ITS Maintenance Cost Formula Update

FY 18/19 – FY 25/26

Florida Department of Transportation (FDOT)

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AVI	Automatic Vehicle Identification
CCTV	Closed-Circuit Television
CEI	Construction Engineering Inspection
CV	Connected Vehicle
DBOM	Design Build Operate and Maintain
DMS	Dynamic Message Sign
FDOT	Florida Department of Transportation
FOC	Fiber Optic Cable
FTE	Florida's Turnpike Enterprise
HAR	Highway Advisory Radio
ITS	Intelligent Transportation Systems
IP	Internet Protocol
ITSFM	Intelligent Transportation Systems Facility Management
LCS	Lane Control Sign/Signal
MOT	Maintenance of Traffic
MVDS	Microwave Vehicle Detection System
RTMC	Regional Transportation Management Center
RWIS	Road Weather Information System
SFP	Small Form Factor Pluggable
TMC	Transportation/Traffic Management Center
TOTR	Work Program Schedule B Target for ITS Equipment Replacement
TSM&O	Transportation Systems Management and Operations
TEOO	Traffic Engineering and Operations Office
UPS	Uninterruptible Power Supply
VDS	Vehicle Detection System
VVDS	Video Vehicle Detection System
WWD	Wrong Way Driving

1.0. Introduction

The Florida Department of Transportation (FDOT) is responsible for an extensive and expanding Intelligent Transportation System (ITS). Sustaining this program requires regular periodic and responsive maintenance such as cleaning, repairing, and monitoring. As ITS infrastructure and equipment ages and warranties expire, annual maintenance costs will only continue to grow.

The FDOT's Transportation Systems Management and Operations (TSM&O) Section of the Traffic Engineering and Operations Office (TEOO) developed the ITS Maintenance Cost formulas included in this report with input from previous efforts in District Four, input from District Offices, and review of historical maintenance contract scopes and annual costs. The goal of updating the formulas is to ensure that ITS maintenance (hereinafter referred to as maintenance) is funded to continue operating at optimal performance capability.

Forecasting future maintenance cost is a complex issue due to undocumented costs, competing maintenance needs, and unique district operating environments. Therefore, the formula and unit costs are based on factors such as device types/quantities, contract overhead, location, regional factors, and historical maintenance costs. These formulas will be updated periodically as the needs of the state and regions change.

2.0. Background

2.1. FDOT Central Office Unit Cost Method

The FDOT Central Office budgets the annual Fiscal Year maintenance needs by multiplying ITS device quantities by maintenance unit rates. Unit rates reflect cost incurred by the district, and is annually adjusted for inflation and system modifications. Budgeted items include: Closed-Circuit Television (CCTV) cameras, Vehicle Detection Systems (VDS), Dynamic Message Signs (DMS), Road Weather Information Systems (RWIS), Highway Advisory Radios (HAR), Ramp Meters, Fiber Optic Cable (FOC), and Transportation/Traffic Management Centers (TMC).

2.2. FDOT District Four Formula

FDOT District Four developed formulas that manually calculate average man-hours spent per device each year based on the results of an extensive survey conducted with the other Districts.

These formulas categorized ITS elements by general, arterial, and express lanes, and added field networking equipment and generators.

2.3. Need for Formula Update

Table 1 shows the actual maintenance costs versus Central Office and District Four estimates for Fiscal Year 2014-2015. The differences shown below between the actual costs and the estimates highlight the need to modify the Central Office forecasting formulas.

Table 1: Fiscal Year 2014-2015 Actual vs. Estimated Maintenance Costs

FDOT District	Actual Cost	Central Office Estimate	District 4 Estimate	Central Office Difference from Actual	District 4 Difference from Actual
1	$1,175,671	$1,938,380	$2,391,378	$762,709	$1,215,707
2	$1,219,247	$1,285,256	$1,878,667	$66,009	$659,420
3*	N/A	$888,725	$1,027,624	N/A	N/A
4	$3,530,277	$3,492,746	$4,655,603	-$37,531	$1,125,326
5	$2,669,859	$2,806,880	$2,780,645	$137,021	$110,786
6	$2,479,449	$1,905,407	$2,705,738	-$574,042	$226,289
7	$2,394,107	$1,807,506	$2,830,258	-$586,601	$436,151
FTE	$2,905,870	$4,327,026	$4,949,236	$1,421,156	$2,043,366

*District 3's ITS maintenance is handled through a Design Build Operate and Maintain (DBOM) contract.

