# Replacing Intelligent Transportation System Field Elements: A Survey of State Practice

*Requested by*
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# Executive Summary

## Background

Intelligent transportation system (ITS) field elements include such components as closed circuit TVs, variable message signs, highway advisory radio hardware, loop detectors and ramp meters. An important part of the ITS field element life cycle is the repair or replacement of in-service equipment when it has reached the end of its useful life.

Caltrans requires a better understanding of how other state departments of transportation (DOTs) fund the replacement of ITS field elements. This knowledge will inform possible changes in practice in California. With little existing information available online, CTC & Associates conducted a national survey of DOTs that examined the agencies' practices in replacing ITS field elements as well as related issues of planning, funding and technology service life.

## Summary of Findings

### Survey of State Practice

A survey was distributed to representatives of systems management and operations departments of state DOTs across the country to seek information about state practices on the replacement of ITS field elements.

Sixteen state DOTs responded to the survey: Alabama, Arkansas, Idaho, Michigan, Nebraska, Nevada, New Jersey, New Mexico, North Carolina, North Dakota, Oregon, Pennsylvania, Vermont, Washington State, West Virginia and Wisconsin.

Complete findings are presented in **Appendix A** of this Preliminary Investigation.

Funding the Replacement of ITS Elements

Respondents were asked to identify the typical source of funding for replacing ITS equipment as well as the alternative funding source when the typical source is not available.

- Typical Funding

  Prompted to identify DOT funding program (i.e., "through capital funding or some other funding program?"), the most common response (from six states) was a combination of maintenance and capital funding. Three states indicated capital funding only, and one indicated maintenance only.

  Five states answered this question not in terms of internal funding programs but in terms of external sources, such as state versus federal funding. Among these there was no clear trend between state funding, federal funding, or a combination of state and federal. One state indicated partner funding as the typical source.

- Alternative Funding

  The most common alternative funding source (among four states) was maintenance. Other individual states listed capital, safety or special project funding, and two states reporting a combination of funding sources.

In one state, nonroutine maintenance is budgeted whereas in another, securing alternative funding is an "ongoing dilemma." In addition, three states indicated that an alternative funding source wasn't needed, whether due to the young age of the equipment or careful planning.

Maintenance Limitations

Respondents were asked to explain limitations placed on their maintenance offices with respect to funding ITS field element replacement and to performing replacement work.

- Permissible Maintenance Funding

  The most common response from the states was that maintenance may fund ITS field element replacement on a limited or as-needed basis. States noted the competition among maintenance dollars for other maintenance work and the limited nature of maintenance budgets.

  This question also revealed that several states are struggling to meet replacement needs. One cited a lack of resources, another does not have capital improvement dollars, and a third described the issue as a challenge.

  Some respondents addressed additional funding imitations not related to maintenance, such as contracting and procurement rules and regional limitations.

- Permissible Maintenance Work

  When describing ITS field element work that their maintenance offices may perform, respondents were asked to distinguish between repair work compared with enhancements and upgrades.

  Only one state responded that its maintenance office may only perform repairs on ITS field elements. Four states allowed limited upgrade work, such as for smaller components, noninvasive procedures or replacement of critical devices. Eight states either did not limit the type of work allowed or reported such limitations were not categorical but instead based on such factors as budget, staffing or time of year.

ITS Management Plans

Respondents were asked if their agencies had ITS management plans and to share them if possible. Seven states did not have any such plans, though some have plans or related documentation in development. Two states provided planning documents related to ITS management, with one providing a number of additional ITS policy and operational documentation.

ITS Replacement Cycles

Respondents were asked to provide planned replacement cycles for ITS field elements. Eleven respondents did not have planned replacement cycles; two of these states are developing them.

Four states provided either planned or expected replacement cycles. The following summary table tabulated and averages values for ITS technologies noted by two or more of these four states:

| Planned or Expected ITS Equipment Replacement Cycles (Years) | | | | | |
|---|---|---|---|---|---|
| **ITS Technology** | **Nebraska** | **North Carolina** | **Oregon** | **Washington State** | **Average** |
| **Dynamic Message Signs** | 10 to 15 | 10 | 20 | 20 | **16** |
| **Automatic Gates** | >10 | | | 25 (“Reversible Roadway System”) | **18** |
| **Roadway Weather Information Systems** | >10 | | 15 | 25 | **17** |
| **Anti-Icing Systems** | 10 | | | 8 | **9** |
| **Closed-Captioned TV Cameras** | | 7 | 10 | 20 | **12** |
| **Weigh-in-Motion** | | 7 | | 10 | **9** |
| **Detectors** | | 5 | 10 | 10 (“Permanent Traffic Recorder”) | **8** |
| **Fiber Optic Cable** | | 20 | | 20 | **20** |
| **Ramp Meters** | | | 30 | 25 | **28** |
| **Highway Advisory Radio** | | | 10 | 20 | **15** |

*Comparison of Planned and Actual Cycles*

When asked how closely actual replacement cycles matched planned cycles, there was no clear trend among the three responding states: Two indicated that it varied, and one said that actual cycles are generally longer than planned.

## Additional Resources

Though little information was available online, following are selected resources related to ITS equipment maintenance and replacement. These include national and state research and guidance found separate of the survey effort.

National

A 2007 Federal Highway Administration (FHWA) guide details system engineering for ITS. It includes a “V” Systems Engineering Model that includes key activities related to retirement/replacement for ITS.

A transportation management center (TMC) pooled fund study published a 2002 guide for practitioners on how to “systematically integrate maintenance into their program planning, resource allocation, policies, system planning and design, and other related activities.”

State

Relevant citations were identified for six states that address the issues of ITS maintenance and replacement:

- **Arizona.** A Phoenix metropolitan area freeway management system master plan cites FHWA’s systems engineering “V” diagram.
- **Kentucky.** A 2004 maintenance and operations plan for ITS includes best practices such as a cost database, maintenance and staffing analyses, and prioritization of maintenance needs.
- **Michigan.** A 2015 report on costs and benefits of Michigan DOT’s ITS deployments includes recent benefit-cost calculations and identifies the most cost-effective technologies.
- **New Jersey.** A 2009 report describes a “state-of-the art and practical ITS inspection and maintenance manual” and “user friendly software tool” developed for New Jersey DOT.
- **North Carolina.** A 2010 report for Research Triangle partners, including North Carolina DOT, addresses the importance of planning for ITS replacement and retirement, an “often-overlooked phase” of ITS deployment.
- **Oregon.** A presentation at the 2000 ITS America conference describes a long-range maintenance plan for Oregon DOT’s existing and planned ITS infrastructure.

## Gaps in Findings

The survey results presented in this Preliminary Investigation only represent those states responding to this survey. There are likely to be noteworthy practices among the states that did not respond. However, given a response rate of nearly one-third of all states, it is reasonable to think that trends may hold across the nation.

For the survey questions addressing ITS management plans and planned ITS replacement cycles, some respondents indicated that development of documentation was in progress. It is possible that checking in with these states after a period of time would yield more results.

## Next Steps

Other states’ rationales and decisions underlying the survey information provided here would likely be of significant interest to Caltrans. A thorough review of the individual responses may prompt the customer team to reach out to individual state contacts to learn more about a particular policy or practice of immediate interest.

In addition, the existing data on planned or expected life may serve as a basis for further investigation. A more detailed or systematic study of maintenance, repair and replacement cycles—ideal as well as actual—would likely serve Caltrans and all highway operators. This would help define benchmarks to better determine how actual replacement cycles compare with planned cycles. Such data would help improve planning and budgeting for ITS field element replacement.

# Detailed Findings

## Survey of State Practice

To gather information about the replacement of ITS field elements, we conducted a survey of state DOTs, distributing the survey to each state's primary member (typically the voting member) of the AASHTO Highway Subcommittee on Transportation Systems Management and Operations (http://stsmo.transportation.org/Pages/SSOMMembershipandOrganization.aspx). For two states we had to look beyond this committee to find the proper person to survey.

Respondents were provided examples of what was meant by ITS field elements (closed-circuit TVs, variable message signs, highway advisory radio hardware, loop detectors, ramp meters, and similar equipment) and asked to forward the survey to the person best equipped to answer the survey questions.

The survey consisted of the following questions:

1. How does your agency typically fund the replacement of *ITS field elements*? Through capital funding or some other funding program?

2. If your typical funding source (described in your answer above) is not available when ITS field elements need to be replaced, what *alternative funding method(s)* does your agency use for replacement?

3. What are your agency's rules or limitations (if any) on *spending maintenance funds for capital replacement of ITS field elements*?

4. What are your agency's limitations (if any) on the *type of work that maintenance is allowed to complete* for ITS field elements? Repairs only, or are systems enhancements/upgrades allowed?

5. If your agency has an *ITS management plan*, please paste a link to it here or email the file to brian.hirt@ctcandassociates.com.

6. Does your agency have *planned replacement cycles* for the ITS field elements that it uses? (Yes or No)

   If so, please specify the planned replacement cycles for the different field elements. (Please list below or email to brian.hirt@ctcandassociates.com.)

7. If you answered yes to the previous question, how close do the *actual replacement periods* come to the planned periods?

We sent one reminder email and received 16 responses from the following state DOTs:

- Alabama.
- Arkansas.
- Idaho.
- Michigan.
- Nebraska.
- Nevada.
- New Jersey.
- New Mexico.
- North Carolina.
- North Dakota.
- Oregon.
- Pennsylvania.
- Vermont.
- Washington State.
- West Virginia.
- Wisconsin.

We followed up by phone and email with selected states (Nebraska, Oregon and Washington) for clarification. The additional information is included with each state's full response in **Appendix A**.

Key findings from the survey and follow-up discussions follow.

## Funding the Replacement of ITS Elements

### Typical Funding

Respondents were asked how their agencies typically fund the replacement of ITS field elements. The question wording prompted a distinction by DOT program (i.e., "through capital funding or some other funding program?"), but respondents also parsed their responses based on a distinction between state and federal sources of funds:

- By DOT funding program, some combination of sources was most common. Among those seven DOTs, six included "maintenance" as one of the multiple funding sources.
- For the respondents who described the external funding source (typically state or federal) rather than the DOT funding program, there was no clear trend of state versus federal.

| Typical Funding Source for Replacement | |
|---|---|
| **Funding Program** | **Agency** |
| **Maintenance** | **Alabama** |
| **Capital** | **Arkansas**, **Nebraska**, **New Jersey** |
| **ITS Bureau Operating Budget** | **New Mexico** |
| **Combination** | **Michigan:** Mostly capital. Selected assets through operations/maintenance to maintain system availability of 85%.<br>**Nevada**, **North Carolina:** Capital and maintenance.<br>**North Dakota:** Capital for midlife repairs; construction for replacement and new installations.<br>**Oregon:** Typically capital, sometimes maintenance.<br>**Washington State:** 25% maintenance, 25% operations, 50% capital (estimates).<br>**Wisconsin:** Planned replacement through a construction improvement project or as part of an annual ITS budget designated for improvements not included in the six-year construction plan; unplanned through maintenance. |
| **External Source** | **Agency** |
| **State Funds** | **West Virginia** |
| **Federal Funds** | **Idaho:** Federal aid/State Transportation Improvement Program (STIP). |
| **Combination of State and Federal** | **New Jersey**, **Vermont** |
| **Partner Funding** | **Pennsylvania** |

## Alternative Funding

A follow-up question asked respondents what alternative funding source was used for ITS field element replacement if the typical source was not available. The most common alternative funding source is maintenance. This can be budgeted as with Michigan or a "fallback" as with Washington State. North Carolina called this an "ongoing dilemma."

Three states indicated that an alternative funding source wasn't needed, whether due to the young age of the equipment (Nevada) or careful planning (New Mexico and Wisconsin).

**Alternative Funding Source for Replacement**

| Source | Agency |
|---|---|
| **Maintenance** | **Nebraska**, **Oregon**<br>**Michigan:** Maintenance budget for ITS has a "nonroutine maintenance" line item for critical system/component failure contingencies beyond maintenance contract terms.<br>**Pennsylvania**: Replaced "less expensive" devices with maintenance contracts. |
| **Capital** | **Idaho** |
| **Safety** | **Vermont** |
| **Special Project Funding** | **Alabama** |
| **Combination** | **North Carolina:** This is an "ongoing dilemma"; would pursue capital improvement, federal Congestion Mitigation and Air Quality Improvement (CMAQ) funding if eligible, and direct allocation from statewide maintenance.<br>**Washington State:** Maintenance and operations are fallbacks for emergent end-of-life. |
| **Not Needed** | **Nevada:** ITS infrastructure not at an age to cause replacement funding issues.<br>**New Mexico:** Careful monitoring and replacement scheduling to avoid shortfalls.<br>**Wisconsin:** Have historically been able to address our ITS replacements in the above referenced budgets. |

## Maintenance Limitations

The customer team was particularly interested in limitations placed on DOTs' maintenance offices with respect to ITS field element replacement. This includes limitations on funding as well as limitations on permissible fieldwork.

### Permissible Maintenance Funding

When states described limitations on maintenance office funding for ITS field equipment replacement, it appeared that several are struggling to meet replacement needs with nonideal funding levels. Pennsylvania cited a "lack of resources," Alabama has "no capital improvement dollars," and North Carolina stated that "this is challenge."

The most common response from the states was that maintenance may fund ITS field element replacement on a limited or as-needed basis. States noted the competition among maintenance dollars for other maintenance work (Washington State, North Carolina) and the limited nature of maintenance budgets (Oregon, Pennsylvania):

- **Washington State:** There are no firm rules but cultural expectations that such funding is for emergent needs and not to impact other maintenance needs. Washington State historically spends $2.5 million annually on the maintenance and repair of ITS field elements, some of which are capital expenditures.
- **Nebraska:** "If it needs to be fixed, we'll find the money."
- **North Carolina:** Maintenance funds for ITS must compete with all other maintenance needs. "This is a challenge considering North Carolina DOT maintains over 80,000 miles of roads."
- **North Dakota:** There is no routine maintenance budget; the work is performed as needed.
- **Oregon:** This is limited by budget. When maintenance funding is used, it is typically for a small project.
- **Pennsylvania:** There is limited funding for ITS maintenance "caused by lack of resources to use maintenance funds for capital replacement."
- **Wisconsin:** The only limitation is that federal funds may not be used for operations-and-management-related expenses.

Two states addressed regional limitations in particular:

- **Alabama:** This is limited regionally. There are no capital improvement dollars at this time.
- **Michigan:** There is no rule per se, but each region ITS coordinator must manage the budget based on a finite amount of nonroutine maintenance money.

Other states expanded on limitations not directly related to maintenance:

- **New Mexico:** Maintenance versus construction is not a distinction within the ITS Bureau. There are price agreements in place for contractors to provide and install equipment, or to install DOT-supplied equipment.
- **New Jersey:** There are in-house procurement rules. Monetary thresholds dictate the amount and complexity of the quotes the agency must request.
- **Vermont:** There is one authorized "bucket" per year for ITS.
- **West Virginia:** The agency uses safety funding for such work.

### Permissible Maintenance Work

Survey respondents also provided information on the type of work that their maintenance departments are allowed to complete for ITS field elements. The question prompted respondents to provide possible distinctions between repair work compared with enhancements and upgrades.

Just one state (West Virginia) noted that only repairs are allowed.

