

APPENDIX C

COST CALCULATIONS FOR EACH DESIGN ALTERNATIVE

CALCULATION OF ALTERNATE SYSTEMS' DOLLAR COSTS

The dollar costs to implement, operate, and maintain each of the three alternate architectures were calculated for each of the three time-frames/level of deployment under consideration: Short-Term (22 miles); Medium-term (35 miles); and Long-term (52 miles). These costs are summarized in Table C-1, and itemized in the following text. It should be noted that for evaluation purposes, a uniform equivalent annual cash flow was calculated for each design alternative ($C_{\text{annualized}}$). As formulated below, this consisted of each design's capital costs (C_{capital}) annualized over a time period of fifteen years (assumed interest rate = 6%), and then added to each design's estimated annual operating costs ($C_{\text{operating}}$) and estimated annual maintenance costs ($C_{\text{maintenance}}$).

$$C_{\text{annualized}} = (C_{\text{capital}} \times \text{CRF}_{15,6\%}) + C_{\text{operating}} + C_{\text{maintenance}}$$

Where, $\text{CRF}_{15,6\%}$ (= 0.10) is the Capital Recovery Factor of a cost that is annualized at 6% interest over a time period of fifteen years.

Estimated Capital Costs

Roadway Surveillance Equipment

For each alternate design:

CCTV: \$30,000 per site; To be located every mile:

Short-Term = 22 sites; Medium-term = 35 sites; Long-term = 52 sites

Detection: \$10,000 per site; **To** be located every one-half mile:

Short-Term = 44 sites; Medium-term = 70 sites; Long-term = 104 sites

Variable Message Signs

Large fiber-optic type (3 rows, 18 characters/row, 18" characters): \$145,000/sign

SHORT-TERM = 8 variable message signs (VMS):

US-131: Southbound: After West River Drive

Northbound: Prior to 44th Street

I-196: Eastbound: Prior to 44th Street

Prior to US- 131

Westbound: Prior to US- 131

I-96: Eastbound: Prior to M-11

Westbound: Prior to 28th Street

Prior to M-37

MEDIUM-TERM = 13 variable message signs (VMS); the above 8 plus:

US-131: Southbound: After **I-96** interchange

Northbound: Prior to Franklin Street Interchange

Prior to **I-96**

I-96 / I- 196 interchange: Eastbound I-96

I-96/US 131 interchange: Eastbound **I-96**

LONG-TERM = 20 variable message signs (VMS); the above 13 plus:

| | | |
|---------|-------------|---|
| US-131: | Southbound: | After Post Drive Prior to Burton Street |
| | Northbound: | At southern project boundary After Burton Street |
| I-96: | Eastbound: | Prior to Eastern M- 11 interchange |
| | Westbound: | Prior to Plainfield Avenue |
| I-196: | Eastbound: | After Chicago Drive |

Relocate 2 signs: \$150,000 total (\$75,000 each).

Communications

For each alternate design:

SHORT-TERM: \$240,000/mile including fiber optic cable, conduit, pullboxes, installation, and termination.

MEDIUM-TERM: \$210,000/mile including fiber optic cable, conduit, pullboxes, installation, and termination.

LONG-TERM: \$193,000/mile including fiber optic cable, conduit, pullboxes, installation, and termination.

Highway Advisory Radio

Permanent AM Radio installation for each alternate design: \$20,000 per site

SHORT-TERM = 10 sites

MEDIUM-TERM = 10 sites

LONG-TERM = 11 sites

Sign installation: \$5,000 per sign, 32 signs total

Field Data Processing Equipment

For Alternate A:

Non-intelligent Processors: \$10,000/processor; To be located every 0.5 miles

Short-Term = 44 sites; Medium-term = 72 sites; Long-term = 104 sites

For Alternate B and Alternate C:

Intelligent Processors: \$20,000/processor; To be located every 0.5 miles

Short-Term = 44 sites; Medium-term = 72 sites; Long-term = 104 sites

Operations Center

All alternate designs are for a new facility to be built on state-owned property. All building sizes assume enough space to accommodate the long-term system (52 miles of coverage).

For Alternate A.

Centralized facility with room for traffic operations, emergency management, and transit operators: 10,000 ft² facility at \$110 / ft²

For Alternate B:

Decentralized facility to handle traffic operations only: 6,000 ft² facility at \$110 / ft²

For Alternate C:

Hybrid facility with room for traffic operations and emergency personnel: 7,000 ft² facility at \$110 / ft²

Central Hardware

Each alternative includes the following costs, plus the costs at the base:

\$50,000/25 miles of controlled freeway; Including \$5,000 for a console, \$10,000 for two video monitors, \$10,000 for one computer workstation, and \$25,000 for miscellaneous items.