3.0. District ITS Maintenance Cost Structure Analysis

3.1. Existing District ITS Maintenance

A comprehensive assessment of the District's existing maintenance programs, contracts, or structure can help identify and track expenses and help improve cost projections. Districts provided their maintenance contracts for analysis of department policies, maintenance procedures, and mandates, to determine their impact on maintenance costs.

3.2. District ITS Maintenance Cost Structure

In principle, ITS maintenance cost includes:

1) **Preventive Maintenance** – regularly scheduled inspections, cleanings, greasing, tightening, recalibration, and pest control, etc.
2) **Minor or Major Maintenance** – repairs, premature replacements, troubleshooting of critical ITS devices due to equipment malfunctions, vandalism, thefts, accidental fiber cuts, weather events, and other acts of nature. Equipment repairs are minor or major, depending on their complexity.
3) **Replacements** – labor cost for programmed end of life-cycle device replacements. FDOT separately funds the capital cost of the device. See Section 4.1 for details.

3.2.1. ITS Device Maintenance Variance

All Districts provide guidance to their ITS maintenance contractors on preventive maintenance, record keeping, repairs, and scheduled replacement activities. Contrasting guidelines among the districts, however, lead to differences in maintenance cost for similar undertakings. For instance, scheduled preventive maintenances for CCTV cameras range from 3 to 12 times per year. The guidelines for express lanes also differ from the guidelines for general lanes, to help minimize downtime.

Some variations in District terminology and classifications on repair maintenance complicates the categorization of costs. For instance, what may be a minor repair in one District could be considered a major repair in another.

How maintenance services are compensated also differ substantially between the Districts. Fixed costs for maintenance activities can include any combination of labor, mobilization, administrative, and Maintenance of Traffic (MOT) facets, or they can be computed separately and then summed together.

3.2.2. TMC Maintenance

Maintenance of the Districts' TMCs are regulated through their maintenance contractors or on separate unrelated operations contracts. Either way, Central Office allocates $275,000 per year for TMC maintenance, while Satellite TMCs are granted $100,000. TMC maintenance includes repairs or diagnostic work necessary to maintain the TMC video system and communications including, but not limited to, the maintenance of the video controller equipment, switches, routers, decoders/encoders, monitors, video cards, and associated software.

3.2.3. Auxiliary ITS Equipment

For maintenance purposes, Districts consider auxiliary ITS equipment at the site of an ITS device as part of the device itself. These components include, but may not be limited to, ITS cabinets, Ethernet switches, Uninterruptible Power Supplies (UPS), and poles. This equipment is considered direct expenses only if they are prematurely replaced.

3.3. Administrative Costs

The maintenance contractors prepare schedules, reports, cost estimates, budgets, and invoices at the direction of the Districts. Reports detail maintenance activities and include information on upcoming preventive maintenances, failure details, repair services, and any other information, as deemed necessary by the Districts.

The maintenance contractors may also review and provide updates to District maintenance guides, noting any changes in maintenance procedures, and device/component additions.

3.4. Staffing Requirements

Districts vary considerably in minimum maintenance contractor staffing requirements. Most Districts dispatch their maintenance contractors on an as-needed basis. Others dedicate full-time staff year-round. This creates considerable differences among Districts in contract overhead costs each year, regardless of how much maintenance is ultimately performed. Full-time staff may include project managers, administrative support staff, warehouse assistants, and technicians.

Based on the District contract reviews, it was determined that Districts that do not require full-time staff have preventive maintenance frequency rates between 1 and 5 per year, while Districts that do require full-time staff have higher preventive maintenance frequency rates between 9-12 per year.