Four states indicated that maintenance staff primarily performs repairs but can do limited upgrade work, such as for smaller components (Michigan), noninvasive procedures (North Dakota) or replacement of critical devices (Pennsylvania):

- **Michigan** can upgrade some individual smaller components during maintenance.
- **Nebraska** typically repairs, but upgrades if repair is not possible.
- **North Dakota** repairs only, but will install noninvasive upgrades or enhancements.
- **Pennsylvania** focuses on repairs, but allows for replacement of critical devices.

Eight states either did not limit the type of work allowed, or reported such limitations were not categorical but instead based on such factors as budget, staffing or time of year:

- **Nevada** and **New Mexico** allow repairs and enhancements/upgrades.
- Three states noted staff limitations:
    - **Oregon** has no limitation by policy, but work must comply with state standards; engineering may be needed. In addition, work is self-limiting to small projects due to remaining maintenance workload.
    - **Wisconsin**'s only limitation is that work that involves major geometric or roadway improvements may not be performed by maintenance forces.
    - **Vermont** uses field staff and temporary workers to perform basic maintenance (cleaning cabinets and cameras, resetting power).
- Two states noted funding limitations:
    - **Washington State** allows repairs and enhancements. If state labor is involved, funding is limited to $60,000 per location (normal conditions) or $100,000 per location (emergency conditions).
    - **North Carolina** is limited only by funding available.
- One state noted calendar limitations:
    - **Alabama** reported that routine maintenance takes precedence in the first eight months of the fiscal year. A forecast of anticipated surplus budget is then taken and utilized to replace inventory reserves or conduct system expansion.

## ITS Management Plans

Respondents were asked if their agencies had ITS management plans, and to share them if possible.

Among the states that answered this question, seven did not have ITS management plans: Alabama, Idaho, Nebraska, New Mexico, North Dakota, Oregon and Pennsylvania.

Some among these states mentioned plans to develop one or alternative documentation in progress:

- **Nebraska** is working on a request for proposals for a statewide device maintenance contract.
- **Oregon** has plans to work on an ITS program plan to pull together and update various documentation, but does not have anything to share at this point. An older Oregon ITS plan from 2000 is cited in the **Additional Resources** section of this Preliminary Investigation.
- **New Mexico** has procedures for ITS operations, but not for equipment maintenance and repair.
- **Pennsylvania** is looking to obtain a more robust ITS asset management system than currently available. The goal is to identify which of the "5 R's" (repair, refurbish, replace, relocate, remove) to apply to each device.

Two states provided planning documents related to ITS management:

- **Wisconsin**'s Traffic Operations Infrastructure Plan was completed in 2008 and will be implemented through 2016. Wisconsin is currently developing a traffic infrastructure process that will evaluate system needs annually and fund the identified ITS infrastructure in the budgets referenced above.

  Wisconsin DOT Traffic Operations Infrastructure Plan, 2008
  http://www.topslab.wisc.edu/its/toip/finalreport.php

- **Washington State** provided a number of ITS management policies and plans. The document addressing the full range of ITS is:

  Washington State DOT Statewide Intelligent Transportation Systems (ITS) Plan, 2009
  http://www.wsdot.wa.gov/partners/prtpo/docs/materials/ITSPlan32409.pdf

  This plan addresses the state's vision and goals for ITS, the current state of deployment and future plans.

  Washington State provided additional documents that address policies and procedures for individual ITS technologies. These include the following:

  - Variable Message Signs: Overview, Guidance, Operations.
  - Highway Advisory Radio (HAR) Policy, 2002.
  - AMBER Alert Standard Operating Procedures (SOPS).
  - Traffic Analysis Procedures Manual.

  Washington State also provided the following strategic planning documents:

  - 511 Strategic Plan, 2007.
  - Corridor Sketch Initiative.
  - ITS Communications & Wireless Technology, 2010-2020 Strategic Plan.
  - Traffic Operations Centers: WSDOT's 2009-2019 Strategic Plan.
  - Traffic Operations Division (Program Q) Strategic Implementation Plan 2009-2011.

  The nine PDFs listed above constitute several hundred pages and are being delivered to Caltrans separately rather than as appendices to this Preliminary Investigation.

## ITS Replacement Cycles

### Planned Cycles

Eleven respondents indicated that their states did not have planned replacement cycles for ITS field elements: Alabama, Arkansas, Idaho, Michigan, Nevada, New Jersey, North Dakota, Pennsylvania, Vermont, West Virginia and Wisconsin.

Two of these states (Idaho and Michigan) indicated that they are developing life cycles and replacement cycles. West Virginia stated that it “fixes equipment when it’s broken.”

**Nebraska** wrote in correspondence that its “replacement cycle is based on the useful life of the device. We will accelerate the replacement of a specific type of device if we notice problems cropping up on other units. At the same time, we’ll relax the replacement schedule if we’re approaching the end of the useful life and have had no issues, relatively, with those units.”

Nebraska wrote further:

- We anticipate over 10 years for DMS [dynamic message signs]. As long as Daktronics is around, should be closer to 15.
- Cameras are hard to predict as the camera itself is just replaced at need. The tower and other infrastructures are usually not replaced, so 10-plus years noncamera items on the camera tower.
- Automated gates should last over 10 years with individual component replacement as needed.
- RWIS is the same as gates. Construction projects force replacement through demolition activities.
- Anti-icing devices have been around for 10 years with yearly maintenance.

North Carolina provided the following expected replacement life cycles:

- Dynamic message signs: 10 years.
- CCTV cameras: 7 years.
- Weigh-in-motion: 7 years.
- Detectors: 5 years.
- Fiber optic cable: 20 years.

Oregon emailed a table showing the life cycle estimates it uses for planning purposes. The table is an estimate of the annual investment required to keep up with aging infrastructure.

| Devices | Existing Inventory | Expected Life (Years) | Annual Replacement (#) | Unit Cost ($) | Total Cost ($) |
|---|---|---|---|---|---|
| **Signals** | | | | | |
| Traffic Signals | 1,480 | 40 | 37.000 | $250,000.00 | $9,250,000 |
| Detection Loops | 30,000 | 10 | 3000.000 | $500.00 | $1,500,000 |
| Ramp Meters | 142 | 30 | 4.733 | $100,000.00 | $473,333 |
| Intersection Flashers | 95 | 20 | 4.750 | $75,000.00 | $356,250 |
| Hazard Beacons | 2,000 | 15 | 133.333 | $12,000.00 | $1,600,000 |
| | | | | | |
| **Signs** | | | | | |
| Major Signs | 13,803 | 15 | 920.200 | $680.00 | $625,736 |
| Minor Signs | 144,763 | 15 | 9650.867 | $76.00 | $733,466 |
| Major Sign Supports | 3,615 | 50 | 72.300 | $9,000.00 | $650,700 |
| Minor Sign Supports | 99,556 | 10 | 9955.600 | $115.00 | $1,144,894 |
| | | | | | |
| **Lighting** | | | | | |
| Roadway Lighting | 21,000 | 40 | 525.0 | 8,500 | 4,462,500 |
| Tunnel Lighting | 9 | 40 | 0.2 | 1,000,000 | 225,000 |
| | | | | **SSI Total** | **$21,021,879** |
| **ITS** | | | | | |
| VMS Type 1 | 61 | 20 | 3.050 | $100,000.00 | $305,000 |
| VMS Type 2 | 21 | 20 | 1.050 | $55,000.00 | $57,750 |
| VMS Type 4 | 16 | 20 | 0.800 | $30,000.00 | $24,000 |
| Bridge (1 & 2) | 37 | 40 | 0.925 | $120,000.00 | $111,000 |
| Cantilever (1 & 2) | 19 | 40 | 0.475 | $100,000.00 | $47,500 |
| Butterfly/Cantilever (4) | 15 | 40 | 0.375 | $35,000.00 | $13,125 |
| Butterfly, Type 1 | 11 | 40 | 0.275 | $70,000.00 | $19,250 |
| Butterfly, Type 2 | 13 | 40 | 0.325 | $60,000.00 | $19,500 |
| Cameras | 301 | 10 | 30.100 | $12,000.00 | $361,200 |
| Camera Poles | 274 | 50 | 5.480 | $12,000.00 | $65,760 |
| RWIS | 94 | 15 | 6.267 | $30,000.00 | $188,000 |
| HAR | 76 | 10 | 7.600 | $40,000.00 | $304,000 |
| HAR Beacon Signs | 54 | 10 | 5.400 | $10,000.00 | $54,000 |
| Snow Zone Signs | 17 | 15 | 1.133 | $75,000.00 | $85,000 |
| Call Box | 2 | 15 | 0.133 | $10,000.00 | $1,333 |
| Weather Warning Systems | 12 | 10 | 1.200 | $30,000.00 | $36,000 |
| | | | | **ITS Total** | **1,692,418** |
| | | | | **Total** | **$22,714,298*** |

The totals in the right column are the estimated average annual costs to maintain the current inventory levels by replacing equipment at expected rates.

Oregon clarified that under the "ITS" section in the table above, the first three items (VMS Types 1, 2 and 4) are the variable message signs themselves, and the next items are the support structures (bridge-, cantilever- and butterfly-style supports).

Washington State noted that while nothing is officially documented, there are cultural practices and planning guides available. These are provided as appendices to this Preliminary Investigation:

- **Appendix B**: WSDOT Highway System Plan — Major Electrical Systems.
  This 2007 draft document addresses the "major electrical systems that WSDOT is responsible for maintaining and operating." On page 20 of the plan is a table of major electrical system inventory and funding needs, and included in this table are estimated expected life cycles.

**Table 1**
**Major Electrical System Inventory / Funding Needs**

| Major Electrical System Item | Unit | Projected Inventory (As of June 2007) | Average Cost (Dollars) | Expected Life-Cycle (Years) | Replacement Cost (During Next 20 Years) |
|---|---|---|---|---|---|
| Traffic Signal Systems | ea. | 965 | $ 240,000 | 25 | $ 185,280,000 |
| Ramp Meter Systems | ea. | 138 | $ 50,000 | 25 | $ 5,520,000 |
| Illumination Systems | ea. | 2,933 | $ 125,000 | 40 | $ 183,312,500 |
| Tunnel and Bridge Electrical Systems | ea. | 5 | $ 2,000,000 | 20 | $ 10,000,000 |
| Dynamic Message Signs (DMS) Systems | ea. | 185 | $ 175,000 | 20 | $ 32,375,000 |
| Highway Advisory Radio (HAR) Systems | ea. | 182 | $ 35,000 | 20 | $ 6,370,000 |
| Closed Circuit Television (CCTV) Cameras Systems | ea. | 502 | $ 35,000 | 20 | $ 17,570,000 |
| Data Station Systems | ea. | 479 | $ 45,000 | 25 | $ 17,244,000 |
| Permanent Traffic Recorder (PTR) Systems | ea. | 110 | $ 30,000 | 10 | $ 6,600,000 |
| Animal Warning Systems | ea. | 6 | $ 70,000 | 10 | $ 840,000 |
| Automated Anti-Icing Systems | ea. | 8 | $ 700,000 | 10 | $ 11,200,000 |
| Fiber Optic Communication Systems | miles | 220 | $ 150,000 | 20 | $ 33,000,000 |
| Communication Hubs | ea. | 30 | $ 200,000 | 20 | $ 6,000,000 |
| Other Communication Systems, (Emergency Telephone, Ethernet, DSL, T1) | miles | 250 | $ 50,000 | 20 | $ 12,500,000 |
| Wireless Communication Systems | ea. (# sites) | 125 | $ 100,000 | 15 | $ 16,666,667 |
| Roadway/Weather Information Systems (RWIS) | ea. | 94 | $ 50,000 | 25 | $ 3,760,000 |
| Transit Signal Priority (TSP) Systems | ea. | 10 | $ 20,000 | 10 | $ 400,000 |
| CVISN Program / Weigh in Motion(WIM) Systems | ea. (# sites) | 13 | $ 50,000 | 10 | $ 1,300,000 |
| Statewide Traveler Information System, (Web(traffic/roads), 511, Traffic TV) | ea. | 1 | $ 1,000,000 | 10 | $ 2,000,000 |
| Traffic System Management Centers (TSMC), (Electronic Equipment, Communication Media and Systems necessary to operate and obtain information from field devices) | ea. (# sites) | 8 | $ 2,000,000 | 10 | $ 32,000,000 |
| Tolling and Electronic Payment Systems | ea. | 2 | $ 1,000,000 | 10 | $ 4,000,000 |
| ITS Systems for Freight Mobility (Ports / Border Crossings / On Board Trucks) | ea. | 1 | $ 3,000,000 | 10 | $ 6,000,000 |
| Reversible Roadway System (I5 & I90, Seattle Area) | ea. (# sites) | 2 | $ 3,000,000 | 25 | $ 4,800,000 |
| **Total Replacement Cost for All Major Electrical Systems Items** | | | | | **$ 598,738,167** |
| **Total Cost per Biennium for All Major Electrical System Items** (Not Adjusted for Inflation) | | | | | **$ 59,873,817** |

- **Appendix C**: WSDOT Major Electrical (P3) Project Prioritization Process Criteria.
  This five-step guide to "the prioritization of major electrical (P3) projects" includes guidance on assessing the replacement needs of specific ITS components based on age, repair history and risk.

## Averages

Among the four states (Nebraska, North Carolina, Oregon and Washington) that provided replacement cycles, we tabulated values for ITS equipment types noted by two or more states. A blank in this table indicates that a state did not provide information for the equipment type.

**Planned or Expected ITS Equipment Replacement Cycles (Years)**

| ITS Technology | Nebraska | North Carolina | Oregon | Washington State | Average |
|---|---|---|---|---|---|
| **Dynamic Message Signs** | 10 to 15 | 10 | 20 | 20 | **16** |
| **Automatic Gates** | >10 | | | 25 (“Reversible Roadway System”) | **18** |
| **Roadway Weather Information Systems** | >10 | | 15 | 25 | **17** |
| **Anti-Icing Systems** | 10 | | | 8 | **9** |
| **Closed Captioned TV Cameras** | | 7 | 10 | 20 | **12** |
| **Weigh-in-Motion** | | 7 | | 10 | **9** |
| **Detectors** | | 5 | 10 | 10 (“Permanent Traffic Recorder”) | **8** |
| **Fiber Optic Cable** | | 20 | | 20 | **20** |
| **Ramp Meters** | | | 30 | 25 | **28** |
| **Highway Advisory Radio** | | | 10 | 20 | **15** |

## Comparison of Planned and Actual Cycles

We asked survey respondents how closely actual replacement cycles matched their planned cycles. Three states responded, with no clear trend among the three:

- **Michigan.** Actual replacement cycles are generally longer than planned.
- **North Carolina.** It varies annually based on available funding.
- **Oregon.** It can be longer or shorter, still driven by actual conditions. Circumstances like manufacturers going out of business or a marine environment can shorten the time to replacement.

# Additional Resources

Following are selected resources related to ITS equipment maintenance and replacement. These include national and state research and guidance.

