in the peak hour, with 6 percent in the peak direction and 4 percent in the off-peak direction.
- Daily benefits are based on 2 peak hours per day (a.m. and p.m.).
- Annual benefits are based on 250 days per year (5 days per week, 50 weeks per year).
- For every accident recorded in the state accident statistics, there are 5 incidents (such as flat tires, stalled cars) that are not recorded.
- An accident in one direction affects flow in the other direction due to rubbernecking. For every minute of delay in the direction of the accident, 0.25 minutes of delay result in the opposite direction.
- Commercial vehicles comprise 5 percent of the traffic and are valued at $25 per hour.
- Passenger vehicles comprise 95 percent of the traffic and are valued at $10 per hour.
- All vehicles in the peak hour benefit from the eight minute reduction in delay per incident. This assumption is made to simplify the estimation of benefits. It is recognized that in actuality, the number of vehicles benefiting from an eight minute reduction in incident delay would depend on the duration of the incident. On one hand, this assumption overstates the benefits because all of the vehicles in the peak hour would not be expected to benefit from an eight minute reduction in incident delay for many of the shorter incidents. On the other hand, the overstatement with respect to the number of vehicles affected may be offset by the fact that for each minute that capacity is reduced due to an incident, up to five minutes of delay may result due to vehicle queuing effects.

EQUATIONS

The equations that describe the calculation of the benefits are as follows:

For the time saved in the peak direction in the peak hour for each minute of incident related delay eliminated:

$$T_P = V_P * [I_P * (1\ minute) + I_O * (0.25\ minute)]$$

Where T_P = Time saved in peak hour in peak direction (in minutes)
V_P = Peak direction peak hour volume
I_P = Number of incidents in peak hour in peak direction
I_O = Number of incidents in peak hour in off-peak direction

For the time saved in the off-peak direction in the peak hour for each minute of incident related delay eliminated:

$$T_O = V_O * [I_O * (1\ minute) + I_P * (0.25\ minute)]$$

Where T_o = Time saved in peak hour in off-peak direction (in minutes)
V_o = Off-peak direction peak hour volume
I_P = Number of incidents in peak hour in peak direction
I_O = Number of incidents in peak hour in off-peak direction

Converting this to an annual dollar value:

$$Annual\ benefit\ =\ [T_P + T_O] * \frac{1hour}{60min} * [(.95)\frac{\$10}{hour} + (.05)\frac{\$25}{hour}] * \frac{2\ peak\ hours}{day} * \frac{250\ days}{year}$$

DATA SOURCES

The benefits calculated for each segment depend on the average volume of the facility segment (the number of vehicles affected), and the accident rate (the probability that an incident will occur). Volumes and accident rates used are based on data provided by Kansas Department of Transportation (KDOT) and Missouri Highway and Transportation Department (MHTD).

Volumes are based on 1994 average annual daily traffic (AADT) values. An average value for the segment was taken, when necessary.

The calculation of accident rates varies slightly between the two states. In Kansas, KDOT accident data was provided for the five year period from 1989 through 1993. Accident data is compiled by KDOT for each facility, by county. High frequency accident spots and high frequency accident segments are also identified. High frequency accidents spots are segments (0.1 mile long in urban areas and 0.3 miles long in rural areas) for which the accident rate exceeds the critical accident rate. The critical accident rate is the 95 percentile accident rate for similar roadways in the state. High frequency accident sections are roadway segments that include a number of high accident spots. The length of high accident sections varies, depending on a variety of things, such as geometric characteristics and jurisdictional boundaries.

For the calculation of the accident rate on a given segment, the weighted average accident rate was calculated. This calculation was based on the length and accident rate in the high frequency accident section, as well as the length and accident rate for portions of the facility not in a high accident section. The average accident rate for the county for a certain facility was assumed to be the accident rate for the portions of the facility not in the high accident section.

In Missouri, data from MHTD's Accident Master database was provided for each facility. This data included information about every accident, by milepost, for a one year period (1994 for Jackson County, 1993 for Cass, Clay and Platte Counties).

RESULTS

Tables 6-2 and 6-3 summarize the estimation of benefits for Kansas and Missouri, respectively.

B.2 Estimation of Costs

The estimated cost for each phase was calculated based on the following assumptions.

Roadway Surveillance Equipment - Roadway surveillance equipment includes:
- CCTV:
  - $30,000 each site
  - 1 site each 0.5 miles
- Detection:
  - $10,000 each site
  - 1 site each 0.5 miles

Variable Message Signs - Variable message signs include:
- Large fiber optic variable message signs
- 3 rows, 18 characters per row, 18" characters
- $120,000 per sign
- Quantities based on locations identified for deployment (Chapter 7)

Highway Advisory Radio - Highway advisory radio includes:
- Permanent installations
- AM Radio
- $17,000 per transmitter
- $3,000 per sign
- Quantities based on locations identified for deployment (Chapter 7)

Field Processors - Field processors include:
- Non-intelligent Processors, $10,000 per processor (for example, a Type 170 controller)
- 1 processor per 0.5 miles

Traffic Operations Center (TOC) - TOC consists of:
- New facility built on DOT property

Building sized for ultimate system size
10,000 square foot facility
1 facility
$110 per square foot

Central Hardware - Central hardware includes:

$50,000 per 15 miles of controlled freeway

(Console $5,000, 2 video monitors at $5,000, Computer Workstation $10,000, Miscellaneous $25,000).

$800,000 base

(Video displays $300,000, Two Servers plus Information Server, $400,000, Miscellaneous $100,000).

Software and Systems Integration - Software and Systems Integration includes:

$1,000,000 Phase 1
$250,000 Phase 2 (incremental cost)
$125,000 Phase 3 (incremental cost)
$125,000 Level 4 (incremental cost)

Annual Operating and Maintenance Costs - Annual operating and maintenance costs include:

Traffic Operations Personnel for 1 TOC:

Phase 1 System - 2 operators/shift
Phase 2 System - 2 operators/shift (incremental), 4 total
Phase 3 System - 3 operators/shift (incremental), 7 total
Phase 4 System - 3 operators/shift (incremental), 10 total
3.5 shifts (3 shifts plus 1/2 shift coverage) for 24 hour coverage
$50,000 per year (fully burdened) per operator

Maintenance Personnel for 1 TOC

Phase 1 System - 5 maintenance people/shift
(4 Field maintainers and 1 TOC maintainer)
Phase 2 System - 3 maintenance people/shift (incremental)
Total 8 maintenance people/shift
(7 Field maintainers and 1 TOC maintainer)

Phase 3 System - - 7 maintenance people/shift (incremental)
Total 15 maintenance people/shift
(13 Field maintainers and 2 TOC maintainers)
1 shift
$50,000 per year (fully burdened) per maintainer

Phase 4 System - - 7 maintenance people /shift (incremental)
Total 22 maintenance people/shift
(20 Field maintainers and 2 TOC maintainers)
1 shift
$50,000 per year (fully burdened) per maintainer

Replacement Parts and Spare Equipment:

Approximately 5 percent of Hardware Costs (all capital costs except the software cost and cost for TOC)