

SECTION 9 TRAFFIC SIGNALS

9.01 GENERAL

The need for new traffic signals or modification of existing traffic signals shall be based on the City General Plan, City Specific Plans and/or warrants contained in the latest edition of the California MUTCD.

Traffic signals or traffic signal modifications shall be designed in accordance with these City Standard Specifications and the latest editions of the following:

- A. CALTRANS STANDARD SPECIFICATIONS.
- B. CALTRANS STANDARD PLANS, including all standard symbols contained therein.
- C. CALTRANS ELECTRICAL SYSTEMS DESIGN MANUAL.
- D. CALIFORNIA MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (CAMUTCD).
- E. U.S. DOT FEDERAL HIGHWAY ADMINISTRATION TRAFFIC SIGNAL TIMING MANUAL.
- F. CITY DESIGN STANDARDS Section 7 - Street Lighting requirements.
- G. CITY STANDARD CONSTRUCTION SPECIFICATIONS - Additional technical traffic signal specifications are located in Section 21.
- H. CITY'S AUTHORIZED MATERIAL LIST.

9.02 SIGNAL STANDARD TYPES

- A. ALL TRAFFIC SIGNAL STANDARDS, posts, and mast arms shall be of the types listed in the most recent edition of the State Standard Plans, City Authorized Material List, and shall meet State wind load design standards.
- B. TYPICAL LUMINAIRE MAST arm length used shall be fifteen (15) feet. Traffic signals shall use the overhead luminaire standard of the State Standard Specifications & Plans and City's Authorized Material List. Signal standard type shall vary depending on the requirements and application of the traffic intersection. Signal mast arm length shall vary depending on the application and position of the travel lanes and vehicle signal head or heads.

9.03 VEHICLE AND PEDESTRIAN SIGNAL TYPES

- A. ALL VEHICLE SIGNALS and pedestrian signals components shall meet the requirements of City's Authorized Material List, State Standard Specifications & Plans, and California MUTCD.
- B. ALL SIGNAL COMPONENTS shall have terminal block components and be of the types listed in the latest edition of the State Standard Plans. Terminal screws shall be used for all bare wire terminations. Crimping terminations shall not be allowed.

- C. ALL MAST ARM MOUNTED vehicle signals shall be twelve (12) inches in diameter and MAS mounted.
- D. PROTECTED LEFT TURN signals shall be all arrows.
- E. ALL VEHICLE VISORS are to be black with half tunnel type.
- F. ALL VEHICLE AND PEDESTRIAN signals must be the LED type.
- G. ALL BACK PLATES for vehicle signals are to be black, louvered with yellow reflective borders per CA MUTCD standards.
- H. PROGRAMMED VISIBILITY vehicle signals shall not be used without prior approval of the City Engineer.
- I. PEDESTRIAN SIGNAL HEADS shall be black, sixteen (16) inch housing meeting all state and federal regulations, and countdown type.
- J. PUSH BUTTONS SHALL meet all state and federal regulations and the City's Authorized Material List.
- K. EMERGENCY VEHICLE PRE-EMPTION shall meet all state and federal regulations and City's Authorized Material List specifications.

9.04 VEHICLE SIGNAL ALIGNMENT

- A. TYPICAL VEHICLE SIGNAL ALIGNMENTS - Case-by-case variations may occur and require approval by the City Engineer.
 - 1. For single left turn lanes with protected left turn movement, the left turn signal shall line up with the center of the left turn lane as close as possible.
 - 2. For dual left turn lanes (which shall have a protected movement), the left turn signal shall line up with the extension of the line between the two left turn lanes as close as possible.
 - 3. When a protected left turn signal is used, the signal for the through movement shall line up with the center of the lane group as close as possible, regardless of the number of through lanes. When fifty (50) feet or fifty-five (55) feet mast arms are used, only one MAS signal shall be used for the through movement instead of two signals as shown in the Caltrans Standard Plans (unless there are four (4) through and right turn only lanes).
 - 4. For one through lane with permissive left turn, the MAS signal shall line up with the center of the left half of the approach through lane, as close as possible.
 - 5. For two through lanes with permissive left turn, the MAS signal shall line up with the center of the #1 through lane (i.e., the lane adjacent to the left turn lane), as close as possible.
 - 6. When a four (4) section MAS signal is used, it shall line up with the center of the left half of the approach of the #1 through lane, as close as possible.

