

# Special Specification 6293

## Adaptive Traffic Signal Control System



### 1. DESCRIPTION

Furnish, install, relocate, or remove adaptive traffic signal control (ATSC) system software and equipment at locations shown on the plans, or as directed.

The Contractor must verify that existing equipment and additional equipment called for in the plans will be suitable for use with the ATSC system they intend to provide. Notify the Department of any concerns prior to bidding.

### 2. MATERIALS

2.1. **General.** Furnish, assemble, fabricate, and install only new materials. Provide an ATSC system that includes traffic adaptive features and functions able to automatically adjust signal operation to adapt to unexpected changes in traffic conditions, provide smooth traffic flow, and ease congestion. ATSC is classified into 3 types as follows:

- Type 1 (software systems that adjust offset and splits);
- Type 2 (software systems that adjust cycle length, offset, and splits); and
- Type 3 (hardware systems that intercept and manipulate detector calls to the controller and use an algorithm to serve traffic based on demand).

2.2. **System Devices and Components.** The overall ATSC system must include the following fundamental subsystems, devices, and components unless otherwise shown on the plans:

- Adaptive control software (central software and controller software)
- Standalone hardware dedicated to ATSC (as applicable)
- Field Master (as applicable)
- Controller assemblies and signals, installed and paid for under Item 680 "Highway Traffic Signals."
- Detection systems, installed and paid for under appropriate detection special specification
- Communication infrastructure, installed and paid for under appropriate communication specification

ATSC systems may use existing signal system components and communication infrastructure, new signal system components and communication infrastructure, or a combination of existing and new equipment, as shown on the plans.

2.3. **Adaptive Control Software.** The ATSC software must be compatible with the signal equipment shown on the plans. Install new firmware, as needed, on existing controller hardware to provide ATSC system functionality. Software and firmware updates must be approved by the Department before installation.

2.3.1. **Availability.** The software design must include features that help achieve high availability. This includes subsystem modularity and features such as system management, communications, web services, transition management, and security. Redundancy, backup and recovery, and failure detection must also be part of the software design. Server software must be able to run in a virtual server environment. Weekly server or service restarts are not allowed. Error checking and validation must be incorporated into system operation. The system must support modes of operation and functions such as configuration, monitoring, adaptive control, and manual control.

2.3.2.

**Configuration and Management.** The system must allow the user to upload, open, edit, store, and download all controller configuration parameters, including: timing plans, overlaps, detectors, coordination parameters and settings, clock settings, time of day settings, holiday settings, special event settings, and preemption settings.

ATSC systems that utilize central server software for adaptive timing analysis and processing must be able to control and adjust a minimum of 50 signals concurrently.

The ATSC system central software must support transportation system management and operations of a minimum of 1,000 intersections.

The system must provide for time synchronization of servers, client workstations, and field devices using GPS, WWV, NTP, or equivalent.

The software must provide a warning to the user if a setting violates a rule or conflicts with other settings, e.g. cycle length is not equal to the total of the splits.

The software must allow calendar scheduling of different functions and plans based on days of the year, time of day, day of week, special, and seasonal occurrence.

2.3.3.

**Operation.** ATSC software must be able to dynamically modify the following parameters for each signalized intersection under adaptive control mode based on detector information to provide real-time adaptive traffic control:

- Modify Cycle Length (types 2 and 3)
- Modify Split
- Modify Offset

In addition to dynamically changing real-time parameters, the ATSC software must monitor traffic volume and modify phase sequences with a frequency similar to typical time-of-day coordination plans.

The system must allow configuration of fixed baselines, boundary limits for automatically adjusted values, and transition frequencies / magnitudes for the above parameters. Ensure that automatic adjustments made by the system remain within user-configured values.

In monitoring mode, the ATSC system must provide real-time information for each monitored intersection. The following list is the minimum data collection required for real-time information:

- Cycle times
- Split allocation
- Offsets
- Sequences / demand dependent phase activation
- Detector fault warnings
- Phase Utilization (such as: gap out, max out, force off).

The system must retain a historical record of system timing changes and adjustments resulting from adaptive traffic control features and functions. The system must allow operators to manually enable and disable adaptive control.