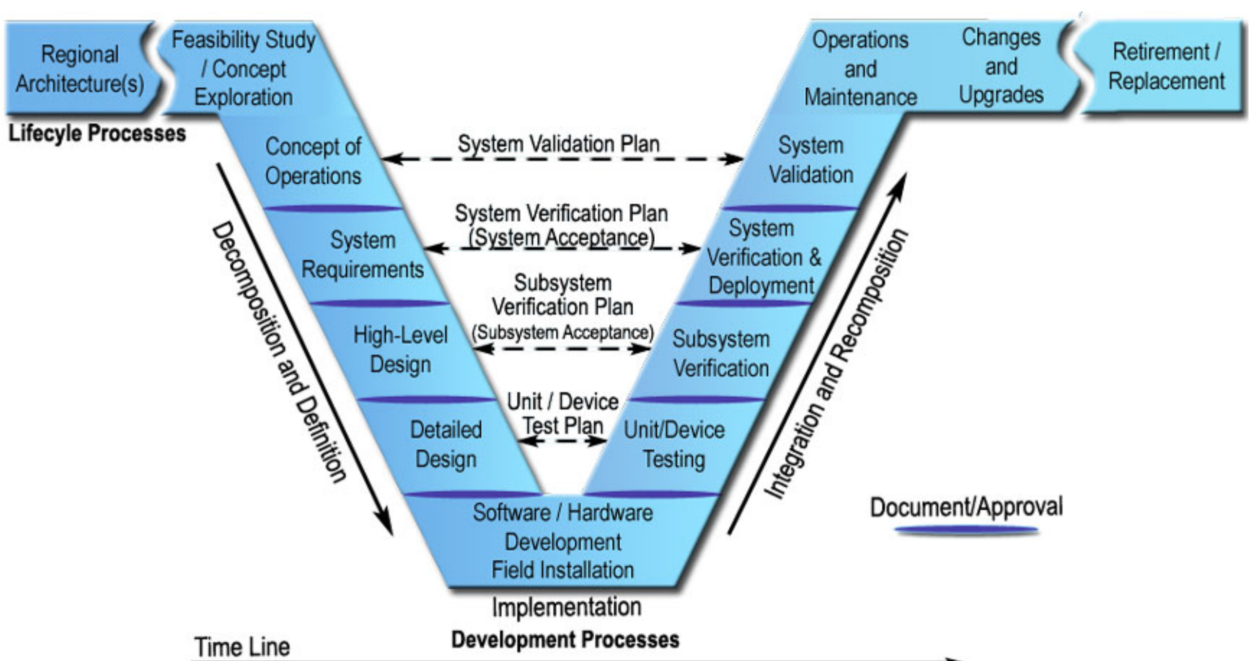
## National

**System Engineering for Intelligent Transportation Systems: An Introduction for Transportation Professionals**, FHWA, 2007.
http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf

From the purpose statement of this report (page 6):

> This guide is intended to introduce you to systems engineering and provide a basic understanding of how it can be applied to planning, designing, and implementing intelligent transportation systems (ITS) projects. The guide leads you step by step through the project life cycle and describes the systems engineering approach at each step. It describes how to begin implementing the systems engineering approach on your next ITS project and incorporate it more broadly into your organization's business processes and practices.

Chapter 3.3 presents the "V" Systems Engineering Model (page 11). This systems engineering approach defines project requirements before technology choices are made and the system is implemented.




Chapter 4.11 (starting on page 81) discusses the end of the "V" diagram at the top-right: "Retirement/Replacement."

> **4.11 Retirement/Replacement**
> In this step: Operation of the ITS system is periodically assessed to determine its efficiency. If the cost to operate and maintain the system exceeds the cost to develop a new ITS

system, the existing system becomes a candidate for replacement. A system retirement plan will be generated to retire the existing system gracefully.

### 4.11.1 Overview

Systems are retired from service for a variety of reasons. Perhaps the system is being replaced by a newer system, or maybe the Concept of Operations has changed such that stakeholder needs are going to be met in an alternative manner that will no longer require use of the system. For example, the emergency call boxes that currently dot many of the nation's highways are beginning to be retired because their usage has decreased dramatically due to widespread use of cell phones. Many of the first-generation ITS systems are twenty years old and approaching the end of their useful life. Regardless of the reason for the retirement of the system, you should make sure that everything is wrapped up (e.g., hardware and software inventory identified for disposal is audited, final software images are captured, and documentation is archived), the contract is closed properly, and the disposal of the system is planned and executed.

### 4.11.2 Key Activities

This step represents the end of the system life cycle – the retirement and disposal of the ITS system. An important characteristic of the systems engineering process is the planning of all events; the retirement of the system should be planned as well.

The retirement plan should include a complete inventory of all software and hardware, final system and documentation configurations, and other information that captures the final operational status of the system. This should include identification of ownership so that owners can be given the option to keep their equipment and use it elsewhere. It should also include how the system and documentation will be disposed of, including an assessment and plan if special security measures should be in place or if there are environmental concerns that might dictate the site of disposal. You should also plan to erase the content of all storage devices to protect any personal data that might pose privacy concerns. The retirement plan should be reviewed and approved by all parties, including the agency or contractor providing O&M, the owner of the system (if different), and other key personnel.

If the system to be retired is not documented as well as it should be, steps are taken to capture all necessary data and reverse engineer interfaces and any system configuration information that is needed to support a replacement system. Existing databases may need to be exported and translated into a format suitable for the replacement system.

The next activity is to execute the retirement plan and record the results. It's also a good idea to hold a "lessons learned" meeting that includes suggested system improvements. All recommendations should be archived for reference in future system disposals. The O&M contract should be officially closed out if one exists.

### 4.11.3 Outputs

A system retirement plan will be generated that describes the strategy for removing the system from operation and disposing of it. Its execution will result in the retirement of the ITS system. The final system configuration, including hardware, software, and operational information, will be documented and archived, together with a list of "lessons learned".

**Transportation Management Center (TMC) Pooled Fund Study**
http://tmcpfs.ops.fhwa.dot.gov/index.htm

From the web site:

> The TMC pooled fund study is intended to identify and address the key issues and challenges that are common among TMCs. Any agency or authority responsible for managing travel on portions of the surface transportation system is eligible to join and participate in the pooled fund study.

According to the web site, Caltrans is currently a member of this pooled fund. Among the activities, the report most relevant to this Preliminary Investigation follows:

> **Guidelines for Transportation Management Systems Maintenance Concept and Plans**, FHWA, TMC Pooled Fund Study, 2002.
> http://ops.fhwa.dot.gov/docs/tmsmaintcptandplans/report-info.htm
> As noted in the introduction, this report seeks to provide "detailed information that could guide practitioners on how to systematically integrate maintenance into their program planning, resource allocation, policies, system planning and design, and other related activities that occur throughout the TMS life-cycle. This document provides this guidance and identifies:
>
> - How to identify, justify, and document the potential components of a maintenance program. Such a program can provide the necessary resources, environment, policies, procedures, and support services needed to maintain a TMS.
> - A multi-year maintenance program plan, including the (a) potential components, (b) processes, (c) stakeholders to be involved, and (d) resources required to support the program.
> - The idea of a 'maintenance concept,' the appropriate elements comprising a maintenance concept, how the maintenance concept can be used to develop system and functional requirements, and how the maintenance concept can be used to develop an operations concept for TMS.
> - Policies, procedures, system and functional requirements, equipment, resources, and services, and other potential activities needed to maintain and support the TMS."

# State

## Arizona

**Freeway Management System (FMS) Communications Master Plan for the Phoenix Metropolitan Area**, Arizona DOT, 2010.
http://azdot.gov/docs/default-source/business/fms-commmstrplan-20100823.pdf?sfvrsn=2

From the executive summary:

> This Arizona Department of Transportation (ADOT) Freeway Management System (FMS) Communications Master Plan document was created as part of the solution to address issues of technology compatibility, upgrades to obsolete infrastructure and equipment, as well as integration of existing technology with new equipment deployments for the Phoenix Metropolitan Area.

Figure 4-1 on page 12 is a system engineering “V” diagram. It shows where retirement/replacement fits in the entire system engineering life cycle (at the top right of the “V”). This “V” diagram is discussed in FHWA’s 2007 System Engineering for Intelligent Transportation Systems: An Introduction for Transportation Professionals cited in detail in the **National** section of this Preliminary Investigation.

## Kentucky

**Maintenance and Operations Plan for Intelligent Transportation Systems in Kentucky**, Jennifer Walton and Joseph Crabtree, Kentucky Transportation Center, 2004.
http://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1211&context=ktc_researchreports
ITS maintenance and operations best practices described in this report include the following topics:

- Document Maintenance and Operations Activities.
- Develop and Maintain a Cost Database for Maintenance and Operations.
- Analyze Maintenance and Operations Requirements.
- Analyze Staffing Requirements for Maintenance and Operations.
- Develop a Training Program for Maintenance and Operations Personnel.
- Prioritize Maintenance Needs.
- Develop and Maintain a Spare Parts Inventory.
- Develop a Maintenance Plan.
- Develop an Operations Manual.

## Michigan

**Costs and Benefits of MDOT Intelligent Transportation System Deployments**, Western Michigan University, 2015.
http://www.michigan.gov/documents/mdot/RC1631_495995_7.pdf
This report analyzes costs and benefits of ITS devices used by the Michigan Department of Transportation and identifies those that are most cost-effective. This report may be of interest to Caltrans as a very recent study with up-to-date ITS equipment costs. The report uses a standard replacement value of 20 years for all ITS systems.

## New Jersey

**Manual of Guidelines for Inspection and Maintenance of Intelligent Transportation Systems**, Kaan Ozbay, Eren Erman Ozguven, Tolga Sertel, Tim Bourne, Nazhat Aboobaker, Bruce Littleton and V. Kivanc Caglar, submitted to TRB Annual Meeting, Washington, D.C., 2009.
http://rits.rutgers.edu/files/trb_09-3124_manual_of_guidelines_for_inspection_and_maintenance_of_intelligent_transportation_systems.pdf

From the abstract:

> Rutgers University, in close collaboration with Orth-Rodgers and Associates, Inc., developed a state-of-the art and practical ITS inspection and maintenance manual, and implemented this manual in the form of a user friendly software tool. This tool provides New Jersey DOT with complete, practical and efficient inspection procedures for the proper installation and preventive or routine maintenance of ITS equipment. The initial feedback

after several hands-on training workshops from the first group of expert users of the manual and its software is found to be very positive and encouraging.

## North Carolina

**ITS System Replacement Report: A Systematic Approach for Scheduling Replacements for ITS Devices and Systems**, Intelligent Transportation System Strategic Deployment Plan Update. Kimley-Horn for Triangle ITS Communications Partners (including North Carolina DOT and FHWA), 2010.
http://www.itre.ncsu.edu/Public/documents/FAMPO-ITS-SDP/Statewide-Final-System-Replacement-Report.pdf

From the introduction:

> The last phase of a typical systems engineering process is system retirement and replacement. This often-overlooked phase is particularly important for intelligent transportation systems (ITS) because of the use of technologies with definite lifecycles and the rapidly changing pace of technology.
>
> The purpose of this report is to provide guidance in developing a replacement plan for a system and guidance in making the decision to continue, upgrade, replace, or retire a system or sub-system. This report will also present information on the expected useful life of various ITS components.

The contents in this five-page publication include typical life cycles for different ITS components and the replacement approach, incorporating a replacement plan and a replacement decision graph.

Page 1 of this report also provides typical life cycles for select ITS field elements. These are slightly higher than North Carolina DOT's survey responses.

| Typical ITS Equipment Life Cycles (Years) | | |
|---|---|---|
| **ITS Technology** | **North Carolina DOT's Survey Response** | **Kimley Horn Report for NCDOT and Partners** |
| **Dynamic Message Signs** | **10** | **10-15** |
| **Closed-Circuit TVs** | **7** | **10-15** |

## Oregon

**Oregon Department of Transportation ITS Maintenance Plan: Addressing the True Maintenance and Organizational Requirements**, Christopher Strong and Kevin Haas, ITS America 10th Annual Meeting and Exposition: Revolutionary Thinking, Real Results, 2000. Citation at http://trid.trb.org/view.aspx?id=655787

From the abstract:

> One critical, but often neglected, element in the successful operation of Intelligent Transportation Systems (ITS) is how they should be maintained after deployment. Failure to adequately maintain the ITS infrastructure may result in poor operations and may accelerate device replacement schedules, lessening the realizable benefits of ITS. Recognizing this, the Oregon Department of Transportation (ODOT) partnered with the Western Transportation Institute at Montana State University-Bozeman (WTI-MSU) to develop a long-range maintenance plan for ODOTs existing and planned ITS infrastructure. The plan was initiated as a companion effort to the Oregon Intelligent Transportation Systems Strategic Plan: 1997-2017, which identified statewide ITS deployment technologies and practices over the next twenty years.

# Appendix A: Survey Results

The full text of each survey response is provided below. For reference, we have included an abbreviated version of each question before the response; for the full question text, please see page 6 of this Preliminary Investigation.

We followed up by phone or email with the listed contact of three states (Nebraska, Oregon and Washington State) for clarification. The additional information is included with each state's full response in this appendix.

## Alabama

Contact: Chris Hilyer, State ITS Program Manager, Alabama DOT, 334-353-6003, hilyerc@dot.state.al.us.

1. **How is ITS field element replacement funded?** Routine maintenance budget.
2. **Alternative funding source if typical source is unavailable?** Special project funding.
3. **Limitations on using maintenance funds for ITS field element replacement?** Typically the routine maintenance dollars are limited on a regional scale. Mission critical systems always take priority. There are no capital improvement dollars allocated at this time.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Routine maintenance takes precedence the first 8 months of the FY. A forecast of anticipated surplus budget is then taken and utilized to replace inventory reserves or conduct system expansion.
5. **Agency ITS management plan?** No plan exists at this time.
6. **Planned replacement cycles? Please specify.** No.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## Arkansas

Contact: Joseph D. Hawkins, Staff Traffic Engineer, Arkansas State Highway and Transportation Department, 501-569-2567, joseph.hawkins@ahtd.ar.gov.

1. **How is ITS field element replacement funded?** Capital Outlay Budget.
2. **Alternative funding source if typical source is unavailable?** None.
3. **Limitations on using maintenance funds for ITS field element replacement?** (No response.)
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** No limitations. All maintenance has traditionally been performed by Highway Department.
5. **Agency ITS management plan?** (No response.)
6. **Planned replacement cycles? Please specify.** No.

7. **How close do actual replacement periods come to planned periods?** (No response.)

## Idaho

Contact: Nestor Fernandez, Mobility Services Engineer, Idaho Transportation Department, 208-334-8488, nestor.fernandez@itd.idaho.gov.

1. **How is ITS field element replacement funded?** A federal-aid project is established yearly on the STIP to operate, maintain and replace ITS field devices/element.
2. **Alternative funding source if typical source is unavailable?** If necessary, we can resource to available capital equipment.
3. **Limitations on using maintenance funds for ITS field element replacement?** The department has not looked into this with the fact that there is a project in the STIP.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Under the ITS project funding, elements enhancements/upgrades can be covered.
5. **Agency ITS management plan?** We currently do not have one.
6. **Planned replacement cycles? Please specify.** No. We are currently working on establishing a life cycle for the field equipment/elements.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## Michigan

Contact: Matt Smith, ITS Program Administrator, Michigan DOT, 248-361-2470, smithm81@michigan.gov.