3.5. Non-Maintenance Activities

Most Districts utilize their maintenance contractors for additional activities that are not the intent of the programmed maintenance funds. Analysis of invoices reveals that maintenance contractors have performed activities in the past such as Construction Engineering Inspection (CEI) work, furnish and install projects, design reviews, consulting, and parts procurement. These activities may account for up to 30% of a District's yearly "maintenance" expenditures and cannot be addressed with formulas, since they vary year to year and from District to District.

4.0. ITS Maintenance Formula Update

The updated ITS maintenance cost formula combines the Central Office and District Four efforts into a single, simpler formula that also reflects the results of the Districts' maintenance program examination. All definitions, assumptions, and equations are described in the following sub-sections. The updated formulas also reflect the proper use of maintenance funding as defined in the Work Program Instructions.

4.1. Definitions

4.1.1. Maintenance Function Definitions

Preventive Maintenance Unit Rate*:* The cost of a single preventive maintenance service at a device site or location includes mobilization costs, travel time, vehicles, equipment, tools, MOT cost, labor, and all other incidental or administrative costs. Preventive Maintenance services at the site include but are not limited to the device itself, the pole, mounting brackets, associated cabinet, communications and network equipment, power equipment, grounding and surge protection equipment, cables, UPS, and all other ancillary equipment. Typical preventive maintenance activities include:

- Checking concrete structure pole (if applicable)
- Visually checking external components, including cabinet, for physical damage
- Inspecting cabinet lighting system
- Verifying power supplies are working correctly
- Checking UPS batteries (if applicable)
- Checking and lubricating cabinet access door and lock
- Checking cabinet fan and thermostat operation
- Applying pest control to cabinet and DMS housing if needed
- Inspecting all conduit for proper mounting
- Inspecting all conduit for environmental damage
- Replacing any missing conduit putty
- Cleaning/dusting of components in cabinet
- Cleaning/replacement of filters
- Firmware version verification/correction (upgrade/regression)
- Cleaning solar panels, checking associated batteries (if applicable)
- Checking grounding (physically and electrically)
- Checking/replacing weather proofing (if applicable)
- Cleaning of camera, including dome (if applicable)
- Cleaning and greasing of lowering device (if applicable)
- Inspecting DMS pixel modules
- Verifying Microwave Vehicle Detectors (MVDS) data, determining if re-calibration is necessary
- Calibrating Automatic Vehicle Identification (AVI) readers
- Inspecting beacon receivers

Minor Maintenance Unit Rate: The cost of a minor maintenance service at a device site or location includes the mobilization costs, travel time, vehicles, equipment, tools, MOT cost, labor, and all other incidental or administrative costs. Minor maintenance usually consists of troubleshooting a failed device, component or part that renders the device or site inoperable, identifying the causes of the failure, and providing a solution. Generally, a repair is considered to be minor when ITS components need repair/replacement due to malfunction. Examples include replacement of damaged surge protection devices, replacement of fiber patch cords, and rebooting the device.

Major Maintenance Unit Rate: The cost of a major maintenance service at a device site or location includes the mobilization costs, travel time, vehicles, equipment, tools, MOT cost, labor, and all other incidental or administrative costs. Major maintenance usually consists of non-typical repairs that need elaborate diagnostic services to identify the problem, extensive repair services, MOT and lane closures requirements, and utility coordination possibly due to vandalism, theft, fiber cuts, other construction activity related issues, etc.

Scheduled Replacement Unit Rate: The cost of a scheduled end-of-life-cycle replacement service at a device site or location includes the mobilization costs, travel time, vehicles, equipment, tools, MOT cost, labor, and all other incidental or administrative costs. The District may employ the maintenance contractor to carry out this task at times. This does not include the cost of the device itself. The device cost is covered under ITS Replacement Cost and is funded separately by the Central Office through Work Program, Schedule B (Target TOTR).

Percent Fail Rate: Percent fail rate is the expected percentage or number of ancillary components such as UPSs, batteries, cabinets, Ethernet switches, and poles that will require replacement each year due to premature failure.

Furnish and Install Rate: Furnish and install rate is the cost for the maintenance contractor to furnish and install a specific ITS supporting element such as a pole, cabinet, switch, etc., that requires immediate replacement due to a critical malfunction or external damage.