The system must provide for priority control and preemption of the controller for emergency vehicles. Signal timing optimization must automatically recover after preemption.

The system must recover automatically after a power outage, power surge, emergency vehicle preemption, and communications failure.

The system must have a central control with a user interface that allows all settings and subcomponents to be configured and include remote monitoring and reporting features.

The system must provide status displays for monitoring traffic adaptive operation such as pattern history and phase timing history. Status displays may be tabular or graphical depending on the information displayed. The system must include a graphical display with signal and detector status overlaid on an aerial image of the intersection for remote observation of operation.

Controllers must revert to a standard operating plan and time of day operation in the event of:

- adaptive control equipment failure;
- a configured number of sporadic detector failures; or
- when the number of failed detectors exceeds a user-defined value.

Ensure the system alters the state of signal controllers to prevent queues from exceeding storage capacity at user-specified locations when conditions meet user-specified criteria.

Ensure the system alters the state of signal controllers to provide equitable distribution of green times when conditions meet user-specified criteria.

Ensure the system alters controller operation to provide two-way progression on a coordinated route.

The system must operate properly without requiring repeated manual adjustments, reconfiguration, or corrective actions to maintain performance once initial configuration is complete.

- 2.3.4. **Phasing.** The system must allow the user to configure maximum and minimum phase times. Ensure the user can configure minimum and maximum values for each phase at each signal controller.

Ensure the ATSC system does not automatically implement any phase duration longer than the maximum value or shorter than the minimum value.

The system must detect repeated phases that do not serve all waiting vehicles and alter operation to minimize repeated phase failures. The ATSC system must be able to optimize and adjust the order of phases, or implement alternate phase sequences, at user-specified intersections.

- 2.3.5. **Routes.** Ensure the ATSC system coordinates signals along user-defined routes. Ensure the ATSC system allows implementation of a stored coordinated route by operator command.

- 2.3.6. **Groups.** The ATSC central software must support groups of signals. Ensure the ATSC system controls a minimum of three groups of signals. Each group must be able to include minimum of 50 signals and must be capable of operating independently.

- 2.4. **Adaptive Control Hardware.** If the ATSC system requires any hardware designed for and dedicated to adaptive control; the equipment must be part of the manufacturer's complete adaptive system and approved by the Department. Hardware must be compatible with the signal equipment.

- 2.5. **Controllers.** Ensure the traffic signal controller is not adversely affected by failure of adaptive signal control system communication or other system components. The ATSC system must interface with the traffic controller using Internet Protocol (IP) unless otherwise shown in the plans.

- 2.6. **Detection.** The system must utilize existing detection systems or include detection system upgrades as shown in the plans and as required by the ATSC system manufacturer to fully support all adaptive signal control features and functionality.

- 2.7. **Communications.** The system must support operation across an IP network and system client applications must be network-deployable.

The adaptive control system must be capable of maintaining once per second communications between field processors, local controllers, and central software.

National Transportation Communications for ITS Protocol (NTCIP) must be used for communication between controllers and central and between central and other external systems.

The software must automatically monitor and provide real-time communications status, provide notifications when communications is lost and restored, and maintain a log of communication-related events.

- 2.8. **Mechanical.** ATSC system devices in the controller cabinet must be fabricated from corrosion resistant materials, such as plastic, stainless steel, aluminum, or brass.

Ensure that all screws, nuts, and locking washers are stainless steel. Do not use self-tapping screws.

Ensure equipment is clearly and permanently marked with manufacturer name or trademark and part number as well as date of manufacture or serial number.

- 2.9. **Electrical.** ATSC system devices in the controller cabinet must operate on nominal 120 V<sub>AC</sub>. Provide a transformer with any system device that requires a nominal operating voltage other than 120 V<sub>AC</sub>.

- 2.10. **Environmental.** ATSC system devices in the controller cabinet must comply with and operate properly during and after being subjected to the environmental testing procedures described in NEMA TS2, Section 2.

- 2.11. **Connectors and Harnesses.** External connections exposed to the outdoor environment must be made with weatherproof connectors. Connectors must be keyed to ensure correct alignment and mating.