1. **How is ITS field element replacement funded?** Most ITS field elements are replaced through capital funding. However, some individual CCTV, and many communications components, are replaced through ongoing operations and maintenance costs so we maintain a system availability of 85%.
2. **Alternative funding source if typical source is unavailable?** Our maintenance budget for ITS has a "non-routine maintenance" line item that can be used as a contingency in case of a critical system/component failure that falls outside of our maintenance contract terms. Large-scale replacement of multiple assets only happens through our 5-year project planning process.
3. **Limitations on using maintenance funds for ITS field element replacement?** There are no rules per se, except for the amount of "non-routine" maintenance money available. Each region ITS coordinator must manage their budget with this in mind; once the "non-routine" maintenance money is depleted, the only option is to wait for a longer-term follow-on project.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** During maintenance, we can upgrade some individual smaller components, such as CCTV, digital encoders, and most communication components.

5. **Agency ITS management plan?** (No response.)
6. **Planned replacement cycles? Please specify.** Yes. We are finalizing the replacement cycles, so they are not available for distribution yet.
7. **How close do actual replacement periods come to planned periods?** The actual replacement periods were actually generally longer than the planned replacement cycles (which is expected asset obsolesce). We are modifying our replacement cycle information to reflect this reality.

## Nebraska

Contact: Austin Yates, ITS Engineer, Nebraska Department of Roads, 402-479-4771, austin.yates@nebraska.gov.

1. **How is ITS field element replacement funded?** Capital funds.
2. **Alternative funding source if typical source is unavailable?** Maintenance funds.
3. **Limitations on using maintenance funds for ITS field element replacement?** If it needs to be fixed, we'll find the money.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Typically repairs but upgrades if repair is not possible.
5. **Agency ITS management plan?** We're working on an RFP for a statewide device maintenance contract.
6. **Planned replacement cycles? Please specify.** Yes.
7. **How close do actual replacement periods come to planned periods?** (No response.)

   **Follow-up email with Austin Yates:**

   Our replacement cycle is based on the useful life of the device. We will accelerate the replacement of a specific type of device if we notice problems cropping up on other units. At the same time, we'll relax the replacement schedule if we're approaching the end of the useful life and have had no issues, relatively, with those units.

   I've spoken to the ITS program team and this is what we have:

   - We anticipate over 10 years for DMS. As long as Daktronics is around should be closer to 15.
   - Cameras are hard to predict as the camera itself is just replaced at need. The tower and other infrastructures are usually not replaced, so 10+ years non-camera items on the camera tower.
   - Automated gates should last over 10 years with individual component replacement as needed.
   - RWIS is the same as gates. Construction projects force replacement through demolition activities.
   - Anti-icing devices have been around for 10 years with yearly maintenance.

## Nevada

Contact: Thomas Moore, Assistant Chief Traffic Engineer, Nevada DOT, 775-888-7566, tmoore@dot.state.nv.us.

1. **How is ITS field element replacement funded?** Both capital and maintenance funding sources.
2. **Alternative funding source if typical source is unavailable?** Our ITS infrastructure has not reached an age that is causing funding issues associated with replacements.
3. **Limitations on using maintenance funds for ITS field element replacement?** (No response.)
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Repairs, enhancements and upgrades.
5. **Agency ITS management plan?** (No response.)
6. **Planned replacement cycles? Please specify.** No.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## New Jersey

Contact: Tim Bourne, Supervising Engineer, New Jersey DOT, 856-486-6702, tim.bourne@dot.nj.gov .

1. **How is ITS field element replacement funded?** Through capital funding (some state, some federal).
2. **Alternative funding source if typical source is unavailable?** If federal is not available, then state.
3. **Limitations on using maintenance funds for ITS field element replacement?** We are guided by in-house procurement rules as to in-house purchases for ITS field elements. There are certain monetary thresholds that dictate the amount and complexity of the quotes we must request.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** (No response.)
5. **Agency ITS management plan?** (No response)
6. **Planned replacement cycles? Please specify.** No.
7. **How close do actual replacement periods come to planned periods?** (No response)

## New Mexico

Contact: Charles Remkes, Manager, ITS Operations, New Mexico DOT, 505-222-6554, charles.remkes@state.nm.us.

1. **How is ITS field element replacement funded?** The ITS Bureau's operating budget is typically used for equipment replacement/repair.
2. **Alternative funding source if typical source is unavailable?** We monitor our budget carefully and try to schedule replacements well in advance to ensure no shortfall of funding. We typically reserve enough for unanticipated needs.
3. **Limitations on using maintenance funds for ITS field element replacement?** Within the ITS Bureau, our funding classification isn't for maintenance or construction it's broken down into either contractual services or equipment. We have price agreements in place where a contractor can provide equipment and install it as well as another agreement for them to install Department supplied equipment.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Both are allowed.
5. **Agency ITS management plan?** Not so much an ITS Management Plan; we have procedures in place for ITS Operations, but not for our equipment maintenance / repair. We coordinate closely with our OEM to schedule and maintain either controller upgrades or latest version for firmware installation.
6. **Planned replacement cycles? Please specify.** No. See above.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## North Carolina

Contact: Greg Fuller, State ITS and Signals Engineer, North Carolina DOT, 919-661-5800, gfuller@ncdot.gov.

1. **How is ITS field element replacement funded?** Combination of some capital projects and available maintenance monies.
2. **Alternative funding source if typical source is unavailable?** We will pursue a capital improvement project, CMAQ [federal Congestion Mitigation and Air Quality Improvement program] (if eligible) and a direct allocation from statewide maintenance program. This is an ongoing dilemma for us in North Carolina.
3. **Limitations on using maintenance funds for ITS field element replacement?** These limited maintenance funds must compete against other needs such as pavement repairs, mowing, delineation, signing, signals, guardrail, drainage, etc. This is a challenge considering NCDOT maintains over 80,000 miles of roads.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** There are no limitations other than available funding for system enhancements and upgrades. See previous response.
5. **Agency ITS management plan?** (No response.)
6. **Planned replacement cycles? Please specify.** Yes.

- Dynamic Message Signs - 10 years.
- CCTV Cameras - 7 years.
- Weigh-in-Motion - 7 years.
- Detectors - 5 years.
- Fiber Optic Cable - 20 years.

7. **How close do actual replacement periods come to planned periods?** Varies each fiscal year based upon available funding.

## North Dakota

Contact: Travis Lutman, Engineer, North Dakota DOT, 701-328-4274, tlutman@nd.gov.

1. **How is ITS field element replacement funded?** Capital funds are used for repairs during the life of the device. Federal and State funds from the construction budget are used to replace devices as end of life and new installs. We do have 1.25 million dollar ITS budget for end of life replacement and new installs of ESS, cameras, and DMS.
2. **Alternative funding source if typical source is unavailable?** We will replace or do a maintenance project using Federal and state funds from our construction budget.
3. **Limitations on using maintenance funds for ITS field element replacement?** We do not have a budget for routine maintenance and parts replacement; it is on an as needed basis.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Our maintenance crews usually do repairs only. IF the upgrade or enhancement is not invasive they will install it.
5. **Agency ITS management plan?** We currently do not have an ITS Management plan.
6. **Planned replacement cycles? Please specify.** No.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## Oregon

Contact: Galen McGill, System Operations and ITS Manager, Oregon DOT, 503-986-4486, galen.e.mcgill@odot.state.or.us.

1. **How is ITS field element replacement funded?** Typically through capital funding; although sometimes with maintenance funding.
2. **Alternative funding source if typical source is unavailable?** Maintenance Funding.
3. **Limitations on using maintenance funds for ITS field element replacement?** There are no rules preventing it. The limitation is primarily budget. We already have more needs than can be addressed with maintenance funding. We have used maintenance funding to replace a small VMS on an existing structure or to upgrade some RWIS equipment. When maintenance funding is used, it is typically for a small project.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** No limitations by policy. Work needs to comply with statewide standards

and depending on type of work, it may need engineering. Work is somewhat self-limited as maintenance staff only have time for fairly small projects due to other maintenance work load.

5. **Agency ITS management plan?** We have plans to work on an ITS Program plan to update and pull together and update various documentation, but I don't have anything really useful to share at this point.
6. **Planned replacement cycles? Please specify.** Yes. I will email a separate document.

**Follow-up email with Galen McGill:**

The attached table shows our lifecycle estimates we use for planning purposes. The table is an estimate of the annual investment required to keep up with aging infrastructure.

| Devices | Existing Inventory | Expected Life (Years) | Annual Replacement (#) | Unit Cost ($) | Total Cost ($) |
|---|---|---|---|---|---|
| **Signals** | | | | | |
| Traffic Signals | 1,480 | 40 | 37.000 | $250,000.00 | $9,250,000 |
| Detection Loops | 30,000 | 10 | 3000.000 | $500.00 | $1,500,000 |
| Ramp Meters | 142 | 30 | 4.733 | $100,000.00 | $473,333 |
| Intersection Flashers | 95 | 20 | 4.750 | $75,000.00 | $356,250 |
| Hazard Beacons | 2,000 | 15 | 133.333 | $12,000.00 | $1,600,000 |
| | | | | | |
| **Signs** | | | | | |
| Major Signs | 13,803 | 15 | 920.200 | $680.00 | $625,736 |
| Minor Signs | 144,763 | 15 | 9650.867 | $76.00 | $733,466 |
| Major Sign Supports | 3,615 | 50 | 72.300 | $9,000.00 | $650,700 |
| Minor Sign Supports | 99,556 | 10 | 9955.600 | $115.00 | $1,144,894 |
| | | | | | |
| **Lighting** | | | | | |
| Roadway Lighting | 21,000 | 40 | 525.0 | 8,500 | 4,462,500 |
| Tunnel Lighting | 9 | 40 | 0.2 | 1,000,000 | 225,000 |
| | | | | **SSI Total** | **$21,021,879** |
| **ITS** | | | | | |
| VMS Type 1 | 61 | 20 | 3.050 | $100,000.00 | $305,000 |
| VMS Type 2 | 21 | 20 | 1.050 | $55,000.00 | $57,750 |
| VMS Type 4 | 16 | 20 | 0.800 | $30,000.00 | $24,000 |
| Bridge (1 & 2) | 37 | 40 | 0.925 | $120,000.00 | $111,000 |
| Cantilever (1 & 2) | 19 | 40 | 0.475 | $100,000.00 | $47,500 |
| Butterfly/Cantilever (4) | 15 | 40 | 0.375 | $35,000.00 | $13,125 |
| Butterfly, Type 1 | 11 | 40 | 0.275 | $70,000.00 | $19,250 |
| Butterfly, Type 2 | 13 | 40 | 0.325 | $60,000.00 | $19,500 |
| Cameras | 301 | 10 | 30.100 | $12,000.00 | $361,200 |
| Camera Poles | 274 | 50 | 5.480 | $12,000.00 | $65,760 |
| RWIS | 94 | 15 | 6.267 | $30,000.00 | $188,000 |
| HAR | 76 | 10 | 7.600 | $40,000.00 | $304,000 |
| HAR Beacon Signs | 54 | 10 | 5.400 | $10,000.00 | $54,000 |
| Snow Zone Signs | 17 | 15 | 1.133 | $75,000.00 | $85,000 |
| Call Box | 2 | 15 | 0.133 | $10,000.00 | $1,333 |
| Weather Warning Systems | 12 | 10 | 1.200 | $30,000.00 | $36,000 |
| | | | | **ITS Total** | **1,692,418** |
| | | | | **Total** | **$22,714,298*** |

7. **How close do actual replacement periods come to planned periods?** Replacement is still driven by actual condition. In some cases, equipment lasts longer than expected. In other cases, manufacturers go out of business or equipment is in a marine environment that drives replacement early than expected.

## Pennsylvania

Contact: Doug Tomlinson, Chief, Traffic Operations, Planning and Operations Section, Pennsylvania DOT, 717-787-3657, dtomlinson@pa.gov.

1. **How is ITS field element replacement funded?** Deployment and replacement of ITS field devices is generally accomplished through planning partner funding.
2. **Alternative funding source if typical source is unavailable?** We have replaced "less expensive" devices using our maintenance contracts. Typically, we need to try to keep devices running until a project is available to replace them.
3. **Limitations on using maintenance funds for ITS field element replacement?** We have limited funding for ITS maintenance. The limitation is caused by lack of resources to use maintenance funds for capital replacement.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** We focus on repairs, but have allowed for the contingency of replacing critical devices.
5. **Agency ITS management plan?** We do not currently have an ITS management plan and we are looking to obtain a more robust ITS Asset Management system than what is currently available. Once in place, our goal will be to identify which of the 5 R's apply to each device:
    - REPAIR — A device will be repaired when parts fail, and the maintenance contractor can easily provide those parts at a reasonable cost. As a "rule of thumb", after a component for a device is repaired three times, consideration should be given to retiring the component, or evaluating if the device itself can be efficiently repaired in the future. At this time, begin to compare the repair B/C to that of the other options listed.
    - REFURBISH — A refurbished device will keep the same skeleton/housing and structure, but have the "guts" removed, and replaced with parts that bring the device into compliance with today's standards. A refurbished device should also be accompanied with a new warranty. When considering the cost of refurbishing a device, compare the refurbish B/C to the replacement B/C to determine if a device should actually be replaced.
    - REPLACE — A device should be replaced when it is determined that it can no longer be repaired effectively, when parts are no longer available, or the supporting structure needs to be replaced. A device should also be replaced if the replacement B/C is greater than that of refurbishment. When a device has reached its end-of-life, and before it is replaced, consider if the need for the device still exists, or whether operations would benefit from relocating the device.
    - RELOCATE — A device should be considered for relocation when the current location no longer provides the maximum amount of coverage, the current location no longer meets standards, or other newer devices in the area / along the corridor provide more information to the motorists or the TMC. After determining a device should be relocated, consider if the existing device/structure can be utilized, or if it should be refurbished or replaced. This option should strongly be considered when planned or active construction projects are nearby.
    - REMOVE — The device should be removed when it is no longer effective in advising motorists to an event, or in the case of CCTV, does not provide accurate

or meaningful information to the TMC. As with relocation, this option should strongly be considered when planned or active construction projects are nearby.

6. **Planned replacement cycles? Please specify.** No. We hope to develop in the future.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## Vermont

Contact: Robert White, Senior Manager III, Vermont Agency of Transportation, 802-522-9867, robert.t.white@vermont.gov.

1. **How is ITS field element replacement funded?** Combination State and Federal funds.
2. **Alternative funding source if typical source is unavailable?** Safety funds.
3. **Limitations on using maintenance funds for ITS field element replacement?** Have one authorized bucket per year for ITS.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Utilize field and temps to perform basic maintenance such as cleaning cabinets, cameras, resetting power, etc.
5. **Agency ITS management plan?** (No response.)
6. **Planned replacement cycles? Please specify.** No.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## Washington State

Contact: Ted Bailey, Traffic Operations Business Manager, Washington State DOT, 360-705-7286, baileyte@wsdot.wa.gov.