4.1.2. ITS Device/Element Definitions

See Appendix A for ITS device and element definitions.

4.2. ITS Facility Classifications

ITS devices and elements are classified by Freeway, Arterial, or Express facility/roadway type. These classifications help to address different unit rates and maintenance frequencies for devices, depending on their roadway type. It also allows Central Office to discern what amount of maintenance funds are going towards each roadway type, for the purpose of higher level budgeting.

4.3. ITS Equation Classes

ITS devices and elements sharing similar maintenance processes and cost structures are grouped into six separate classes with specific equations and assumptions. The equations are valid for freeway, arterial, and express facilities, as shown below:

- **Class 1** – CCTVs, VDSs (all types, except Wireless Magnetometers), DMSs, Embedded DMSs/Lane Control Signs (LCS), RWISs, Ramp Meters, Wireless Radio Devices, and Connected Vehicle (CV) Units
- **Class 2** – HARs and Communication/Master Hubs
- **Class 3** – Wireless Magnetometers (In-Pavement), Cabinets, CCTV Concrete Poles, Type II & III Poles, UPSs, and Layer 2/3 Switches
- **Class 4** – FOC and Intelligent Transportation Systems Facility Management (ITSFM)
- **Class 5** – Permanent Generators
- **Class 6** – TMCs and Satellite TMCs

4.4. General Rules and Assumptions

Assumptions in this section are applicable to all equation classes and are shown below.

1) The formula treats each ITS device at a location with multiple devices as one complete site in of itself with all corresponding auxiliary equipment.
2) Equipment serving both general and express lanes are counted as express lane equipment.
3) Tolling equipment is not accounted for in these formulas.
4) FTE's general toll lanes will be regarded as a general freeway facility. Other District's toll roads will be counted as if they are express facilities.
5) Administrative costs such as project management, coordination, reports, etc., are included in the individual unit rates.
6) The FDOT Work Program Cost Inflation factors are applied to all future year unit rates.
7) Freeways, arterials, and express facilities are calculated separately for device or component.

4.5. ITS Maintenance Equations

4.5.1. Class 1 ITS Maintenance Equation

4.5.1.1. ITS Devices

Class 1 ITS devices include:

- CCTV Cameras (Freeway, Arterial, Express)
- DMS (Freeway, Arterial, Express)
- Embedded DMS/LCS (Freeway, Arterial, Express)
- MVDS (Freeway, Arterial, Express)
- Bluetooth/AVI Readers (Freeway, Arterial, Express)
- Video Vehicle Detectors (Freeway, Arterial, Express)
- Loop Detectors (Freeway, Arterial, Express)
- Ramp Meters (Freeway, Express)
- RWIS (Freeway, Arterial, Express)
- Wireless Radio Devices (Freeway, Arterial, Express)
- CV Units (Freeway, Arterial, Express)

4.5.1.2. Assumptions

The following assumptions are made for the Class 1 ITS maintenance formulas:

1) General lane ITS devices will have three (3) preventive maintenance services per year.
2) Express lane ITS devices will have four (4) to six (6) preventive maintenance services per year, depending on the device.
3) 20% of ITS devices will require minor maintenance services per year.
4) 10% of ITS devices will require major maintenance services per year.
5) Scheduled device replacement costs do not include the cost of the device. Replacement is funded separately by Central Office.

4.5.1.3. Equation

Yearly Maintenance Cost =

$$\begin{gathered} Preventive\ Maintenance\ Frequency \times Unit\ Rate \times Number\ of\ Planned\ Devices \\ + \\ Minor\ Maintenance\ Unit\ Rate \times 20\% \times Number\ of\ Planned\ Devices \\ + \\ Major\ Maintenance\ Unit\ Rate \times 10\% \times Number\ of\ Planned\ Devices \\ + \\ Replacement\ Unit\ Rate \times Number\ of\ Existing\ Devices\ Scheduled\ for\ Replacement \end{gathered}$$

4.5.2. Class 2 ITS Maintenance Equation

4.5.2.1. ITS Devices

Class 2 ITS devices include:

- HAR (Freeway)
- Master/Communication Hubs (Freeway, Arterial, Express)