Ensure all conductors are properly color coded and identified. Ensure that every conductive contact surface or pin is gold-plated or made of a noncorrosive, nonrusting, conductive metal.

- 2.12. **Documentation.** Provide hardcopy operation and maintenance manuals, along with a copy of all product documentation on electronic media. Include the following documentation for all system devices and software:

- operator manuals,
- installation manuals with installation procedures,
- maintenance and troubleshooting procedures, and
- manufacturer's specifications (functional, electrical, mechanical, and environmental).

Provide certification from an independent laboratory demonstrating compliance with NEMA TS2 environmental requirements for temperature, humidity, transients, vibration, and shock.

Provide certification that ATSC electronic equipment meets FCC class B requirements for electromagnetic interference and emissions.

- 2.13. **Warranty.** Warrant the equipment against defects or failure in design, materials, and workmanship for a minimum of 5 yr. or in accordance with the manufacturer's standard warranty if that warranty period is greater. The start date of the manufacturer's standard warranty will begin after the equipment has successfully passed all tests contained in the final acceptance test plan. Any equipment with less than 90% of its warranty remaining after the final acceptance test is completed will not be accepted by the Department. Guarantee that equipment furnished and installed for this project performs according to the manufacturer's published specifications. Assign, to the Department, all manufacturer's normal warranties or guarantees on all electronic, electrical, and mechanical equipment, materials, technical data, and products furnished for and installed on the project.

Malfunctioning equipment must be repaired or replaced at the Contractor's expense prior to completion of the final acceptance test plan. Furnish replacement parts for all equipment within 10 days of notification of failure by the Department.

During the warranty period, technical support must be available via telephone within 4 hr. of the time a call is made by a user, and this support must be available from factory certified personnel.

Software and firmware updates must be provided at no additional cost during the ATSC manufacturer's warranty period.

- 2.14. **Training.** Conduct a training class for a minimum of 24 hr., unless otherwise directed, for up to 10 representatives designated by the Department on installation, configuration, operation, testing, maintenance, troubleshooting, and repair. Submit a training session agenda, a complete set of training material, the names and qualifications of proposed instructors, and proposed training location for approval at least 30 days before the training. Conduct training within the local area unless otherwise directed. Provide 1 copy of course material for each attendee. Ensure that training includes:
- "Hands-on" operation of system software and equipment;
  - explanation of all system commands, their function and usage; and
  - system "troubleshooting," operation, and maintenance.

### 3. CONSTRUCTION

- 3.1. **System Installation.** Install ATSC system devices per the manufacturer's recommendations. The ATSC system must operate using existing signal system communication infrastructure unless otherwise shown on the plans. Completion of the work must present a neat, workmanlike, and finished appearance.
- Provisions must be made for installation and configuration of software on Department computers.
- 3.2. **Mechanical Components.** Ensure that all fasteners, including bolts, nuts, and washers with a diameter less than 5/8 in. are Type 316 or 304 stainless steel and meet the requirements of ASTM F593 and ASTM F594 for corrosion resistance. Ensure that all bolts and nuts 5/8 in. and over in diameter are galvanized and meet the requirements of ASTM A307. Separate dissimilar metals with an inert dielectric material.
- 3.3. **Wiring.** All wiring and electrical work supplying the equipment must meet the requirements of the most current version of the National Electrical Code (NEC). Supply and install all wiring and incidentals necessary to complete the work. If additional cables are required, the Contractor must furnish and install them at no additional cost to the Department. Provide conductors at least the minimum size indicated on the plans and insulated for 600 V.
- Cables must be cut to proper length prior to assembly. Provide cable slack for ease of removal and replacement. All cable slack must be neatly laced with lacing or straps in the bottom of the cabinet. Ensure cables are secured with clamps and include service loops.
- 3.4. **Electrical Service.** The Contractor is responsible for checking the local electrical service to determine if a modification is needed for the equipment.
- 3.5. **Grounding.** Ensure all ATSC system devices are grounded in accordance with the NEC and manufacturer recommendations.
- 3.6. **Controllers.** The Contractor must upgrade existing controllers, provide and install the adaptive control system, and configure all operational parameters to complete an operational adaptive control system as shown on the plans or as required to fully support all ATSC system adaptive signal control features and functionality.
- 3.7. **Detectors.** The Contractor must upgrade existing detectors as shown on the plans or as required to fully support all ATSC system adaptive signal control features and functionality.
- 3.8. **Controller removal and replacement.** Notify the Project Engineer prior to removal and replacement of controller and ATSC equipment to minimize traffic congestion and maintain safe construction practices.