1. **How is ITS field element replacement funded?** A mixture of Maintenance (25%), Operations (25%) and Capital Funding (50%) - rough estimates. As ITS field elements fail during normal operations, quick response maintenance and low cost enhancement operational funding come to the rescue. For systematic Life Cycle replacement, preservation funds (Capital) are programmed in a 6 year plan.
2. **Alternative funding source if typical source is unavailable?** Other Capital Improvement and Preservation program funding sources that are conducting nearby work. Regional (MPO/RTPO), and Federal Grants (TIGER/ARA). As noted above Maintenance and Operations funding are typical fall backs for emergent end of Life Cycle ITS Field element replacement.
3. **Limitations on using maintenance funds for ITS field element replacement?** There are not firm rules on the use of Maintenance funds, but culturally the expenditure needs to be emergent in nature and within the scope, expertise and procurement contract availability of maintenance while not significantly impacting maintenance performance of other preventative maintenance and repair activities. Historically WSDOT spends about

2.5M/year on the maintenance and repair of ITS field elements some of which are capital expenditures.

4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Both repairs and system enhancements are allowed. The only restriction is a State Law that restricts Maintenance Expenditures to $60,000 per location under normal conditions or $100,000 per location under emergency conditions if state labor is part of the project (i.e. maintenance can hire contractors to perform the work).
5. **Agency ITS management plan?** WSDOT has the following ITS management policies/plans. *Note: Bailey sent these files via email.*
   - Statewide VMS Operational Policy
   - Highway Advisory Radio (HAR) Policy
   - AMBER Alert Standard Operating Procedures (SOPS)
   - Traffic Analysis Procedures Manual
   - Strategic Plans Traffic Operations (Q Budget) Strategic Plan
   - 511
   - ITS Communications & Wireless Technology
   - Joint Operations Policy Statement (JOPS)
   - Statewide ITS Plan
   - Traffic Operations Centers
   - Moving Washington
6. **Planned replacement cycles? Please specify.** No. Nothing that is firmly documented. There are cultural practices and planning guides available. I will forward some examples.

   **Follow-up email with Ted Bailey:**

   I have attached a number of strategic planning and operational policy documents per your request in the survey.

   I also [have] two attached Word files related to WSDOTs current prioritization process for ITS Field element replacement along with a summary (a few years old) of various Major Electrical (aka ITS Field elements), including a basic description, some inventory quantities and associated costs and life cycle estimates.

   Below is a summary document from one of the word files that you may find of particular use.

Table 1
Major Electrical System Inventory / Funding Needs

| Major Electrical System Item | Unit | Projected Inventory (As of June 2007) | Average Cost (Dollars) | Expected Life-Cycle (Years) | Replacement Cost (During Next 20 Years) |
|---|---|---|---|---|---|
| Traffic Signal Systems | ea. | 965 | $ 240,000 | 25 | $ 185,280,000 |
| Ramp Meter Systems | ea. | 138 | $ 50,000 | 25 | $ 5,520,000 |
| Illumination Systems | ea. | 2,933 | $ 125,000 | 40 | $ 183,312,500 |
| Tunnel and Bridge Electrical Systems | ea. | 5 | $ 2,000,000 | 20 | $ 10,000,000 |
| Dynamic Message Signs (DMS) Systems | ea. | 185 | $ 175,000 | 20 | $ 32,375,000 |
| Highway Advisory Radio (HAR) Systems | ea. | 182 | $ 35,000 | 20 | $ 6,370,000 |
| Closed Circuit Television (CCTV) Cameras Systems | ea. | 502 | $ 35,000 | 20 | $ 17,570,000 |
| Data Station Systems | ea. | 479 | $ 45,000 | 25 | $ 17,244,000 |
| Permanent Traffic Recorder (PTR) Systems | ea. | 110 | $ 30,000 | 10 | $ 6,600,000 |
| Animal Warning Systems | ea. | 6 | $ 70,000 | 10 | $ 840,000 |
| Automated Anti-Icing Systems | ea. | 8 | $ 700,000 | 10 | $ 11,200,000 |
| Fiber Optic Communication Systems | miles | 220 | $ 150,000 | 20 | $ 33,000,000 |
| Communication Hubs | ea. | 30 | $ 200,000 | 20 | $ 6,000,000 |
| Other Communication Systems, (Emergency Telephone, Ethernet, DSL, T1) | miles | 250 | $ 50,000 | 20 | $ 12,500,000 |
| Wireless Communication Systems | ea. (# sites) | 125 | $ 100,000 | 15 | $ 16,666,667 |
| Roadway/Weather Information Systems (RWIS) | ea. | 94 | $ 50,000 | 25 | $ 3,760,000 |
| Transit Signal Priority (TSP) Systems | ea. | 10 | $ 20,000 | 10 | $ 400,000 |
| CVISN Program / Weigh in Motion(WIM) Systems | ea. (# sites) | 13 | $ 50,000 | 10 | $ 1,300,000 |
| Statewide Traveler Information System, (Web(traffic/roads), 511, Traffic TV) | ea. | 1 | $ 1,000,000 | 10 | $ 2,000,000 |
| Traffic System Management Centers (TSMC), (Electronic Equipment, Communication Media and Systems necessary to operate and obtain information from field devices) | ea. (# sites) | 8 | $ 2,000,000 | 10 | $ 32,000,000 |
| Tolling and Electronic Payment Systems | ea. | 2 | $ 1,000,000 | 10 | $ 4,000,000 |
| ITS Systems for Freight Mobility (Ports / Border Crossings / On Board Trucks) | ea. | 1 | $ 3,000,000 | 10 | $ 6,000,000 |
| Reversible Roadway System (I5 & I90, Seattle Area) | ea. (# sites) | 2 | $ 3,000,000 | 25 | $ 4,800,000 |
| Total Replacement Cost for All Major Electrical Systems Items | | | | | $ 598,738,167 |
| Total Cost per Biennium for All Major Electrical System Items (Not Adjusted for Inflation) | | | | | $ 59,873,817 |

7. **How close do actual replacement periods come to planned periods?** (No response.)

## West Virginia

Contact: Jim Lambert, TMC Manager, West Virginia DOT, 304-558-9492, jim.e.lambert@wv.gov.

1. **How is ITS field element replacement funded?** State Highway Funds.
2. **Alternative funding source if typical source is unavailable?** Federal funds.
3. **Limitations on using maintenance funds for ITS field element replacement?** WVDOT uses Safety funding.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Repairs only.
5. **Agency ITS management plan?** (No response.)
6. **Planned replacement cycles? Please specify.** No. Break / Fix.
7. **How close do actual replacement periods come to planned periods?** (No response.)

## Wisconsin

Contact: Mark Lloyd, ITS Planning Engineer, Wisconsin DOT, 414-999-9999, mark.lloyd@dot.wi.gov.

1. **How is ITS field element replacement funded?** The planned replacement of ITS devices is typically funded as part of an upcoming construction improvement project or as part of an annual ITS budget designated for improvements not included in the 6-year construction plan. The unplanned replacement of ITS devices is funded in the annual maintenance budget. Life cycle equipment replacement may be funded in any of these budgets depending on the equipment priority and budget availability.
2. **Alternative funding source if typical source is unavailable?** We have historically been able to address our ITS replacements in the above referenced budgets. At the end of the business year, we review the improvement and maintenance budgets and may use surplus to address our highest priority needs.
3. **Limitations on using maintenance funds for ITS field element replacement?** Historically, we have not had limitations, although federal funds may not be used for O&M related expenses.
4. **Limitations on type of work (repairs, enhancements) on ITS field elements by maintenance?** Historically, we have not had these types of limitations. Any work that involves major geometric or roadway improvements may not be performed by maintenance forces.
5. **Agency ITS management plan?** WisDOT's Traffic Operations Infrastructure Plan (TOIP) was completed in 2008 and will be implemented through 2016. The plan is available at http://www.topslab.wisc.edu/its/toip/. We are currently, developing a Traffic Infrastructure Process that will evaluate system needs annually and fund the identified ITS infrastructure in the budgets referenced above.
6. **Planned replacement cycles? Please specify.** No.
7. **How close do actual replacement periods come to planned periods?** (No response.)

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# Definition

## Overview of Major Electrical System Rehabilitation

The following list represents the types of major electrical systems that WSDOT is responsible for maintaining and operating. In general, these items encompass the WSDOTs Illumination and Intelligent Transportation (ITS) Systems. By definition, ITS refers to "electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system."[23 Code of Federal Regulations (CFR), Section 940.3] The "Major Drainage & Electrical" category is a subcomponent of "Other Facilities" of the Preservation Program, referred to as "P3". The Major Electrical System Items listed below are not entirely maintained and preserved by the P3 program. Facilities, structures, appurtenances or components that are necessary to keep those facilities or structures functioning not part of "P3".

## Major Electrical System Items

- Traffic Signal Systems
- Ramp Metering Systems
- Illumination Systems
- Tunnel and Bridge Electrical Systems
- Dynamic Message Signs (DMS) Systems
- Highway Advisory Radio (HAR) Systems
- Closed Circuit Television (CCTV) Camera Systems
- Data Station Systems
- Permanent Traffic Recorder (PTR) Systems
- Animal Warning System
- Automatic Anti-Icing System
- Fiber Optic Communication Systems
- Communication Hubs
- Other communication Systems, (Emergency Telephone, Ethernet, DSL, T1)
- Wireless Communication Systems
- Roadway Weather Information Systems (RWIS)
- Transit Signal Priority (TSP) Systems
- CVISN Program / Weight In Motion Systems
- Statewide Traveler Information Systems, (Web, 511, Traffic TV)
- Traffic System Management Centers (TSMC), (Electronic Equipment, Communication Media and Systems necessary to operated and obtain information from field devices)
- Tolling and Electronic Payment Systems
- ITS Systems for Freight Mobility (Ports / Border Crossings / On Board Trucks)
- Reversible Roadway System, (I5 & I90, Seattle Area)

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WSDOT has applied ITS to transportation problems since the 1960s, when CCTV Cameras were installed during the construction of I-5. In the 1980s, freeway ramp meters were deployed to decrease urban freeway congestion, and in the 1990s, incident response teams, using and providing information to ITS systems began operating on I-5 in the Puget Sound area. Through experience and expertise gained over nearly 5 decades, WSDOT has become a national leader in implementing ITS solutions that ultimately save time, dollars, and lives.

The following section will briefly define each of the Major Electrical System Items. The purpose is to provide a high level scope of the existing system along with basic needs for preservation at current performance levels. The final sections will present the strategies performance monitoring efforts that are related to or affected by funding levels of the P3 program.

## Traffic Signal Systems

WSDOT owns and is responsible for maintaining 965 traffic signals (including pedestrian signals, temporary signals and emergency signals) statewide. All signals use micro-processor based controllers with active vehicle and pedestrian detection. A portion of these signals are maintained and operated by others through agreement. In general, Signals Systems have a life expectancy of 25years. Many components of a signal system must be replaced or upgraded more frequently during the overall life cycle due to changes in technology and/or preventative maintenance activities.

**Vehicle Signal Display (LED)**

**Signal Controller Cabinet**

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## Ramp Meter Systems

Over 138 ramp meters monitor occupancy levels on freeway ramps and help smooth freeway traffic by regulating vehicle entrance rates. Metering rates are automatically adjusted by the system based on prevailing freeway traffic conditions. In general, Ramp Metering Systems have a life expectancy of 25years. Preventative maintenance activities are similar to that of a traffic signal system.


**Typical Ramp Meter – Seattle Area**

## Illumination Systems

WSDOT maintains approximately 2,933 illumination systems statewide. Most are in the vicinity of interchanges, intersections, chain-up areas, transit flyer stops, with continuous illumination placed along some roadway sections as a result of congestion and safety issues. Some systems contain 1 or 2 lights while others may contain 100 or more lights on 40-50 ft light standards or 100ft high mast poles. As part of the illumination system WSDOT maintains 199 sign-lighters statewide which provide increased visibility for overhead signs. In general, the life expectancy of an illumination system is 40 years. During this period, various preventative maintenance activities, such as re-lamping luminaires and inspecting anchor bolts, are necessary to maintain performance and safety.

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The primary purpose of lighting a roadway at night is to increase the visibility of the roadway and its immediate environment, thereby permitting the driver to maneuver more efficiently and safely. The justification for highway lighting is in terms of a cost savings due to accident reduction. Although estimates vary, the savings can be enough to pay for a lighting installation in a few years. Estimates by Box (1989) indicated that lighting can reduce the ratio of night-to-day accidents by as much as 14 percent of total accidents. In a more recent analysis by Griffith (1994), the safety benefit was found to be much higher, with an accident reduction of 32 percent for (property-damage-only accidents).

**S. 317th HOV Direct Access & I-5**
**(Continuous High Mast & 50ft Light Standard Illumination System)**

## Tunnels and Bridge Electrical Systems

**Tunnel Systems**
The systems in the tunnels are both complex and simplistic depending on the system. For example one control panel in the TSMC allows for manual control of exhaust fans, traffic directional lights, carbon dioxide indicator gauges, tunnel lighting and back-up generators. A second control panel controlled via computer monitors these same systems as well as closed circuit television for which there are three control points. Redundancy is also built into these systems.

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Tunnel Systems consist of the electronics, communication media, and equipment necessary to monitor and perform traffic operations functions, ventilation, fire protection, surveillance and security systems. WSDOT currently operates and maintains 2 tunnel systems; I-90 through Mercer Island; and I-5 under the convention center in downtown Seattle. In general, these tunnels systems have a life expectancy of 20 years.

**Bridge Systems**

Bridge Systems consist of the electronics, communication media, and equipment necessary to monitor and perform traffic operations functions; ventilation; fire protection, surveillance and security; navigation lighting; electrical systems are used for raising, lowering or rotating a draw span; and electrical services which provide power to pumps for pontoons. WSDOT currently operates and maintains 3 bridge systems, Hood Canal, I-90 and SR 520 floating bridges. In general, these bridge systems have a life expectancy of 20 years. WSDOT also maintains and operates 17 navigation lighting and bridge obstruction systems statewide.

**SR 520 Floating Bridge in Seattle**
**(Midspan Opening)**

## <u>Dynamic Message Signs (DMS)</u>

Statewide, 185 dynamic message signs (DMS) are used on roadways to provide motorist with important information about traffic congestion, incidents, roadwork zones, travel times, special events, or speed limits on a specific highway segment. They may also recommend alternative routes, limit travel speed, warn of duration and location of problem, or simply provide alerts or warnings. In general, the life expectancy of a DMS system is 20 years. Periodic DMS System upgrades are necessary, such as control software and electronic components upgrades as technology advances with more advanced communication protocol such as NTCIP.

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**Dynamic Message Sign (DMS)**
**(Displaying Travel Times)**

## Highway Advisory Radio (HAR) Systems

TSMCs also operate highway advisory radio (HAR) systems at 182 locations statewide. HAR systems are licensed low-power AM radio stations installed along the roadway to provide alerts and general information regarding traffic and travel conditions. The presence of a HAR transmitter is marked by a roadway sign instructing motorist to "Tune to 1610 AM". The 1610 frequency is one of several used by HAR radios and identified on the signs. In general, the life expectancy of a HAR system is 20 years.

## Closed Circuit Television (CCTV) Camera Systems

TSMCs depend on field devices such as the 502 closed-circuit TV cameras to detect and respond to incidents and congestion along with monitoring roadway conditions. The camera images are sent to the TSMCs for operations monitoring, to the web for travelers and to the media for news broadcasts. In general, the life expectancy of a CCTV Camera system is 20 years.