4.5.2.2. Assumptions

The following assumptions are made for the Class 2 ITS maintenance formulas:

1) HARs and Communication Hubs will have three (3) preventive maintenance services per year.
2) 20% of HARs and Master Hubs will require minor maintenance services per year, such as re-attaching loose connectors, power rebooting, minor parts replacement, etc.
3) 10% of HARs and Hubs will require major maintenance services per year, such as repairing external damage to the device or cabinet, power or fiber cuts, and major equipment malfunctions.
4) HARs will not be replaced upon complete failure.
5) Complete Master Hub replacement is not within the scope of the maintenance contractor's activities.

4.5.2.3. Equation

Yearly Maintenance Cost =

$$Preventive\ Maintenance\ Frequency \times Unit\ Rate \times Number\ of\ Planned\ HAR/Hubs$$
$$+$$
$$Minor\ Maintenance\ Unit\ Rate \times 20\% \times Number\ of\ Planned\ HAR/Hubs$$
$$+$$
$$Major\ Maintenance\ Unit\ Rate \times 10\% \times Number\ of\ Planned\ HAR/Hubs$$

4.5.3. Class 3 ITS Maintenance Equation

4.5.3.1. ITS Devices

Class 3 ITS devices include:

- Wireless In-Pavement Magnetometers (Freeway, Arterial, Express)
- Cabinets (Freeway, Arterial, Express)
- UPS (Freeway, Arterial, Express)
- CCTV Concrete Poles (Freeway, Arterial, Express)
- Type II and Type III Concrete Poles (Freeway, Arterial, Express)
- Layer 2 Switches (Freeway, Arterial, Express)
- Layer 3 Switches (Freeway, Arterial, Express)

4.5.3.2. Assumptions

The following assumptions are made for the Class 3 ITS maintenance formulas:

1) Fail rates are based on engineering estimates and will be continually re-assessed for accuracy.
2) Truck parking magnetometers are counted as freeway magnetometers.

4.5.3.3. Equation

Yearly Maintenance Cost =

$$Percent\ Fail\ Rate \times Number\ of\ Planned\ Component\ Type \times Furnish\ and\ Install\ Rate$$

4.5.4. Class 4 ITS Maintenance Equation

4.5.4.1. ITS Devices and Services

Class 4 ITS devices and services include:

- FOC (Freeway, Arterial, Express)
- ITSFM (Freeway, Arterial, Express)

4.5.4.2. Assumptions

The following assumptions are made for the Class 4 ITS maintenance formulas:

1) ITSFM quantities are for the existing ITS infrastructure that is already in place and not previously populated in ITSFM.
2) ITSFM effort for fiber and device maintenance and relocation activities are factored into the individual cost of the devices.
3) Future ITS deployments ITSFM efforts will not be the responsibility of the maintenance contractor.

4.5.4.3. Equation

Yearly Maintenance Cost =

$$ITSFM\ or\ Fiber\ Optic\ Cable\ Maintenance\ Rate\ Per\ Mile\ \times\ Planned\ Number\ of\ Miles$$

4.5.5. Class 5 ITS Maintenance Equation

4.5.5.1. ITS Devices

Class 5 ITS devices include:

- Permanent Generators (Freeway, Arterial, Express)

4.5.5.2. Assumptions

The following assumptions are made for the Class 5 ITS maintenance formulas:

1) Only permanent generators will be accounted for in the formula and are assumed to be maintained on a monthly basis.

4.5.5.3. Equation

Yearly Maintenance Cost =

$$Number\ of\ Planned\ Generators\ \times\ Monthly\ Maintenance\ Rate\ \times\ 12$$

4.5.6. Class 6 ITS Maintenance Equation

4.5.6.1. ITS Elements

Class 6 ITS elements include:

- TMC
- Satellite TMC

4.5.6.2. Assumptions

The following assumptions are made for the Class 6 ITS maintenance formulas:

1) Local TMCs not directly supported by FDOT are not accounted for as their funding is acquired from other sources.
2) Satellite TMCs are those that the FDOT has financially invested into and have at least one (1) FDOT operator and is not operated on a 24/7/365 basis.