For Alternate A (Centralized):

\$650,000 at base; This consists of \$300,000 for video displays, \$250,000 for the central computer, and \$100,000 for miscellaneous items.

For Alternate B (Decentralized):

\$440,000 at base; This consists of \$300,000 for video displays, \$40,000 for central servers, and \$100,000 for miscellaneous items.

For Alternate C (Hybrid):

\$500,000 at base; This consists of \$300,000 for video displays, \$40,000 for central servers, and \$100,000 for miscellaneous items.

Software

For Alternative A:

Short-Term = \$750,000; Medium-term = \$1,000,000; Long-term = \$1,250,000

For Alternate B:

Short-Term = \$500,000; Medium-term = \$750,000; Long-term = \$900,000

For Alternate C:

Short-Term = \$600,000; Medium-term = \$850,000; Long-term = \$1,000,000

Estimated Annual Operating Costs

For each alternative design, annual operating costs were estimated to include 4 positions; manager, assistant manager, operator, and secretarial/clerical. The manager is estimated at \$50,000/year, the assistant manager is estimated at \$45,000/year, the operator is estimated at \$30,000/year, and the secretary/clerk is estimated at \$32,000/year.

For Alternate A (with traffic, emergency, and transit):

Short-term = 1 manager, 3 operators, and a part-time secretary/clerk; Medium-term = 1 manager, 5 operators, and a part-time secretary/clerk; Long-term = 1 manager, 1 assistant manager, 8 operators, and a part-time secretary/clerk.

For Alternate B (traffic only):

Short-term = 1 manager, 2 operators, and a part-time secretary/clerk; Medium-term = 1 manager, 4 operators, and a part-time secretary/clerk; Long-term = 1 manager, 1 assistant manager, 4 operators, and a part-time secretary/clerk.

For Alternate C (traffic and some emergency):

Short-term = 1 manager, 2 operators, and a part-time secretary/clerk; Medium-term = 1 manager, 4 operators, and a part-time secretary/clerk; Long-term = 1 manager, 1 assistant manager, 6 operators, and a part-time secretary/clerk.

Estimated Annual Maintenance Costs

Maintenance Personnel

For each alternative design, annual maintenance personnel costs were estimated to be \$35,000 per year per maintainer. Assuming adequate field maintainers and control center maintainers for one shift, the total number of maintainers estimated to be needed for each alternative and for each time frame are:

For Alternate A (with traffic, emergency, and transit):

Short-term = 3 maintainers; Medium-term = 4 maintainers needed; Long-term = 5 maintainers needed

For Alternate B traffic only):

Short-term = 2 maintainers needed; Medium-term = 2 maintainers needed; Long-term = 3 maintainers needed

For Alternate C traffic and some emergency):

Short-term = 3 maintainers needed; Medium-term = 3 maintainers needed; Long-term = 4 maintainers needed

Factory Repair and Spare Equipment

For each alternative design, the annual costs for factory repair and spare equipment were assumed to be approximately 5% and 3%, respectively, of hardware costs.

The estimated annual operating and maintenance costs are shown in Table C-2.

CALCULATION OF ALTERNATE SYSTEMS COST UTILITIES

Chapter 4 summarized the basic methodology used to convert the above dollar costs into utility factors. The actual values used are shown in Table C-3.