9.05 NUMBER AND SIZE OF VEHICLE SIGNAL INDICATIONS

- A. TYPICAL INDICATIONS ARE AS FOLLOWS and referenced in the latest edition of the CA MUTCD:
1. For Protected Left Turn Movements - One three (3) section all arrow MAS and one three (3) section all arrows far left side pole-mounted signal.
 2. For Intersections with a Left Turn Pocket (for Permissive Left Turn Movements) There shall be an additional far (left) side three (3) section pole mounted head. Signal head shall be all circular indications.
 3. For Through Movements (With Protected Left Turns) - One three (3) section MAS, one three (3) section far right-side, pole-mounted signal, and one three (3) section near right side pole mounted signal. At City Engineer's discretion, near side signals may not be required if the intersection is less than one hundred (300) feet wide, approach speeds are thirty (30) mph or less, and it is not needed to meet continuous sight distance requirements.
 4. For Through Movements (With Permissive Left Turns) - One three (3) section MAS, one three (3) section far left side pole-mounted signal, one three (3) section far right-side pole-mounted signal, and one three (3) section near right side pole-mounted signal. At City Engineer's discretion, near side signals may not be required if the intersection is less than one hundred (100) feet wide, approach speeds are thirty (30) mph or less, and it is not needed to meet continuous sight distance requirements. If left turns are not permitted the far side left pole mounted signal head is not required.
 5. For Split Phased Situations - One four (4) section MAS (w/GA), one four (4) section far left side pole-mounted signal (w/GA), one three (3) section far right-side pole-mounted signal, and one three (3) section near right side pole-mounted signal.
 6. For Right Turn Arrow Overlap Situations - Same as above except the far right-side and near-right side pole-mounted signals shall be five (5) section with green and yellow arrows. Overlaps required prohibited U-turn on associated protected left movements. Right turn arrow overlaps shall not be provided without prior approval of the City Engineer.

Size of vehicle indications shall be in accordance with the California MUTCD, but an individual indication's size may be adjusted by the City Engineer.

9.06 VEHICLE LOOP DETECTOR LAYOUT AND INPUTS

If loop vehicle detection is shown on the Construction or Improvement Plans or if modifications or repairs are required on an existing traffic signal that uses vehicle loop detection, the State Standard Specifications shall apply.

9.07 MULTI SENSOR VIDEO DETECTION SYSTEM (MSVDS)

- A. ALL MULTI SENSOR VIDEO DETECTION SYSTEM (MSVDS) shall meet the requirements of City's Authorized Material List, State Standard Specifications, and California MUTCD. The Multi Sensor Video Detection System (MSVDS) shall consist of video imaging and radar. The system shall detect and track vehicles and bicycles at distances over five hundred (500) feet. In a low-visibility condition, the system shall be capable to switch automatically to either radar detection mode or constant call mode. The MSVDS shall fuse vehicle information from the two sensors to provide highly accurate and precise detection for simultaneous stop bar presence detection, advanced detection, and special or advanced applications. System shall provide a sufficient number of cameras to process vehicles presence, advanced, and all system detection zones as shown on the Construction Plans. All equipment, system components, cables and hardware must be from the same manufacturer.

The detection system shall be in accordance with the City's Authorized Material List or an approved equal and meet the manufacturer's specifications for installation and operation.

- B. SYSTEM HARDWARE - Unless otherwise required by the City the MSVDS shall consist of hybrid video camera/radar sensors for all approaches, a shelf mounted for factor Central Control Unit (CCU) with up to four (4) detection processors capable of processing from up to four (4) sensors, video surge suppressors, a seven (7) inch monitor, keyboard, system software, and a pointing device. Should the intersection be a multi-arterial intersection or an intersection with more than four (4) legs, there may be additional design requirements by the City. Verify detection system requirements with the City prior to initiating design work.