4.5.6.3. Equation

Yearly Maintenance Cost =

$$Number\ of\ TMCs\ \times\ Yearly\ Maintenance\ Rate$$

$$+$$

$$Number\ of\ Satellite\ TMCs\ \times\ Yearly\ Maintenance\ Rate$$

4.6. Unit Rates and Regional Factors

4.6.1. Unit Rates

Districts differ in each facet of the maintenance activities and variations are built into their unit rates. In order to address these differences, an attempt was made to calculate comprehensive unit rates for each District that included equipment, labor, administrative, and MOT costs. However, not all Districts' contracts clearly indicate how unit prices are determined. Therefore, a new method was planned to determine rates in which the Districts with clearly defined unit rates were identified and their unit rates were averaged to form the "base" rates for these formulas.

4.6.2. Regional Factors

Districts have varying characteristics and face different challenges in maintaining ITS infrastructure, which affect costs for similar maintenance functions. These variations include:

- Contract overhead (full-time vs. responsive staff)
- Administrative cost (from 10 to 120 hours per week)
- Personnel rates per regional cost of living
- Fuel consumption rates
- Levels of required MOT
- Higher traffic volumes, travel time variability, and event frequencies suggest a need for higher level of device and communication network up-time availability

To balance these different funding needs, the regional factors were developed to account for differing district characteristics and are then applied to the base rates. The regional factors will be updated periodically to ensure accurate funding levels are being provided to the Districts. Table 2 shows the regional factors used.

Table 2: Regional Factors

FDOT District	Regional Factor
1	1.00
2	1.22
3	1.00
4	1.44
5	1.44
6	1.56
7	1.44
FTE	1.00

5.0. Maintenance Formula Considerations

5.1. Formula Application

The new maintenance cost formulas are easy to use and understand. Districts simply input equipment quantities and number of scheduled life cycle replacements into the orange highlighted cells of the cost calculator spreadsheet (See Appendix C). The formulas used in the spreadsheet automatically generate costs while adjusting for inflation for each fiscal year.

Scheduled life cycle replacement quantities should match those entered by Districts in the ITS replacement summary sheet (See Appendix B). The ITS replacement summary sheet is a separate formula that computes expected future ITS end-of-life cycle replacement capital costs, and is funded separately.

5.2. Annual Formula Assessment

The formulas will be assessed annually to ensure that assumptions remain realistic, and meet Districts' expectations. Modifications may be necessary due to new ITS technology deployments and changes in District contractual structure or overhead cost. Annual assessment of the formulas keeps them up-to-date and minimizes inaccuracies. For instance, as Wrong Way Driving (WWD) Systems are being deployed across the State on a more frequent scale, they will now be factored into the 19/20 fiscal year maintenance cost formula.

It is also essential that regularly comparing actual maintenance costs with the estimates determines if other changes are needed to the formula, or if the District's regional needs are influencing the costs.

5.3. Maintenance Cost Estimate Comparisons

Table 3 shows the actual costs versus the original Central Office estimates and the new formula estimates for fiscal year 2014-2015. The new formula estimates are closer to the actual costs than the original Central Office formula. The new formula still has room for improvement, but has lessened the gap from the actual costs and what is being programmed.

Table 3: Fiscal Year 2014-2015 Actual vs. Estimated Maintenance Costs

FDOT District	Actual Cost	Previous Central Office Estimate	New Formula Estimate	Central Office Difference from Actual	New Formula Difference from Actual
1	$1,175,671	$1,938,380	$1,276,639	$762,709	$262,404
2	$1,219,247	$1,285,256	$1,121,398	$66,009	$1,102
4	$3,530,277	$3,492,746	$3,470,454	-$37,531	$474,232
5	$2,669,859	$2,806,880	$2,766,393	$674,021	$317,662
6*	$2,479,449	$1,905,407	$2,271,430	-$574,042	-$339,758
7	$2,394,107	$1,807,506	$2,144,898	-$586,601	-$189,074
FTE	$2,905,870	$4,327,026	$3,106,469	$1,421,156	$654,670

Note: District 3's ITS program was still under construction during this time.