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**Closed Circuit Television (CCTV) Camera**

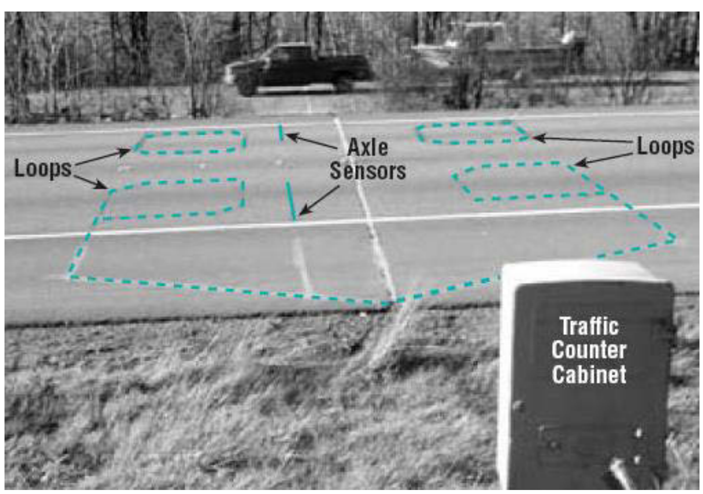
## Data Station Systems

TSMCs also depend on field devices such as the 479 traffic data stations with thousands of loop detectors located in sections of the roadway around the state. Data stations provide critical volume, speed, and occupancy data which are used for planning, design, operations, construction and maintenance activities. This information is also used for measuring performance and providing information to the traveling public, such as travel times. The information obtained through these data stations provides critical information for WSDOT initiatives and is used in benefit/cost analyses. In general, the life expectancy of a data station is 25 years. Depending upon the roadway condition at the data station location, periodic replacement of in-pavement loops may be necessary to maintain current performance.

## Permanent Traffic Recorder (PTR) Systems

The WSDOT Transportation Data Office (TDO) has 110 permanent traffic reporting systems. These sites collect either (or a combination of) volume, classification, speed or weight traffic data depending on the type of sensors and traffic recorder installed at the site. PTR sites, which are managed by the TDO, work together with data stations to complete the picture for WSDOT managed roadways.

Due to Federal reporting requirements for PTR system collected data. The preventative maintenance standards for these systems are much higher than for data station systems. As a result, the life expectancy for a PTR system is estimated at 10 years.




**PTR Site on SR 16 near Burley**

## Animal Warning Systems (AWS)

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WSDOT maintains 6 animal warning systems (AWS) installed or planned statewide. These systems are designed to inform drivers of animals entering or in the roadway along select rural roadway section. In general, the life expectancy of an AWS system is 10 years.


**(Roadside Animal Warning System)**

## Automatic Anti-Icing System (AAIS)

WSDOT maintains 8 Automated Anti-Icing Systems (AAIS) statewide with a life expectancy of 10 years. The primary purpose of winter highway maintenance is to provide vehicular traffic with a roadway surface that can be safely traveled. Roadway geometrics and an icy surface may create specific locations that are particularly susceptible to snow and ice related accidents. Revisions to roadway geometrics are very expensive, so problem areas typically become the responsibility of highway maintenance to mitigate the hazard by winter maintenance operations. AAIS greatly improves WSDOTs ability to address icy roadway conditions at problems areas. A 2001 WSDOT study of an AAIS system on I-90 in North Central Region indicated the following: "*The analysis indicates that the proposed automatic anti-icing system is a viable and cost effective method of reducing the snow and ice related accidents in the Interstate 90 HAC under evaluation. Benefit cost ratio is greater than two (2.36) and the net benefit is over one million dollars ($1,179,274)*."

## Fiber Optic Communication Systems

The primary backbone of WSDOT ITS communication network is fiber optics. WSDOT currently owns and maintains more than 220 miles of fiber optic cable. Fiber optic cable allows traffic information to be shared in a timely manner. Where these cables are not used, information travels over telephone lines at slower rates and higher costs. Fiber optics allow real-time streaming video of traffic cameras, images that help traffic managers make real-time decisions, rather than a delayed view which occurs when the information travels through telephone lines. Fiber Optic Cable has proven to be very reliable with an average life expectancy of 20 years. Periodic replacement of electronic equipment used to transmit and receive data along the fiber line along with repair at splice points and patch panels are necessary to maintain peak system performance.

### Advantages of Fiber Optics

Why are fiber-optic systems revolutionizing video communications? Compared to conventional metal wire (copper wire), optical fibers are:

- **Less Expensive** - Several miles of optical cable can be made cheaper than equivalent lengths of copper wire.
- **Thinner** - Optical fibers can be drawn to smaller diameters than copper wire.
- **Higher Carrying Capacity** - Because optical fibers are thinner than copper wires, more fibers can be bundled into a given-diameter cable than copper wires.
- **Less Signal Degradation** - Optical fiber signal loss is less than in copper wire.
- **Light Signals** - Unlike electrical signals in copper wires, light signals from one fiber do not interfere with those of other fibers in the same cable.
- **Low Power** - Because signals in optical fibers degrade less, lower-power transmitters can be used instead of the high-voltage electrical transmitters needed for copper wires.
- **Digital Signals** - Optical fibers are ideally suited for carrying digital information, which is especially useful in computer networks.
- **Non-Flammable** - Because no electricity is passed through optical fibers, there is no fire hazard.
- **Lightweight** - An optical cable weighs less than a comparable copper wire cable. Fiber-optic cables take up less space in the ground.

**Installation of HDPE conduit for Fiber Optic Cable**

## Communication Hubs

Statewide there are approximately 30 communication Hubs that support the ITS Communication Systems. Communication Hubs are basically an above or below ground structure where ITS communications systems from multiple systems interconnect as information from filed devices is brought back to the TSMC and vice versa. These hubs

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house large amounts of electronic equipment and allow for fiber optic cable and other communication media to be spliced. Temperature and Humidity control are critical for extending system life expectancy which is estimated at 20 years, although this kind of field environment is prone to periodic replacement of some electronic equipment due to failure.

## Other Communication Systems

**(Emergency Telephone, Ethernet, DSL, T1)**

The WSDOT manages a large communication network made up of primarily copper cable. Many of the ITS systems that are operated on the Highways today communicate to TSMCs through copper connections. The copper connections assist in the operation of Traffic Signals, HARS, DMS, Data Stations, Ramp Meters, Illumination, CCTV Cameras and other electrical devices. The installation cost for copper systems is less expensive than the fiber optic alternative; however the operating costs is far more expensive over time. In general, the life expectancy WSDOTs 250 miles of copper communication are 20 years with periodic equipment replacement.

## Wireless Communication Systems

**Microwave Tower and Communications Building at Skyline Lake, 1.5 miles above Stevens Pass**

**Equipment Inside Skyline Lake Communications Building**

WSDOT provides wireless communications in support of the departments Intelligent Transportation Systems (ITS) and Traffic System Management Centers (TSMC). The Wireless communication system has two primary missions; to provide 24 hour emergency communications to the departments personnel via the TMC's, and to provide the traveling public with real time information on the conditions of the states highway system via the ITS program.

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There are over 125 communication sites included in the system statewide. The facilities used are a variety of owned, shared with sister agencies and leased from private companies. These facilities have a life expectancy of 50 years. Within the facilities is a combination of support equipment that has a life expectancy of 15 years.

## Roadway/Weather Information Systems (RWIS)

WSDOT maintains and operates 94 Road/weather Information Systems (RWIS) which are installed along the roadway with instruments and equipment which provide weather and road surface condition observations. This information is used to facilitate decisions on maintenance strategies and to provide information to drivers.

A typical RWIS system may measure air and road surface temperature, barometric pressure, humidity, wind speed and direction, precipitation, visibility and road surface condition (dry, wet, freezing). In general, the life expectancy of an RWIS system is 25 years although periodic replacement of select electronic components is necessary to maintain current performance.

**(RWIS installation)**

**ARROWS (Automated Realtime ROad Weather System)** which takes current weather data received from RWIS systems and generates forecasts for roadway temperatures which allows WSDOT to anticipate de-icing needs. This system is also managed and maintained by 2 meteorologists at the University of Washington.

## Transit Signal Priority (TSP) Systems

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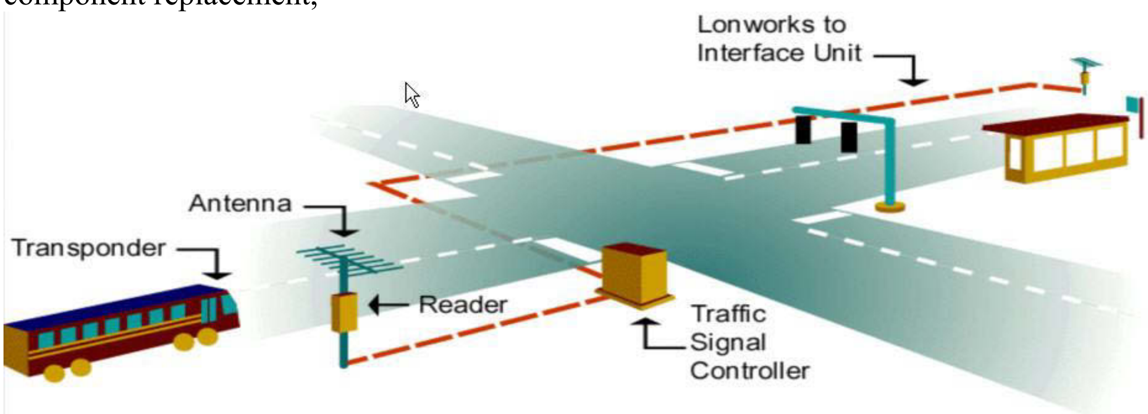
Transit Signal Priority (TSP) is a traffic signal control strategy to provide incremental benefits to public transit for the purpose of improving transit speed and reliability. Traffic signal timing is slightly modified to provide a benefit to the transit vehicle. Transit vehicle arrival times are estimated from on-street detection or from a GPS based Automatic Vehicle Location (AVL) system.

WSDOT current operates and maintains 10 TSP systems in the greater Seattle Area. In general, the life expectancy of a TSP system is 10 years with periodic electronic component replacement,




**Transit Signal Priority System**
**(Integration with City of Lynwood Advanced Traffic Management System (ATMS))**

## CVISN Program / Weigh-In-Motion (WIM) Systems

As of July 1, 2006, the Commercial Vehicle Information Systems and Networks (CVISN) program is now providing electronic screening at 10 weigh stations statewide to 4,539 trucking companies with 40,998 trucks equipped with transponders. These 10 sites include weigh-in-motion (WIM) scales. In addition, there are 3 WIM sites that are under development. In general, the life expectancy of a WIM system is 10 years with periodic replacement of select electronic components.


**CVISN / Weight in Motion (WIM) (Deployment Site Map)**

**Typical WIM Installation (Enlargement of Transponder in Truck)**

## Statewide Traveler Information Systems (Web, 511, Traffic TV)

The Washington State Department of Transportation (WSDOT) continues to provide valuable on-line traveler information to the public in creative and effective ways.

- **Web** - The current web site has information available on the following:
  - **CCTV Camera Images** – Camera Images are updated every minute providing travelers with a visual or roadway conditions at most critical locations around the state.
  - ***Travel Alerts & Slowdowns*** - which combines incidents, construction, events, and anything else that might impede or slow travel on the roads.
  - ***Consolidated mountain pass information -*** with each major pass, such as Snoqualmie and Stevens passes, occupying its own page. These pages allow visitors to view camera images spanning the length of the pass, traction advisories, highway radio messages, and current and forecasted weather information.
  - ***Dedicated weather pages*** - using the original rWeather site which contains both current weather and weather forecasts. WSDOTs rWeather web site has led the country in using intelligent transportation systems data to provide travelers with real-time road and weather information.
  - ***Construction*** – provides travelers with information about ongoing construction activities around the state that may impact their travel plans.

- ***511 -*** What is 511? Real time traffic and weather information is available by simply dialing 5-1-1 from most phones. The system builds upon the highly successful Washington State Highway hotline previously accessed through 1-800 toll free numbers. Updated every few minutes, 511 allows callers to get a variety of information:
  - Puget Sound Traffic Conditions
  - Statewide Construction Impacts
  - Incident Information
  - Mountain Pass Conditions
  - Ferry System Information
  - 800 numbers for passenger rail and airlines
  - Weather

  State-of-the-art speech recognition technology allows callers to verbally tell the system what they want, such as "traffic" or "mountain pass" information. The requested information is then "spoken" back to the user. Callers can use key words to quickly navigate the system to the specific road segment for the information sought.

What does 511 offer?

- Ease of use and convenience
- Real-time, accurate, quality road and traffic conditions
- Avoiding traffic congestion and road construction
- Information to help users make informed travel choices

Technology permits fully automated conversions of traffic congestion and incident data into everyday speech. Road sensors identify traffic volumes that are converted into levels of congestion for each highway section. Incidents are identified by video camera observations or information from the Washington State Patrol.

The traffic volume data are then converted into speech, and using voice recognition, traffic reports on a specific road segment are played back. In Washington State within the greater Seattle area, prerecorded speech is being used to provide real-time traffic congestion reports within a few minutes of their detection. Text to speech technology is being used to provide statewide incidents and construction reports. In these most sophisticated systems, a caller connects to 511 and can speak their request at any time, interrupting the prompts to receive specific information by route and direction.

- ***Traffic TV*** – Traffic camera images and the vehicle speed flow map for the Seattle area are available on select local cable channels.

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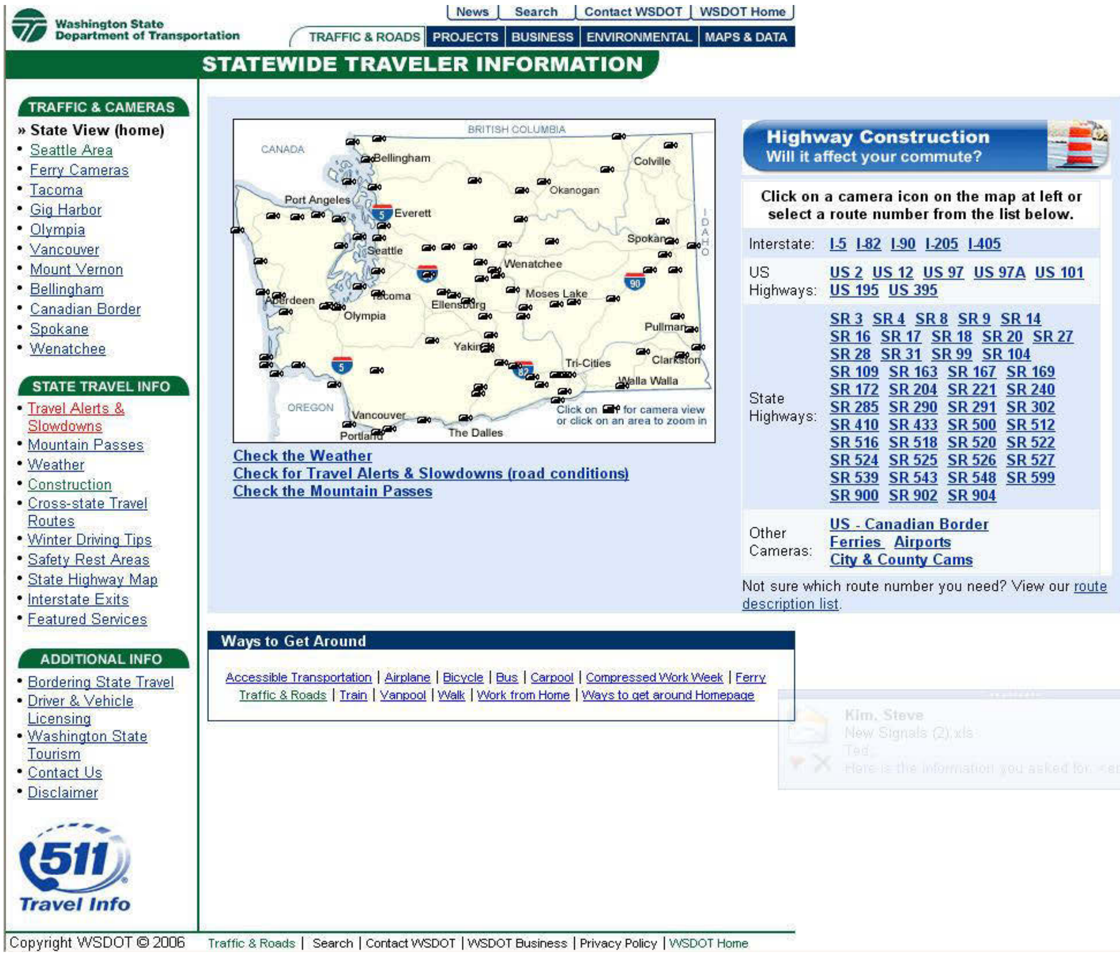


**Statewide Traveler Information Web Page**
**(www.wsdot.wa.gov/traffic/)**

It goes beyond saying that the web site has been extremely popular with the traveling public, with the site seeing record visits during extreme weather. In general, the electronic equipment and software necessary to operate the statewide traveler information system has a life expectancy of 10 years with more frequent replacement of select components to maintain peak performance.