System software shall discriminately detect the presence of individual vehicles and bicycles in a single, or multiple lanes using only the video image and sends vehicle and bicycle calls out to the controller via separate outputs. The system software shall also utilize artificial intelligence and deep learning to automatically count and detect pedestrian movements in the crosswalk, count turning movement counts and learn the background to count and distinguish left, through and right turn movements. The software system shall be able to work simultaneously with the City's existing traffic signal monitoring software system, Centrac. A minimum of thirty-two (32) video detection zones and thirty-two (32) radar detection zones per sensor shall be available.

In addition to creating vehicle and bicycle zones, the system shall provide a tracking mechanism that counts pedestrian volumes moving within the crossing zone and determine the average, maximum, and minimum speed of pedestrians moving within the crossing zone. The system shall also provide discrete outputs when pedestrians are in the crosswalk, during normal crossing phases (one in each direction of travel)

and when a red phase input has been detected. The system also shall provide a visual indication on the video image that a pedestrian is in the crosswalk.

- C. CENTRAL CONTROL UNIT (CCU) - The CCU shall be a single detector card width and provide provisions for up to four sensor/cameras. The detector processor shall be embedded in the CCU to provide one single cabinet interface. Each sensor/camera shall be connected to the CCU via ethernet cable. The interface connectors shall be RJ-45 type. The CCU shall have four (4) detection status LEDs on the front panel. The CCU shall enable the loading of modified or enhanced software through the ethernet or front-panel USB port (using a USB thumb drive). The shelf-mounted format CCU shall be powered by a forty-eight (48) V DC power supply. The CCU power consumption shall not exceed one-hundred-fifty (150) watts. The CCU shall have logic inputs for future use.
- D. MSVDS SENSOR/CAMERA - The MSVDS sensor shall have two components: a camera sensor and a radar sensor. The MSVDS sensor shall utilize a single CATSE or CAT 6 cable for power, communications, and video. Cable termination at the camera shall not require crimping or special tools. An optional RJ-45 direct connector shall be made available to the City upon request.

The MSVDS sensor/camera shall detect vehicles, bicycles, and pedestrians in real time as they travel across each camera detection zone. Vehicles, bicycles, and pedestrians' detection outputs shall be on separate channels with the same field of view. The MSVDS sensor/camera shall default to a safe condition, such as a constant call on each active detection channel, in the event of unacceptable interference or loss of the video and/or radar signal.

The MSVDS sensor camera and sensor system shall have the capability to change the characteristics of the detection zone based on external inputs such as signal phase. Each detection zone shall be able to switch from one zone type (i.e., presence, extension, pulse, etc.) to another zone type based on the signal state.

9.08 CONDUIT

- A. CONDUIT REQUIREMENTS - Conduit requirements shall conform to the State Standard Specifications unless specified below. Service run conduit shall be three (3) inch minimum diameter.
- B. CONDUIT FROM THE main pull box to the Controller shall be two (2) three (3) inch diameter conduits minimum as a practical limit, projects for new construction/ installation shall be designed with twenty-six (26) percent of conduit fill x-section occupied by conductors. City Standard Detail #612 lists conductor sizes and available conduit area.
- C. ANY SIGNAL RUN AND interconnect conduit shall be two (2) inch minimum diameter.
- D. ALL STREET CROSSING conduit runs shall be a minimum of three (3) inches.

- E. A MINIMUM OF FOUR (4) conduits shall be installed on arterial roadways to provide signal interconnectivity and to support other communications requirements. All conduit stub ups require bell ends or bushings and duct seal.

9.09 CONDUCTORS

Traffic signal conductors, including delineation on the plans, shall be in accordance with the State Standard Specifications. All conductor runs for each signal phase to each terminal block on a pole shall be direct from the controller home run pull box. The conductor schedule shall not allow for splicing at intermediate pull box location. This paragraph does not cover fiber optic cable materials and installation which is covered in Section 9.13 below.