Table C-1 Estimated Capital Costs per Phase and Alternative

| # of miles: | Short-Term | | | Medium-Term | | | Long-Term | | | |
|---|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | A | B | C | A | B | C | A | B | C | |
| | 22 | 22 | 22 | 35 | 35 | 35 | 52 | 52 | 52 | |
| Roadway Surveillance Equip. | | | | | | | | | | |
| CCTV: | cost/site | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 |
| | freq./mile (# of sites) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Total | \$0.66 | \$0.66 | \$0.66 | \$1.05 | \$1.05 | \$1.05 | \$1.56 | \$1.56 | \$1.56 |
| Detection: | cost/site | \$0.010 | \$0.010 | \$0.010 | \$0.010 | \$0.010 | \$0.010 | \$0.010 | \$0.010 | \$0.010 |
| | freq./mile | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Total | \$0.44 | \$0.44 | \$0.44 | \$0.70 | \$0.70 | \$0.70 | \$1.04 | \$1.04 | \$1.04 |
| Variable Message Signs | | | | | | | | | | |
| | Cost/site | \$0.145 | \$0.145 | \$0.145 | \$0.145 | \$0.145 | \$0.145 | \$0.145 | \$0.145 | \$0.145 |
| | freq./mile | 8 | 8 | 8 | 13 | 13 | 13 | 20 | 20 | 20 |
| | Total | \$1.16 | \$1.16 | \$1.16 | \$1.89 | \$1.89 | \$1.89 | \$2.90 | \$2.90 | \$2.90 |
| | Relocate 2 Signs | \$0.15 | \$0.15 | \$0.15 |
| Communications | | | | | | | | | | |
| | cost/mile | \$0.240 | \$0.240 | \$0.240 | \$0.210 | \$0.210 | \$0.210 | \$0.240 | \$0.240 | \$0.240 |
| | Cost: | \$5.28 | \$5.28 | \$5.28 | \$7.35 | \$7.35 | \$7.35 | \$10.04 | \$10.04 | \$10.04 |
| Highway Advisory Radio | | | | | | | | | | |
| Transmitters | Cost/site | \$0.020 | \$0.020 | \$0.020 | \$0.020 | \$0.020 | \$0.020 | \$0.020 | \$0.020 | \$0.020 |
| | # of sites | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 |
| | Total | \$0.20 | \$0.20 | \$0.20 | \$0.20 | \$0.20 | \$0.20 | \$0.22 | \$0.22 | \$0.22 |
| HAR Signs | Cost/sign | \$0.005 | \$0.005 | \$0.005 | \$0.005 | \$0.005 | \$0.005 | \$0.005 | \$0.005 | \$0.005 |
| | # of signs | 29 | 29 | 29 | 29 | 29 | 29 | 32 | 32 | 32 |
| | Total | \$0.15 | \$0.15 | \$0.15 | \$0.15 | \$0.15 | \$0.15 | \$0.16 | \$0.16 | \$0.16 |
| Field Data Processing Equipment | | | | | | | | | | |
| Non-Intlgnt: | \$/processor | \$0.010 | | | \$0.010 | | | \$0.010 | | |
| | freq./mile | 2 | | | 2 | | | 2 | | |
| | Total | \$0.44 | | | \$0.70 | | | \$1.04 | | |
| Intelligent: | \$/processor | | \$0.020 | \$0.020 | | \$0.020 | \$0.020 | | \$0.020 | \$0.020 |
| | freq./mile | | 2 | 2 | | 2 | 2 | | 2 | 2 |
| | Total | | \$0.88 | \$0.88 | | \$1.40 | \$1.40 | | \$2.08 | \$2.08 |
| Operations Center | | | | | | | | | | |
| | cost/sq.ft. | \$110 | \$110 | \$110 | \$110 | \$110 | \$110 | \$110 | \$110 | \$110 |
| | sq.ft./center | 10,000 | 6,000 | 7,000 | 10,000 | 6,000 | 7,000 | 10,000 | 6,000 | 7,000 |
| | Total | \$1.10 | \$0.66 | \$0.77 | \$1.10 | \$0.66 | \$0.77 | \$1.10 | \$0.66 | \$0.77 |
| Central Hardware (Distrib. Center) | | | | | | | | | | |
| Centralized: | base cost | \$0.650 | | | \$0.650 | | | \$0.650 | | |
| | cost/mile | \$0.002 | | | \$0.002 | | | \$0.002 | | |
| | Total | \$0.69 | | | \$0.72 | | | \$0.75 | | |
| Distributed/ Hybrid: | base cost | | \$0.440 | \$0.500 | | \$0.440 | \$0.500 | | \$0.440 | \$0.500 |
| | cost/mile | | \$0.002 | \$0.002 | | \$0.002 | \$0.002 | | \$0.002 | \$0.002 |
| | Total | | \$0.48 | \$0.54 | | \$0.51 | \$0.57 | | \$0.54 | \$0.60 |
| Software | | | | | | | | | | |
| | Cost: | \$0.75 | \$0.50 | \$0.60 | \$1.00 | \$0.75 | \$0.85 | \$1.25 | \$0.90 | \$1.00 |
| Subtotals for 15-Yr. Life | | | | | | | | | | |
| | Contingency 10% | \$1.10 | \$1.06 | \$1.08 | \$1.50 | \$1.48 | \$1.51 | \$2.02 | \$2.02 | \$2.05 |
| | Design and Implementation | \$1.87 | \$1.79 | \$1.84 | \$2.83 | \$2.80 | \$2.85 | \$3.93 | \$3.94 | \$3.99 |
| | Capital Recovery Factor (6%) | 0.10296 | 0.10296 | 0.10296 | 0.10296 | 0.10296 | 0.10296 | 0.10296 | 0.10296 | 0.10296 |
| Annualized Capital Costs | | | | | | | | | | |
| | | \$1.44 | \$1.38 | \$1.42 | \$1.99 | \$1.96 | \$2.00 | \$2.69 | \$2.70 | \$2.73 |