Inspect existing controller systems and field equipment as required with a representative from the Department. Document any evidence of damage or malfunction prior to removal and replacement.

Remove and replace system devices per manufacturer guidelines.

Remove existing field equipment as shown on the plans only when authorized by the Engineer.

Use care to prevent damage to cabinet connections and equipment.

Deliver items to be retained by the Department to the location shown on the plans or as indicated in the plan notes. The Contractor is responsible for any removed equipment until released by the Engineer.

- 3.9. **Relocation of ATSC Field Equipment.** Perform the relocation in strict conformance with the requirements herein and as shown on the plans. Completion of the work must present a neat, workmanlike, and finished appearance. Maintain safe construction practices during relocation.

Inspect the existing ATSC field equipment with a representative from the Department and document any evidence of damage prior to removal. Conduct a pre-removal test in accordance with the testing requirements contained in this Item to document operational functionality. Remove and deliver equipment that fails inspection to the Department.

Prior to removal of existing ATSC field equipment, disconnect and isolate the power cables from the electric power supply and disconnect all communication cabling from the equipment located inside the cabinet. Coil and store power and communication cabling inside the cabinet until such time that it can be relocated. Remove existing ATSC field equipment as shown on the plans only when authorized by the Engineer.

Use care to prevent damage to cabinet or any support structures. Any equipment or structure damaged or lost must be replaced by the Contractor (with items approved by the Engineer) at no cost to the Department.

Make all arrangements for connection to the power supply and communication source including any permits required for the work to be done under the Contract. Provide conductors for the power connection at least the minimum size indicated on the plans and insulated for 600 V.

- 3.10. **Removal of ATSC Field Equipment.** Perform removal in strict conformance with the requirements herein and as shown on the plans. Completion of the work must present a neat, workmanlike, and finished appearance. Maintain safe construction practices during removal.

Disconnect and isolate any existing electrical power supply prior to removal of existing field equipment.

Use care to prevent damage to any support structures. Any equipment or structure damaged or lost must be replaced by the Contractor (with items approved by the Engineer) at no cost to the Department.

All materials not designated for reuse or retention by the Department will become the property of the Contractor and be removed from the project site at the Contractor's expense. Deliver items to be retained by the Department to a location shown on the plans or general notes. The Contractor is responsible for any removed equipment until released by the Engineer.

- 3.11. **Contractor Experience Requirements.** Contractor or designated subcontractor must meet the following experience requirements:

- 3.11.1. **Minimum Experience.** Three years of continuous existence offering services in the installation of ATSC systems.

- 3.11.2. **Completed Projects.** Three completed projects where personnel installed, tested, and integrated ATSC field equipment. The completed installations must have been in continuous satisfactory operation for a minimum of 2 yr.

- 3.11.3. **Equipment Experience.** One project (may be 1 of the 3 projects in the preceding paragraph) in which the personnel worked in cooperation with technical representatives of the equipment supplier to perform installation, integration, or acceptance testing of the work. The Contractor will not be required to furnish equipment on this project from the same supplier who was referenced in the qualification documentation.

Submit the names, addresses, and telephone numbers of the references that can be contacted to verify the experience requirements given above.

#### 4. TESTING

Ensure that the following tests are performed on equipment and systems unless otherwise shown on the plans. The Department may witness all the tests.

- 4.1. **Test Procedures Documentation.** Provide an electronic copy of the test procedures and blank data forms 60 days prior to testing for each test required on this project. Include the sequence of the tests in the procedures. The Engineer will approve all test procedures prior to submission of equipment for tests. Conduct all tests in accordance with the approved test procedures.