9.10 PULL BOXES

- A. REFER TO CALTRANS Standard Plans No. ES-8A and ES-8B. All pull boxes, covers, and extensions shall be concrete material and meet or exceed Caltrans performance standards. All pull boxes shall be set with a six (6) inch by six (6) inch concrete collar around the pull box and the lid shall have a City approved vandal proof locking system in accordance with the City’s Authorized Material List.
- B. THE MINIMUM SIZE for pull boxes shall be #5. However, #6 pull boxes shall be used at the ends of street crossings and when four (4) or more conduits enter the box. Covers shall be marked “Traffic Signal.”
- C. LARGER PULL BOXES shall be required as follows:

Table 9-1 - Pull Boxes

Condition	Size
Any pull box with 12 or more cross sectional inches of conduit entering	A pull box extension or 20" x 42" dual lid pull box may be required.
Home run pull box for a 2, 3, or 5, phase signal	20" x 42" dual lid pull box shall be required
Home run pull box for an 8-phase signal	30" x 48" dual lid pull box shall be required

- D. TRAFFIC SIGNAL INTERCONNECT conduit shall be installed in separate concrete pull boxes and their covers shall be marked “I.C.” or “Interconnect.”
- E. PULL BOXES SUBJECTED to vehicular travel shall be H-20 traffic rated and be installed with one quarter inch steel plate covers (galvanized after fabrication) with a diamond-type surface in accordance with ES-8A and ES-8B of the Caltrans Standard Plans.

9.11 CONTROLLER CABINET

- A. LOCATION - Controller cabinet location shall be approved by the City. Both controller cabinet and service pedestal should be located such that the conduit from the service point to the service pedestal does not require trenching across a street. The entire intersection should be visible by the operator from the controller cabinet.
- B. REQUIREMENTS - All controller cabinet and controller equipment requirements shall meet the requirements of the City's Authorized Material List, State Standard Specifications, and California MUTCD.

9.12 PROTECTED VS. PERMISSIVE LEFT TURN PHASING

- A. PROTECTED/PERMISSIVE PHASING, if proposed, would require prior written approval of the City Engineer. Any proposal will maintain consistency with other regional applications, which include four (4) section signal heads that incorporate steady red left-turn arrow, steady yellow left-turn arrow, flashing yellow left-turn arrow for permissive left turn phasing, and steady green left-turn arrow for protected left-turn phasing, along with accompanying "left-turn on flashing yellow" signage.
- B. PROTECTED LEFT TURN PHASING should be provided under the following conditions per the California Manual on Uniform Traffic Control Devices (CAMUTCD):
- C. GUIDANCE FROM CAMUTCD Section 4D.19 - Signal Indications for Protected Only Mode Left Turn Movements - For an intersection with one through lane and a left turn pocket, a protected left turn phase may be required at the discretion of the City Engineer, if it meets conditions outlined in the CAMUTCD.

9.13 TRAFFIC SIGNAL FIBER INTERCONNECT

- A. CABLE - Traffic signal fiber interconnect shall conform to the State Standard Specifications and City's Authorized Material List. Traffic signal interconnect shall be provided for new signal installations, and for modification of existing signals which currently do not have interconnect. The interconnect cable shall be in its own conduit and pull boxes. The interconnect cable shall not be spliced anywhere other than in traffic signal cabinet at the fiber patch panel and the mainline connection. Fiber optic for future use shall coil fifty (50) feet of single mode fiber optic in the interconnect pull box and inside of the cabinet. A minimum of twelve (12) strand single mode fiber optic shall be provided for traffic signals to the pull box.

The interconnect shall connect the subject signal with at least one (1) existing traffic signal. If the subject signal is between two (2) existing signals, the interconnect shall connect all three (3) signals.

In cases where fiber interconnect conduit is or will be provided, but for some reason fiber interconnect cable is not being provided, the fiber interconnect conduit shall be

provided with a green #10 AWG pull wire with two thousand five hundred (2500) pound tensile strength mule tape. If fiber interconnect cable installation is not possible, provisions for radio connection to existing system shall be made.