## Traffic Systems Management Centers (TSMC)

(Electronic Equipment, Communication Media and Systems necessary to operated and obtain information from field devices)

WSDOT operates 7 regional TSMCs; Seattle (Shoreline), Tacoma, Spokane, Vancouver, Yakima, Bellingham, Hyak (Snoqualmie Pass - winter season only) and Wenatchee. In addition, an Emergency Operations Center (EOC) is located in Olympia. This TSMC provides a central location for WSDOT executives to help manage traffic operations, incident response and maintenance during “emergency” events.

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TSMCs are the nerve centers for WSDOTs operations activities. Real-time information is gathered 24 hours a day, 7 days a week from many sources including traffic detectors, CCTV cameras, ramp meters, the Washington State Patrol (WSP), road crews, WSDOTs incident response teams and media traffic reporters. WSDOT uses this information to coordinate responses to clear accidents, deal with other problems that occur, and notify the public and the media of these events.

Although the TSMC facility itself is outside the scope of the P3 program, the extensive electronic equipment, media and software that is required to communicate with and operated the field ITS equipment is a critical component of the Major Electrical System portion of the preservation program. The life expectancy of these items is estimated at 10 years in order to maintain current performance and maintain pace with technological advancements.

**TSMC Seattle at Regional Headquarters**

## Tolling and Electronic Payment Systems

In the near future WSDOT will begin maintenance and operations of 2 significant tolling and electronic payments systems for the new Tacoma Narrows Bridge and the SR 167 HOT lanes pilot. In general, the life expectancy of the electronics, software and communication media portion of the Tolling and Electronic Payment System is estimated at 10 years with periodic replacement of select components.

***Good To Go!*** – Is the new, convenient, easy-to-use electronic toll collection program that gives you the power to pay tolls on the new Tacoma Narrows Bridge span and SR 167 HOT lanes without stopping.

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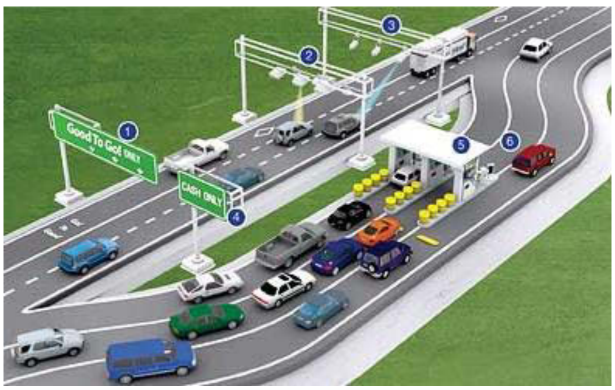
**Sample Windshield Pass**
**(Electronic Tolling Systems)**




**Tacoma Narrows Bridge Tolling Plaza**
**(Good To Go – Pass Holders Bypass Plaza)**

**SR 167 HOT Lanes**

## <u>ITS Systems for Freight Mobility</u>

**(Ports / Border Crossings / On Board Trucks)**

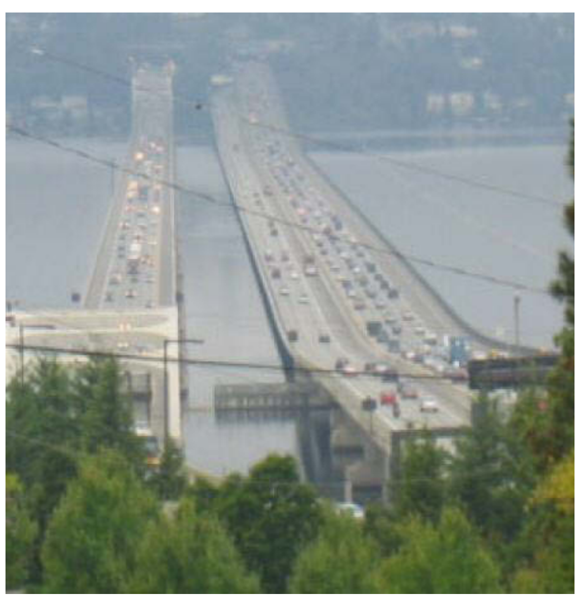
WSDOT has deployed a number of ITS Systems specifically to improve and monitor freight mobility. ITS transponder reading equipment located at the Port of Tacoma, Port of Seattle, the Canadian Border, and along I-5, I-90 and I-82 monitor truck movement to provide travel time estimates.  Some trucks that are equipped with “Eseals” are tracked from the Port until they leave the U.S. guaranteeing an unopened container.  This greatly reduces the number of required customs inspections and increased freight mobility. Other systems include GPS tracking devices in volunteer, probe trucks along with the transponder data (CVISN program) gathered from roadside devices which together provide significant information about the freight mobility in Washington State.  In general, these types of ITS Systems have a life expectancy of 10 years, with periodic replacement of some electronic equipment.


**Canadian Border Crossing (Transponder Readers)**


**E-Seal**

## <u>Reversible Roadway System</u>
**(I-5 & I-90, Seattle Area)**

WSDOT maintains 2 reversible roadway systems; one from downtown Seattle North along I-5; one from downtown Seattle East along I-90. The reversible roadway system consists of 129 gates and 17 gate control systems and a large number of mechanical overhead drum signs that help regulate the flow and direction of traffic at different times each day. In general, the life expectancy of these systems is 25 years with periodic electronic equipment replacement.



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**Reversible Roadway - Center Lanes**
**(I-90 Floating Bridge - Seattle Area)**

# Needs

Continuous use of these major electrical systems; aging equipment; difficulties in acquiring older parts due to evolving technology; reduced safety of degrading insulation and corrosion due to environmental factors has presented WSDOT with a dilemma of how to plan for ongoing maintenance and the ultimate replacement of these systems as they approach their life expectancy. The traveling public and nearly every component of WSDOT planning, design, construction, operations and maintenance has become accustomed to and relies heavily upon the information and services these systems provide. As shown in Table 1, WSDOTs major electrical system inventory has an approximate replacement cost of $599 Million dollars. A planned replacement of these systems helps maintain the current performance of these systems. The current preservation cost of these systems is estimated at $60 Million dollars per biennium in order to maintain current performance. **This estimate does not take into account the front load costs for systems that are currently past their life expectancy.** At some point, the cost to keep these systems functional through maintenance will outpace the amortized cost of replacement.

Historically over the past 12 years, Major Electrical Systems Funding (P3) has been well below the estimate of $59 Million dollars per biennium as outlined previously. Further system expansion, which is necessary to increase or maintain capacity of the existing infrastructure, will continue to amplify these issues.

**Historical Major Electrical Systems Funding (Sub Component of P3)**

- 1995 – 1997 $2 M
- 1997 – 1999 $6 M
- 1999 – 2001 $9 M
- 2001 – 2003 $28 M
- 2003 – 2005 $16 M
- 2005 – 2007 $7 M
- 2007 – 2009 $17 M (estimate)

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**Table 1**
**Major Electrical System Inventory / Funding Needs**

| Major Electrical System Item | Unit | Projected Inventory (As of June 2007) | Average Cost (Dollars) | Expected Life-Cycle (Years) | Replacement Cost (During Next 20 Years) |
|---|---|---|---|---|---|
| Traffic Signal Systems | ea. | 965 | $ 240,000 | 25 | $ 185,280,000 |
| Ramp Meter Systems | ea. | 138 | $ 50,000 | 25 | $ 5,520,000 |
| Illumination Systems | ea. | 2,933 | $ 125,000 | 40 | $ 183,312,500 |
| Tunnel and Bridge Electrical Systems | ea. | 5 | $ 2,000,000 | 20 | $ 10,000,000 |
| Dynamic Message Signs (DMS) Systems | ea. | 185 | $ 175,000 | 20 | $ 32,375,000 |
| Highway Advisory Radio (HAR) Systems | ea. | 182 | $ 35,000 | 20 | $ 6,370,000 |
| Closed Circuit Television (CCTV) Cameras Systems | ea. | 502 | $ 35,000 | 20 | $ 17,570,000 |
| Data Station Systems | ea. | 479 | $ 45,000 | 25 | $ 17,244,000 |
| Permanent Traffic Recorder (PTR) Systems | ea. | 110 | $ 30,000 | 10 | $ 6,600,000 |
| Animal Warning Systems | ea. | 6 | $ 70,000 | 10 | $ 840,000 |
| Automated Anti-Icing Systems | ea. | 8 | $ 700,000 | 10 | $ 11,200,000 |
| Fiber Optic Communication Systems | miles | 220 | $ 150,000 | 20 | $ 33,000,000 |
| Communication Hubs | ea. | 30 | $ 200,000 | 20 | $ 6,000,000 |
| Other Communication Systems, (Emergency Telephone, Ethernet, DSL, T1) | miles | 250 | $ 50,000 | 20 | $ 12,500,000 |
| Wireless Communication Systems | ea. (# sites) | 125 | $ 100,000 | 15 | $ 16,666,667 |
| Roadway/Weather Information Systems (RWIS) | ea. | 94 | $ 50,000 | 25 | $ 3,760,000 |
| Transit Signal Priority (TSP) Systems | ea. | 10 | $ 20,000 | 10 | $ 400,000 |
| CVISN Program / Weigh in Motion(WIM) Systems | ea. (# sites) | 13 | $ 50,000 | 10 | $ 1,300,000 |
| Statewide Traveler Information System, (Web(traffic/roads), 511, Traffic TV) | ea. | 1 | $ 1,000,000 | 10 | $ 2,000,000 |
| Traffic System Management Centers (TSMC), (Electronic Equipment, Communication Media and Systems necessary to operate and obtain information from field devices) | ea. (# sites) | 8 | $ 2,000,000 | 10 | $ 32,000,000 |
| Tolling and Electronic Payment Systems | ea. | 2 | $ 1,000,000 | 10 | $ 4,000,000 |
| ITS Systems for Freight Mobility (Ports / Border Crossings / On Board Trucks) | ea. | 1 | $ 3,000,000 | 10 | $ 6,000,000 |
| Reversible Roadway System (I5 & I90, Seattle Area) | ea. (# sites) | 2 | $ 3,000,000 | 25 | $ 4,800,000 |
| **Total Replacement Cost for All Major Electrical Systems Items** | | | | | **$ 598,738,167** |
| **Total Cost per Biennium for All Major Electrical System Items (Not Adjusted for Inflation)** | | | | | **$ 59,873,817** |

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# Strategies

### Preventative Maintenance

All electrical systems require periodic review in addition to non-scheduled maintenance caused by unpredictable events such as storms, accidents, and equipment failure. The intent of periodic preventative maintenance is to keep the system operating at an acceptable level of service to the public and avoid an abrupt system failure. Routine inspections, repairs and replacement of select electronic components are a few examples of preventative maintenance activities.

### Identifying the Need

WSDOT is continuing to develop and refine the process for developing and documenting the statewide inventory of electrical system infrastructure. Having this information in one central database will greatly improve the efficiency of identifying and addressing problem areas along with defining future funding needs and priorities. By continuing to pursue a central inventory and maintenance activity tracking system, it will become more feasible to predict failures and prioritize preventative maintenance activities.

### Prioritizing the Need

WSDOT Maintenance on request of Systems Analysis and Program Development will compile a list of needs around the state. WSDOT Headquarters Traffic then reviews the list in the field with region maintenance staff and prioritizes a draft list. Systems Analysis and Program Development also requests the regions provide estimates in order to develop a list of needs given available dollars.

Some portions of existing electrical systems may be replaced as part of other projects at that location, but the majority of the systems will be replaced through the Major Electrical Systems Preservation subprogram.

In general, major electrical systems, P3 projects will be prioritized and programmed based on impact to the traveling public and WSDOT initiatives.

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# Performance

The underlying theme between all Major Electrical System Items is providing information to the traveling public, media and WSDOT planning, design, construction, operations and maintenance as decisions are made based on the operation condition of the roadway infrastructure. Information provided by major electrical systems is critical for providing data that feeds number of Gray Notebook performance measures as listed below. In addition, the performance of all the disciplines listed above and the ability for the traveling public to make an informed decision as they plan their trip or commute would be decreased as systems that are maintained through major electrical system P3 funding fail.

To date, measuring performance of the major electrical systems portion of the P3 program is currently accomplished through a variety of Gray Notebook performance measures. Other performance measures, such as Signal Operations, are under development. These performance measures provide insight into the impact major electrical systems have on the traveling public and WSDOT initiatives.

**Gray Notebook Performance Measures**

The following is a list of Gray Notebook Performance Measures that rely on major electrical systems for data and/or the performance of these performance measures will decrease as these major electrical systems fail.

- Measuring Congestion – Travel Time Analysis
- Measuring Congestion – Lost Throughput Analysis
- Measuring Congestion – Percent of Days When Speeds Were Less than 35 MPH
- Measuring Congestion – Measuring Travel Delay
- Measuring Congestion – HOV Lane Performance
- Measuring Congestion – Case Studies - Before and After Results
- Measuring Congestion – Understanding the Relationship Between Safety and Congestion
- Measuring Congestion – Traffic Data Collection for Arterial Highways

- Incident Response – Number of Responses and Average Clearance Time
- Incident Response – Response Increases to Fatality Collisions

- Travel Information – 5-1-1 (Total Calls to Travel Information)
- Travel Information – Website Usage

**Other Performance Measures**

- Signal Operations – Time Between Operational Reviews by Signal Type with Specific Review Criteria

# Major Electrical (P3) Project Prioritization Process Criteria

## Overview

The following 5 Steps are intended to guide the prioritization of major electrical (P3) projects for upcoming biennium. Since comprehensive asset / maintenance management data isn't consistently available for all types of systems statewide, it is the intention that these steps be applied to a short list of priority projects that have already been identified for replacement by the regions through some other means. P3 projects routinely contain multiple types of System and Subsystem components that are rolled up into one project. Although bundling multiple system and subsystem components that are located in the same geographic area together is effective for project delivery, it is important that the following steps be applied to the systems and subsystem components independently in order to isolate and highlight the priority needs within a project. Keep in mind that the process outlined below is intended to be a step toward that ultimate goal of having a fully functional asset / maintenance management system that could compressively track and prioritize needs for all Major Electrical systems statewide.