* Includes both the General and Express lane maintenance costs.

6.0. Conclusion

The analysis of the maintenance programs reveals that contract structure is the largest influencer of the annual costs. Also, requiring full-time vs. on-demand staff profoundly affects yearly overhead costs, but does not affect the fail rates, according to the calculated fail rates in the District Four formulas.

The administrative cost also varies significantly along with the hours of administrative work that range from 10 to 120 hours per week. It is likely that many of these contracts were newly introduced with no track record for estimating the number of hours needed for project management, reports, etc.

The new ITS Maintenance Scope of Services Template issued by Central Office will help to address some of these inefficiencies. Once all Districts have migrated to this contract, it is expected that it will be much easier to predict and manage future costs. It is recommended, however, that the Central Office update this Template to better reflect the needs of the maintenance programs. The Central Office is completing a study on "performance-based" maintenance contracting and depending on the results of that study, the Central Office is also considering development of a maintenance template where all or part of the basis of payment is dependent on the uptime of the ITS field equipment and communications network, as well as other factors.

The updated ITS maintenance cost formula minimizes the differences between actual and budgeted costs and helped identify cost structures and needs by examining Districts' maintenance contracts and procedures. A standard set of definitions, assumptions, and equations to calculate maintenance costs for ITS devices and elements are part of the new formulas.

Regional factors were developed to address needs in Districts with higher than average costs due to contract structures, urbanization, MOT requirements, and maintenance frequencies.

The formula assumptions, unit rates, regional factors, and ITS device types will be assessed periodically to ensure that they remain relevant as ITS technologies and District needs evolve over time.

Appendix A – ITS Definitions

Bluetooth & AVI Detectors: A roadside pole mounted device that anonymously detects and matches bluetooth or radio frequency identifiers. Maintenance includes, but is not limited to: the detector units, mounting brackets, associated junction box, power equipment, grounding and surge protection devices, cables, UPS, batteries, and other ancillary equipment.

Cabinets: Equipment housing that protects and stores the ITS equipment. Parts include but are not limited to: foundation, conduit, sun shields, power, cables, ground and surge equipment.

CCTV Camera System: Provides visual monitoring and verification of roadway conditions and other critical junctures. Maintenance of the CCTV includes, but is not limited to: PTZ or Thermal CCTV Cameras, camera dome and enclosure, camera lowering device, mounting brackets, power equipment, grounding and surge devices, cables, UPS, and other ancillary equipment.

CV Units: In-cabinet equipment that sends and receives signals to connected vehicles. Maintenance of the CV units includes, but is not limited to: the wireless communication components and antennas, processor, controller, associated cabinet components, power equipment, grounding and surge equipment, cables, and all other ancillary equipment.

Communication/Master Hub Building: A small building that serves as a critical point in the overall network in collecting and sending data to the TMC. Maintenance of the hub includes, but is not limited to: the AC units and filters, generator units, fuel tanks, UPS and batteries, power equipment, grounding and surge protection devices, and all other ancillary equipment.

DMS System: Large electronic signs which overhang the roadway and are typically used to display information about traffic conditions, travel times, and road incidents. Maintenance of the DMS includes, but is not limited to: the DMS Panel, DMS controller, facial cleaning, mounting brackets, associated cabinet, power equipment, grounding and surge equipment, cables, UPS, batteries, and other ancillary equipment.

Embedded DMS & LCS: Small electronic signs which are used to display variable toll rates, lane status messaging, travel times, and advisory messages. Maintenance includes, but is not limited to: the panels, controller, facial cleaning, mounting brackets, associated cabinet, power equipment, grounding and surge equipment, cables, UPS, batteries, and other ancillary equipment.

Ethernet Switches: A computer networking device that connects devices together with the TMC.

FOC: A high speed transmission medium that consists of bundled glass threads, each of which is capable of transmitting messages modulated onto light waves. Maintenance of the FOC includes, but is not limited to: cables, enclosures, splice trays, pull boxes, utility locates, and all other related equipment.

Generators: A fuel powered apparatus that provides back up power for ITS devices and Master Hubs in the event of temporary or long term commercial power failure. Maintenance of the generator includes, but is not limited to: replenishing fuel and oil, filters, batteries, surge equipment, and other system components.