- B. CONDUIT - Conduit requirements shall conform to State Standard Specifications unless specified below.
 - 1. Service run conduit shall be three (3) inch minimum diameter.
 - 2. Conduit from the main pull box to the controller shall be two (2) three (3) inch diameter conduits minimum. As a practical limit, projects for new construction /installation shall be designed with twenty-six (26) percent of conduit fill x-section occupied by conductors. City Standard Detail #612 list conductor sizes and available conduit area.
 - 3. Any signal run and interconnect conduit shall be three (3) inch minimum diameter.
 - 4. All street crossing conduit runs shall be a minimum of three (3) inches.
 - 5. A minimum of four (4) conduits shall be installed on arterial roadways to provide signal interconnectivity and to support other communications requirements. All conduit stub ups require bell ends or bushings and duct seal.
- C. PULL BOX - Fiber optic pull boxes shall meet State Standards and be labeled "Traffic Signal" or "Interconnect" on the lid as required by the City Engineer.

9.14 MAST ARM STREET NAME SIGNS

- A. MAST ARM STREET name signs shall be required for all approaches and conform to the State Standard Specifications. Mast arm street name signs shall meet the requirements of City Standard Detail #253. Mast arm street sign shall be placed on street signal mast arms in all directions.
- B. FOR TRAFFIC SIGNALS located at the intersection of multiple arterials, Internally Illuminated Street Name Signs (IISNS) shall be used. IISNS shall conform to the City's Authorized Material List and per manufacturers specifications.

9.15 GLOBAL POSITIONING TRANSIT PRIORITY SYSTEM (GPTSPS)

All new or modified traffic signals shall have Global Positioning Transit Priority System (GPTSPS) for all directions of approach on public streets and conform to the City's Authorized Material List, State standards, and CA MUTCD. The system is a matched system of emergency/transit vehicle equipment and intersection equipment that utilizes data encoded radio communications to identify the presence of emergency/transit vehicles to advance and/or hold a desired traffic signal display selected from phases normally available. The GPTSPS system must communicate with emergency/transit vehicles and other intersection radios at distances up to two-thousand-five hundred (2500) feet. With no obstructed direct line of sight, unless defined otherwise. Additional equipment details, specifications and manufacturer and model information is located within the City's Authorized Material List.

9.16 SIGNAL PHASING

- A. SIGNAL PHASING WHERE the major street is north-south oriented, northbound shall be Phase 2 and southbound shall be Phase 6. All other signal phases shall follow NEMA phasing.
- B. SIGNAL PHASING WHERE the major street is east-west oriented, eastbound shall be Phase 2 and westbound shall be Phase 6. All other signal phasing shall follow NEMA phasing.
- C. SIGNAL PHASING FOR the intersection of two (2) major streets, northbound shall be Phase 2 and southbound shall be Phase 6. All other signal phasing shall follow NEMA phasing.

9.17 ADVANCE FLASHING BEACONS

- A. SPEED FEEDBACK AND ADVANCED WARINING - Advance flashing beacons shall be included at the discretion of the City Engineer. Typically, they are located on roads with speed limits forty-five (45) mph or greater when there are no controlled intersections over the previous mile. All flashing beacon assemblies shall meet all Caltrans and California MUTCD requirements.

9.18 MISCELLANEOUS APPURTENANCES

- A. BICYCLE DETECTOR LOOPS - Shall be included for all approaches unless otherwise covered by an MSVDS detection system or as specified by the City Engineer.
- B. AUDIBLE ACCESSIBLE PEDESTRIAN SIGNALS (APS) - For the blind shall be required at new intersections and existing intersections that are being modified. APS shall conform to the latest edition of State Standard Specifications, City's Authorized Material List, and latest MUTCD requirements. The APS system shall include two (2) wire push buttons and pedestrian head control units. The APS shall:
 - 1. Utilize both a vibrating arrow button and audible sounds.
 - 2. All sounds shall be emanating from the back and front of the unit or in accordance with the latest ADA requirements for APS equipment.
 - 3. Provide a visual, tactile, and audible confirmation that the button has been pushed.
 - 4. Provide a total of up to ten (10) walk sound options.
 - 5. Provide a choice of four (4) locating tones including Canadian Melody or verbal countdown.
 - 6. Vibrate on the Walk indication.
 - 7. Provide the capacity to set volume minimum and maximums for sounds.
 - 8. Provide an extended push button feature to boost and/or turn volumes.