## Step 1 – Separate projects by type of System

If a project has multiple system types and/or multiple installations of the same type of system (e.g. 3 traffic signals, 5 services, 4 CCTV camera poles installed at different points in time), each System should be evaluated (steps 2, 3 & 4 independently).

1. Signals / Ramp Meters / Flashing Beacons
2. Illumination
3. ITS
4. Communications
5. Electrical Service / Power Supply

## Step 2 – Determine the age of Select System Subcomponents

The goal is to break the Systems into subcomponents that are typically replaced at the same time or could be replaced independently of the rest of the system. Follow the format below. **(Enter the age of the subsystem component and mark if you have documentation of the age or if this is an estimate. If the ages vary for whatever reason, use the oldest age for that group of subsystem components.)**

- Signals / Ramp Meters / Flashing Beacons
  - Structures and associated Foundations→ **(Age, Doc. or Est.)**
  - Controller Cabinet→ (exclude age of internal components) **(Age, Doc. or Est.)**
  - UPS→ (Cabinet, controller, etc.., exclude batteries) **(Age, Doc. or Est.)**
  - Internal Cabinet Components→ **(Age, Doc. or Est.)**
  - Conduit, junction boxes & Conductors *(exclude communications conductors)* → **(Age, Doc. or Est.)**
    *Note: For programming purposes exclude the age of above ground appurtenances (PPB, Ped / Signal displays, etc.). P3 funds would still be*

*used to replace these components, but given their short life expectancy and typical replacement with maintenance funds, they are not being included in the prioritization process.*

- Illumination
  - Structures and associated Foundations → *(Note: Luminaires, Mounting Hardware, Lowering Devices, Grounding System, Lamps etc.. would be replaced, but the age for programming will be determined based on the structure and associated foundation age.)* **(Age, Doc. or Est.)**
  - Conduit, junction boxes, Conductors → **(Age, Doc. or Est.)**

- ITS
  - Structures and associated Foundations (poles, gantries, etc. → **(Age, Doc. or Est.)**
  - Controller Cabinet → (exclude age of internal components) **(Age, Doc. or Est.)**
  - Conduit, junction boxes, pull boxes, cable vaults, Conductors *(exclude communications conductors* → **(Age, Doc. or Est.)**
  - UPS → (Cabinet, controller, etc.., exclude batteries) **(Age, Doc. or Est.)**
  - End Equipment (Major) → VMS, CCTV, Radar Detector, Electronic Signs, Gates, etc. **(Age, Doc. or Est.) (List the ages separately for each Major End Equipment Component.)**
  - End Equipment (Minor) / Internal Cabinet Components → Include all the components that make the major component(s) operational. This should consider equipment inside the HUB or the TMC **(Age, Doc. or Est.)**

- Communications → (Included all conduit, conductors, junction boxes and end equipment associated with the communication to the system.)
  - Conduit and Junction boxes → **(Age, Doc. or Est.)**
  - Conductors (Copper) → **(Age, Doc. or Est.)**
  - Fiber → **(Age, Doc. or Est.)**

    *Note: For programming purposes do not include any Microwave / Radio Equipment in the roadside cabinet or on the mountain top that is necessary to complete the communication system. P3 funds could still be used to replace these components.*

- Electrical Service / Power Supply (Include everything from the Utility transformer to the Service including foundations, grounding system, cabinet, conductors, PLC with photocell, Transformers, Subpanels, etc.) **(Age, Doc or Est.)**

## Step 3 – Repair History / Condition of Systems

System failures can result from other issues beyond the age of the system. Even systems with components well within their life expectancies can fail without warning. Failures could be a result of 3rd party damage, software, manufacturing, installation, weather, etc. that are not preventable through scheduled preventative maintenance activities. **Using the repairs documented in SiMMS determine the total number of repairs and associated cost of the repairs for each system for past 3 biennium (05-07, 07-09, 09-11).**
*(Note: Don't include scheduled PMs or repairs that are completed during a PM in these numbers. The intention is to pull and report the raw "repair" numbers directly from SiMMS.)*

- Signals / Ramp Meters / Flashing Beacons → (Total Number of Repairs / Total Cost of the Repairs)
- Illumination → (Total Number of Repairs / Total Cost of the Repairs)
- ITS → (Total Number of Repairs / Total Cost of the Repairs)
- Communications → (Total Number of Repairs / Total Cost of the Repairs)
- Electrical Service / Power Supply → (Total Number of Repairs / Total Cost of the Repairs)

**Note: Review PM notes in SiMMS and include comments related to the overall condition of the system.**

## Step 4 – Risk Assessment

As the systems age there is increased potential for partial or complete system failure. Since the associated risk potential varies depending upon the type of system, location of system and a number of other variables answers to the following questions will be used to assign a relative level of risk.

For each of the following system types associated with the project answer the following (Yes / No) Risk Questions.

**System Types**

1. Signals / Ramp Meters / Flashing Beacons
2. Illumination
3. ITS
4. Communications
5. Electrical Service / Power Supply

**Risk questions**

a) System Failure would result in an immediate roadway closure (Y/N)
b) System failure would result in immediate corrective action given the TMC operational benefits of the system. (Y/N) *(Note: e.g. immediate corrective action means → address issue within 1 week and/or OT authorized to maintenance)*
c) System failure would result in immediate corrective action given the inherent safety benefits of the system. (Y/N) *(Note: e.g. immediate corrective action means → address issue within 1 week and/or OT authorized to maintenance)*
*d)* Other Construction Work is anticipated to occur simultaneously in the Vicinity of this project (Y/N) (*Note: Bundling projects within the same vicinity has value, but should not be the determining reason for replacing equipment.)*
*e)* Obsolescent equipment (Y/N) *(Note: Mark yes if this system contains equipment that there is no reasonable way to purchase replacement equipment or parts to fix it if it breaks. Provide comments on what the equipment is and a rough estimate of the cost to replace. If one piece breaking causes a daisy chain equipment replacement include those costs and comments as well.*

## Step 5 – Final Evaluation and Ranking

A committee of individuals with representatives from HQ Traffic Operations and Design, CPDM, Region Maintenance and Region Traffic will review the information provided through Steps 2, 3 and 4 to determine the appropriate scoring ranges and weighting that will be used to determine the final project ranking. Projects will be funded on a priority basis with consideration given to work force planning, project delivery and business issues associated with the final programming of projects by region and location within that region.

**Below is the step by step overview of the scoring criteria and method that was used to develop the project priority list.**

**Step A** - Establish an approximate Life Cycle for each type of system.

1. Signals / Ramp Meters / Flashing Beacons – 50 years
2. Illumination – 50 years
3. ITS – 20 years
4. Communications – 20 years
5. Electrical Service / Power Supply – 40 years

**Step B** – Calculate the number of points for each project receives based on age as a proportion of the established Life Cycle. *(Note: For system categories 1, 2 & 3 take the Structures and Associated Foundation Age / Life Cycle age to assign the point value. For system categories 4 & 5 take the highest reported age for all sub systems / Life Cycle age to assign the point value based on the following point schedule.)*

**AGE Points**

| Range | | Point |
|---|---|---|
| 0.00% | 9.99% | 0 |
| 10.00% | 19.99% | 0.5 |
| 20.00% | 29.99% | 1 |
| 30.00% | 39.99% | 1.5 |
| 40.00% | 49.99% | 2 |
| 50.00% | 59.99% | 2.5 |
| 60.00% | 69.99% | 3 |
| 70.00% | 79.99% | 3.5 |
| 80.00% | 89.99% | 4 |
| 90.00% | 99.99% | 4.5 |
| 100.00% | 109.99% | 5 |
| 110.00% | 119.99% | 5.5 |
| 120.00% | 129.99% | 6 |
| 130.00% | 139.99% | 6.5 |
| 140.00% | 149.99% | 7 |
| 150.00% | 159.99% | 7.5 |
| 160.00% | 169.99% | 8 |
| 170.00% | 179.99% | 8.5 |
| 180.00% | 189.99% | 9 |
| 190.00% | 199.99% | 9.5 |
| 200.00% | 209.99% | 10 |

**Step C** – Calculate the number of points each project receives based on repairs as a proportion of the project CE and PE estimate. *(Note: Take the total cost of all repairs for the past 6 years for all subsystem components divided by the total of (CE + PE) to assign the point value based on the following point schedule.)*

**Repair Points**

| Range | | Point |
|---|---|---|
| 0.00% | 0.99% | 0 |
| 1.00% | 1.99% | 0.5 |
| 2.00% | 2.99% | 1 |
| 3.00% | 3.99% | 1.5 |
| 4.00% | 4.99% | 2 |
| 5.00% | 5.99% | 2.5 |
| 6.00% | 6.99% | 3 |
| 7.00% | 7.99% | 3.5 |
| 8.00% | 8.99% | 4 |
| 9.00% | 9.99% | 4.5 |
| 10.00% | 10.99% | 5 |
| 11.00% | 11.99% | 5.5 |
| 12.00% | 12.99% | 6 |
| 13.00% | 13.99% | 6.5 |
| 14.00% | 14.99% | 7 |
| 15.00% | 15.99% | 7.5 |
| 16.00% | 16.99% | 8 |
| 17.00% | 17.99% | 8.5 |
| 18.00% | 18.99% | 9 |
| 19.00% | 19.99% | 9.5 |
| 20.00% | 20.99% | 10 |
| 21.00% | 21.99% | 10.5 |
| 22.00% | 22.99% | 11 |
| 23.00% | 23.99% | 11.5 |
| 24.00% | 24.99% | 12 |
| 25.00% | 25.99% | 12.5 |
| 26.00% | 26.99% | 13 |
| 27.00% | 27.99% | 13.5 |
| 28.00% | 28.99% | 14 |
| 29.00% | 29.99% | 14.5 |
| 30.00% | 30.99% | 15 |
| 31.00% | 31.99% | 15.5 |

| | | |
|---|---|---|
| 32.00% | 32.99% | 16 |
| 33.00% | 33.99% | 16.5 |
| 34.00% | 34.99% | 17 |
| 35.00% | 35.99% | 17.5 |
| 36.00% | 36.99% | 18 |
| 37.00% | 37.99% | 18.5 |
| 38.00% | 38.99% | 19 |
| 39.00% | 39.99% | 19.5 |
| 40.00% | 40.99% | 20 |
| 41.00% | 41.99% | 20.5 |
| 42.00% | 42.99% | 21 |
| 43.00% | 43.99% | 21.5 |
| 44.00% | 44.99% | 22 |
| 45.00% | 45.99% | 22.5 |
| 46.00% | 46.99% | 23 |
| 47.00% | 47.99% | 23.5 |
| 48.00% | 48.99% | 24 |
| 49.00% | 49.99% | 24.5 |
| 50.00% | 50.99% | 25 |
| 51.00% | 51.99% | 25.5 |
| 52.00% | 52.99% | 26 |
| 53.00% | 53.99% | 26.5 |
| 54.00% | 54.99% | 27 |
| 55.00% | 55.99% | 27.5 |
| 56.00% | 56.99% | 28 |
| 57.00% | 57.99% | 28.5 |
| 58.00% | 58.99% | 29 |
| 59.00% | 59.99% | 29.5 |
| 60.00% | 60.99% | 30 |
| 61.00% | 61.99% | 30.5 |
| 62.00% | 62.99% | 31 |
| 63.00% | 63.99% | 31.5 |
| 64.00% | 64.99% | 32 |
| 65.00% | 65.99% | 32.5 |
| 66.00% | 66.99% | 33 |
| 67.00% | 67.99% | 33.5 |
| 68.00% | 68.99% | 34 |
| 69.00% | 69.99% | 34.5 |
| 70.00% | 70.99% | 35 |
| 71.00% | 71.99% | 35.5 |
| 72.00% | 72.99% | 36 |
| 73.00% | 73.99% | 36.5 |
| 74.00% | 74.99% | 37 |

| | | |
|---|---|---|
| 75.00% | 75.99% | 37.5 |
| 76.00% | 76.99% | 38 |
| 77.00% | 77.99% | 38.5 |
| 78.00% | 78.99% | 39 |
| 79.00% | 79.99% | 39.5 |
| 80.00% | 80.99% | 40 |
| 81.00% | 81.99% | 40.5 |
| 82.00% | 82.99% | 41 |
| 83.00% | 83.99% | 41.5 |
| 84.00% | 84.99% | 42 |
| 85.00% | 85.99% | 42.5 |
| 86.00% | 86.99% | 43 |
| 87.00% | 87.99% | 43.5 |
| 88.00% | 88.99% | 44 |
| 89.00% | 89.99% | 44.5 |
| 90.00% | 90.99% | 45 |
| 91.00% | 91.99% | 45.5 |
| 92.00% | 92.99% | 46 |
| 93.00% | 93.99% | 46.5 |
| 94.00% | 94.99% | 47 |
| 95.00% | 95.99% | 47.5 |
| 96.00% | 96.99% | 48 |
| 97.00% | 97.99% | 48.5 |
| 98.00% | 98.99% | 49 |
| 99.00% | 99.99% | 49.5 |
| 100.00% | 100.99% | 50 |

**Step C** – For each project the following Risk Questions were asked. Points were assigned as follows for every yes answer.

**Risk Assessment Questions(a through e)**

| | **Risk Points per Project** |
|---|---|
| **a) System Failure immediate roadway closure** | **0.5** |
| **b) System failure immediate corrective action given the TMC operational benefits of the system issued within 1 week and/or OT authorized to maintenance)** | **0.25** |
| **c) System failure would result in immediate corrective action given the inherent safety benefits of the system.** | **0.25** |
| **d) Other Construction Work is anticipated to occur simultaneously in the Vicinity of this project** | **0.25** |
| **e) Obsolescent equipment** | **0.25** |

**Step D** – Total the Points for Steps A, B and C to determine the overall project priority list for each of the 5 categories.

1. Signals / Ramp Meters / Flashing Beacons
2. Illumination
3. ITS
4. Communications
5. Electrical Service / Power Supply

**Step E** – Funding Levels for each of the 5 categories are as stated below. It is estimated the $45Million will be available for P3 Major Electrical Preservation projects over the next 6 years. Since very few Communication and Electrical Service / Power Supply projects were submitted the decision was made to fund all projects. The remaining funds were allocated as shown below.

## Funding Levels

| | | |
|---|---|---|
| **6 years Funding** | | $ 45,000,000.00 |
| **6 years Funding - Total Communication- ES** | | $ 44,778,000.00 |
| | Percentage | |
| **1. Signal, RampMeter, Flash Bacon** | 40% | $ 17,911,200.00 |
| **2. Illumination** | 40% | $ 17,911,200.00 |
| **3. ITS** | 20% | $ 8,955,600.00 |
| **4. Communication** | $ 122,000.00 | |
| **5.ES** | $ 100,000.00 | |