Record test data on the data forms, as well as quantitative results. Ensure the data forms are signed by an authorized representative (company official) of the equipment manufacturer.

- 4.2. **Pre-deployment Site Surveys.** The Contractor must assess and confirm that existing signal equipment is suitable for use with the ATSC system or upgrade field equipment as required to fully support all ATSC system adaptive signal control features and functionality. Tests must include physical inspection and verification of device operation and suitability for ATSC system integration, including controllers, detection systems, and communication equipment.

- 4.3. **Design Approval Test.** Ensure that electronic devices installed in traffic controller cabinets as part of the ATSC system have successfully completed a Design Approval Test that confirms compliance with the environmental requirements of this specification.

Provide a certification and test report from an independent testing laboratory as evidence of a successfully completed Design Approval Test. Ensure that the testing by this laboratory is performed in accordance with the requirements of this specification.

- 4.4. **Demonstration Test.** Conduct a Demonstration Test on applicable equipment at an approved Contractor facility. Notify the Engineer 10 working days before conducting this testing. Perform the following tests:

- 4.4.1. **Examination of Product.** Examine each unit carefully to verify that the materials, design, construction, markings and workmanship comply with the requirements of this specification.

- 4.4.2. **Continuity Tests.** Check the wiring to determine conformance with the requirements of this specification.

- 4.4.3. **Operational Test.** Operate each unit for at least 15 min. to permit equipment temperature stabilization and observation of a sufficient number of performance characteristics to ensure compliance with this specification.

- 4.5. **Stand-Alone Test.** Conduct a Stand-Alone Test for each unit after installation. The test must exercise all stand-alone (non-network) functional operations. Notify the Engineer 5 working days before conducting this test.

- 4.6. **System Integration Test.** Conduct a System Integration Test on the complete functional system. Demonstrate all control and monitor functions for each system component for 72 hr. Supply 2 copies of the System Operations manual before the System Integration Test. Notify the Engineer 10 working days before conducting this testing.

- 4.7. **Consequences of Test Failure.** If a unit fails a test, submit a report describing the nature of the failure and the actions taken to remedy the situation prior to modification or replacement of the unit. If a unit requires modification, correct the fault and then repeat the test until successfully completed. Correct minor discrepancies within 30 days of written notice to the Engineer. If a unit requires replacement, provide a new unit and then repeat the test until successfully completed. Major discrepancies that will substantially delay receipt and acceptance of the unit will be sufficient cause for rejection of the unit.

If a failure pattern develops in similar units within the system, implement corrective measures, including modification or replacement of units, to all similar units within the system as directed. Perform the corrective measures without additional cost or extension of the Contract period.

- 4.8. **Final Acceptance Test.** Conduct a Final Acceptance Test on the complete functional system. Demonstrate all control, monitoring, and communication requirements and operate the system for 90 days. The Engineer will furnish a Letter of Approval stating the first day of the Final Acceptance Test. The completion of the Final Acceptance Test occurs when system downtime due to mechanical, electrical, or other malfunctions to equipment furnished or installed does not exceed 72 hr. and any individual points of failure identified during the test period have operated free of defects.

- 4.9. **Consequences of Final Acceptance Test Failure.** If a defect within the system is detected during the Final Acceptance Test, document and correct the source of failure. Once corrective measures are taken, monitor the point of failure until a consecutive 30-day period free of defects is achieved.

If after completion of the initial test period, the system downtime exceeds 72 hr. or individual points of failure have not operated for 30 consecutive days free of defects, extend the test period by an amount of time equal to the greater of the downtime in excess of 72 hr. or the number of days required to complete the performance requirement of the individual point of failure.

- 4.10. **Relocation and Removal**

- 4.10.1. **Pre-Test.** Tests may include, but are not limited to, physical inspection of the unit and cable assemblies. Include the sequence of the tests in the procedures along with acceptance thresholds. Contractor to resubmit, if necessary, rejected test procedures for final approval within 10 days. Review time is calendar days. Conduct all tests in accordance with the approved test procedures.