HAR System: Licensed low-power broadcast radio stations that provide information to motorists regarding travel, situations of imminent danger and emergencies. HAR broadcast locations are marked by signs that have flashing beacons to alert motorists to tune-in. Maintenance of the HAR includes, but is not limited to: transmitters, flashing beacon assemblies, solar panel assembly, batteries, power equipment, grounding and surge equipment, cables, and all other ancillary equipment.

ITSFM: Includes, but is not limited to, the task of GPS and cable mapping, equipment site inventory, fiber patch panel mapping, and fiber splice enclosure mapping for existing sections of FOC lengths.

Loop Detectors: Insulated, electrically-conducting loop installed in the pavement to detect vehicles passing or arriving at a certain point. Maintenance of the loop detectors includes, but is not limited to: loops, periodic testing and tuning of detection, associated cabinet equipment, power equipment, grounding and surge equipment, and all other ancillary equipment.

Magnetometers: Sensors installed in holes in the roadway or parking spots that use wireless magneto-resistive sensors to detect the presence and movement of vehicles. The sensors transmit detection data to nearby access points. Maintenance of the magnetometers includes, but is not limited to: magnetometers, periodic testing and tuning of detection, associated cabinet equipment, power equipment, grounding and surge equipment, and all other ancillary equipment.

MVDS: Microwave radar detector that is mounted on a roadside pole, and aimed at the side of vehicles to provide presence and vehicle detection data. Maintenance of the MVDS includes, but is not limited to: detector units, mounting brackets, periodic testing and recalibration of speed and volume sensing, associated junction box, power equipment, grounding and surge equipment, cables, UPS, batteries, and other ancillary equipment.

Poles: A long slender, rounded piece of concrete used with one end placed in the ground as a support for a device or similar.

Ramp Meter Signal System: A device with a two or three section signal light together with a signal controller that regulates the flow of traffic entering freeways and express facilities according to current traffic conditions. Maintenance of the ramp meters may include but not limited to: the ramp signals, detectors supporting the ramp signal operations (i.e., loops), supporting flashing beacon assemblies, cameras, cables, associated cabinet equipment, power equipment, grounding and surge equipment, and all other ancillary equipment.

RWIS: A network of meteorological and pavement sensors that provide accurate real-time weather information and critical observations for forecasts. Maintenance of the RWIS includes but is not limited to: sensors, mounting brackets, lowering mechanisms, associated cabinet components, power equipment, grounding and surge equipment, cables, and all other ancillary equipment.

Satellite TMC: A smaller part-time TMC that typically operates between 8-16 hours a day. For purposes of accounting, only those that are directly invested into by the Central Office will be factored into the formula.

TMC: The Transportation/Traffic Management Center (TMC) are the facilities that may contain multiple agencies interested in the management and operations of transportation facilities and services. These centers are usually hubs for communications infrastructure and contain information systems that support these facilities and services. Maintenance of the TMC includes: services for the video wall, associated controller, video cubes, filters and lamp replacement, power equipment, workstations, and other ancillary equipment.

UPS: Uninterruptible power supply is an electrical apparatus that provides conditioned power to a load, and short-term backup power when the input power source or main power fails. They are typically placed in cabinets at critical ITS locations.

Video Vehicle Detector System (VVDS): Cameras installed over the center or side of the roadway that use an image processor for interpreting the images and converting them into traffic flow data. Maintenance of the VVDS includes, but is not limited to: the camera, processor, controller, associated cabinet components, power equipment, grounding and surge equipment, cables, and all other ancillary equipment.

Wireless Master and Access Point Radios: Low power radios wirelessly linked to another radio or magnetometer sensors in the pavement to transmit or receive data. Maintenance of the wireless radios includes, but is not limited to: the wireless antennas, radios, periodic signal strength testing and adjustment, mounting brackets, lowering mechanisms, associated cabinet components, power equipment, grounding and surge equipment, cables, and all other ancillary equipment.

Appendix B – Sample Replacement Sheet

Appendix C – Sample Maintenance Formula Sheet