Note: All costs are in millions of dollars except operations center in dollars/square foot.

| | Short-Term | | | Medium-Term | | | Long-Term | | |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | A | B | C | A | B | C | A | B | C |
| Operations Center Personnel | | | | | | | | | |
| Manager | \$0.050 | \$0.050 | \$0.050 | \$0.050 | \$0.050 | \$0.050 | \$0.050 | \$0.050 | \$0.050 |
| # of managers | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total | \$0.050 |
| Assistant Manager | | | | | | | \$0.045 | \$0.045 | \$0.045 |
| # of asst. managers | | | | | | | 1 | 1 | 1 |
| Total | | | | | | | \$0.045 | \$0.045 | \$0.045 |
| Operator | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 | \$0.030 |
| # of Operator | 3 | 2 | 2 | 5 | 4 | 4 | 8 | 4 | 6 |
| Total | \$0.090 | \$0.060 | \$0.060 | \$0.150 | \$0.120 | \$0.120 | \$0.240 | \$0.120 | \$0.180 |
| Secretary/Clerical | \$0.032 | \$0.032 | \$0.032 | \$0.032 | \$0.032 | \$0.032 | \$0.032 | \$0.032 | \$0.032 |
| # of Sec./Clerks | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Total | \$0.016 |
| Motorist Assistance Patrol | | | | | | | | | |
| Total | \$0.175 |
| Maintenance Personnel | | | | | | | | | |
| cost/maintainer | \$0.035 | \$0.035 | \$0.035 | \$0.035 | \$0.035 | \$0.035 | \$0.035 | \$0.035 | \$0.035 |
| # of maintainers | 3 | 2 | 3 | 4 | 2 | 3 | 5 | 3 | 4 |
| Total | \$0.11 | \$0.07 | \$0.11 | \$0.14 | \$0.07 | \$0.11 | \$0.18 | \$0.11 | \$0.14 |
| Factory Repair & Spare Equipment (calculated as a percent of hardware costs) | | | | | | | | | |
| Factory Repair % | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% |
| hardware cap. costs | \$2.61 | \$3.28 | \$3.89 | \$3.56 | \$4.75 | \$4.81 | \$4.81 | \$6.68 | \$6.74 |
| Total | \$0.13 | \$0.16 | \$0.19 | \$0.18 | \$0.24 | \$0.24 | \$0.24 | \$0.33 | \$0.34 |
| Spare Parts % | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% |
| hardware cap. costs | \$3.16 | \$3.83 | \$3.89 | \$4.45 | \$5.64 | \$5.70 | \$6.18 | \$8.05 | \$8.11 |
| Total | \$0.09 | \$0.11 | \$0.12 | \$0.13 | \$0.17 | \$0.17 | \$0.19 | \$0.24 | \$0.24 |
| Total Annual Operating and Maintenance Costs | \$0.66 | \$0.65 | \$0.72 | \$0.84 | \$0.84 | \$0.88 | \$1.13 | \$1.09 | \$1.19 |

| | Short-Term | | | Medium-Term | | | Long-Term | | |
|---------------------|------------|---------|---------|-------------|---------|---------|-----------|---------|---------|
| | A | B | C | A | B | C | A | B | C |
| Capital: | \$11.02 | \$10.56 | \$10.83 | \$15.00 | \$14.80 | \$15.07 | \$20.21 | \$20.25 | \$20.52 |
| % of Greatest | 0.54 | 0.51 | 0.53 | 0.73 | 0.72 | 0.73 | 0.98 | 0.99 | 1.00 |
| Utility Factor: | 4.6 | 4.9 | 4.7 | 2.7 | 2.8 | 2.7 | 0.2 | 0.1 | 0.0 |
| Operating: | \$0.16 | \$0.13 | \$0.13 | \$0.22 | \$0.19 | \$0.19 | \$0.35 | \$0.23 | \$0.29 |
| % of Greatest | 0.44 | 0.36 | 0.36 | 0.62 | 0.53 | 0.53 | 1.00 | 0.66 | 0.83 |
| Utility Factor: | 5.6 | 6.4 | 6.4 | 3.8 | 4.7 | 4.7 | 0.0 | 3.4 | 1.7 |
| Maintenance: | \$0.33 | \$0.35 | \$0.42 | \$0.45 | \$0.48 | \$0.52 | \$0.60 | \$0.68 | \$0.72 |
| % of Greatest | 0.46 | 0.48 | 0.58 | 0.63 | 0.66 | 0.72 | 0.83 | 0.94 | 1.00 |
| Utility Factor: | 5.4 | 5.2 | 4.2 | 3.7 | 3.4 | 2.8 | 1.7 | 0.6 | 0.0 |