Conduct basic functionality testing prior to removal of ATSC field equipment. Test all functional operations of the equipment in the presence of representatives of the Contractor and the Department. Ensure that both representatives sign the test report indicating that the equipment has passed or failed each function. Once removed, the equipment becomes the responsibility of the Contractor until accepted by the Department. Compare test data prior to removal and test data after installation. The performance test results after relocation must be equal to or better than the test results prior to removal. Repair or replace those components within the system that failed after relocation, but passed prior to removal.

- 4.10.2. **Post-Test.** Testing of the ATSC field equipment is for the purpose of relieving the Contractor of maintenance of the system. The Contractor will be relieved of the responsibility for maintenance of the system in accordance with Item 7, "Legal Relations and Responsibilities," after a successful test period. The Contractor will not be required to pay for electrical energy consumed by the system.

After all existing ATSC field equipment has been installed, conduct approved continuity, stand alone, and performance tests. Furnish test data forms containing the sequence of tests including all the data taken as well as quantitative results for all tests. Submit the test data forms to the Engineer at least 30 days prior to the day the tests are to begin. Obtain Engineer's approval of test procedures prior to submission of equipment for tests. Send at least 1 copy of the data forms to the Engineer.

Conduct an approved stand-alone test of the equipment installation at the field site(s). At a minimum, exercise all stand-alone (non-network) functional operations of the field equipment installed per the plans as directed by the Engineer. Complete the approved data forms with test results and turn over to the Engineer

for review and either acceptance or rejection of equipment. Give at least 30 working days notice prior to all tests to permit the Engineer or his representative to observe each test.

The Department will conduct approved ATSC field equipment system tests on the field equipment with the central equipment. The tests will, as a minimum, exercise remote control functions and confirm communication with field equipment.

If any unit fails to pass a test, prepare a report and deliver it to the Engineer. Describe the nature of the failure and the corrective action needed. If the failure is the result of improper installation or damage during reinstallation, reinstall or replace the unit and repeat the test until the unit passes successfully, at no additional cost to the Department or extension of the Contract period.

## 5. MEASUREMENT

This Item will be measured as ATSC system software and equipment for each intersection is furnished, installed, made fully operational, and tested in accordance with these Special Specifications and as directed.

## 6. PAYMENT

- 6.1. **Furnish and Install.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit bid price "Adaptive Traffic Signal Control System," of the various types specified. This price is full compensation for furnishing, installing, configuring, integrating, and testing the completed installation; and for all labor, tools, equipment, documentation, testing, training, software, and incidentals necessary to complete the work.

Furnishing and installing traffic signals, controllers, cabinets, conduit, power wiring to the equipment, detectors, and other traffic signal related items shall be paid for separately under their respective Item and specification.

- 6.2. **Install Only.** The work performed and materials furnished in accordance with this Item will be paid for at the unit bid price for "Adaptive Traffic Signal Control System (Install Only)," of the various types specified. This price is full compensation for installing, configuring, integrating, and testing the completed installation; and for all labor, tools, equipment, documentation, testing, training, software, and incidentals necessary to complete the work.

Installation of traffic signals, controllers, cabinets, conduit, detectors, and other items shall be paid for separately under their respective Item and specification.

- 6.3. **Relocate.** The work performed and materials furnished in accordance with this Item will be paid for at the unit bid price for "ATSC Hardware (Relocate)." This price is full compensation for relocating and making fully operational existing equipment; furnishing and installing additional cables or connectors; testing, delivery, and storage of components designated for salvage or reuse; and all labor, tools, equipment, and incidentals necessary to complete the work.

Relocation of traffic signals, controllers, cabinets, conduit, detectors, and other traffic signal related items shall be paid separately under their respective Item and specification.

- 6.4. **Remove.** The work performed in accordance with this Item will be paid for at the unit bid price for "ATSC Hardware (Remove)." This price is full compensation for removing existing equipment as shown on the plans; for testing, delivery, and storage of components designated for salvage; and all labor, tools, equipment, and incidentals necessary to complete the work.

Removal of traffic signals, controllers, cabinets, conduit, detectors, and other traffic signal related items shall be paid for separately under their respective Item and specification.