9. Provide for customized audio messages, firmware updates and configuration settings, which can be uploaded wirelessly, e.g., via Bluetooth using Windows or IOS.
10. Provide for an independent ambient adjustment setting for the location tone for low ambient noise conditions.
11. Be vandal resistant.
12. Additional pedestrian push buttons on medians of four or more lane roads may be required to be installed by the City where the center median/pedestrian refuge area is a minimum six (6) feet in width.
13. Pedestrian signal heads shall be installed per Section 9.03 of this Design Standard document.
14. Additional technical traffic signal specifications are located in the City Standard Specifications, Division IV, City Standard Construction Specifications, Section 21.

9.19 RESERVED

9.20 RESERVED

9.21 PREPARATION OF PLANS

Traffic signal plan sheets shall conform to Section 2 of these Design Standards, including submittal requirements, AutoCAD files, etc. Signal plans can be part of a larger Improvement Plan set. Traffic signal plans shall have a title sheet followed by a signal and listing sheet for each intersection. Signing, striping, and interconnect information may be included on the signal and lighting sheets, or may be included on separate sheets, depending on ease or readability. The format, symbols, and content shall follow the recommendations as outlined in Section 2 of these Design Standards, the California MUTCD and State Standard Plans. Plans shall include:

- A. TITLE SHEET - The title sheet shall include the following:
 1. Title of project, which shall include the location.
 2. A vicinity map (not required to be to scale) with north arrow.
 3. Pertinent signature blocks and revision block.
 4. A legend for symbols not found in the Standard plans (e.g., Utility lines, etc.).
 5. Below the legend, place the following note: Note: See Caltrans Standard Plans ES-1a and ES-1b for explanation of other symbols.
 6. General notes and construction notes.
 7. Name, addresses, and phone numbers for the utility companies and City Services.
- B. SIGNAL AND LIGHTING SHEET - The signal and lighting sheet shall be drawn at a scale of one-inch equals twenty feet (1" = 20'), and shall include the following:

1. A north arrow.
 2. The plan shall be orientated to show the major street to be laid out horizontally on the plan sheet, with the north arrow to be either pointed up or to the right. The phase diagram shall show phases per the California MUTCD with Phase 2 to be for eastbound traffic and the remainder of phases in regular NEMA order, unless otherwise directed by the City Engineer.
 3. Existing and proposed field conditions which include, but are not limited to, the following: underground and overhead utilities, driveways, fire hydrants, poles, signs, fences, streetlights, edge of pavement, curb and gutter, sidewalk, right-of-way line, P.U.E.'s, roadway striping, medians, centerline, pull boxes, wheelchair ramps, trees (particularly those needing trimming), adjacent topography, etc. Existing field conditions, appurtenances, etc., shall be dashed and screened. Proposed construction shall be solid and bold.
 4. Complete traffic signal design, including but not limited to, the following: conduit runs, detector loops with input designations, detector handholes, vehicle and pedestrian signals (with phase designation), luminaries, pedestrian push buttons (with phase designation), controller, service pedestal, service point, emergency vehicle detectors, signing, striping, interconnect, and location for phone line service.
 5. On a separate sheet the service equipment schedule and wiring diagram with legend, pole and equipment schedule, and conductor and conduit schedule. The schedule shall include rows showing percent fill values, and conduit quantity/size.
 6. Phasing for emergency vehicle/transit vehicle preemption (and railroad preemption where applicable). Protected left turn phases shall be combined with the concurrent through movement during GPSTS preemptions.
 7. Conduit shall not be shown to pass through detector loops.
 8. Right-of-way lines and easements to be shown on all plans.
 9. All submittals for review shall be electronic and be in accordance with the requirements of Section 2 of these Design Standards, Improvement Plans and Specifications. Subsequent submittal shall include all comments from previous submittals with responses to the comments and revisions to the submittals.
- C. UTILITY RELOCATION PLAN (as required) - Shall show all existing and proposed underground and overhead utilities.
- D. STRIPING AND SIGNING PLAN (40, 50, or 100 scale) - Shall include all existing signs, curb and pavement markings, and shall show disposition of each (removal, relocate or remain). Plan shall also show all necessary parking removal signs and curb markings.
- E. SIGNAL INTERCONNECT PLAN (as necessary).
- F. CIVIL PLAN (20 or 40 scale) - To include all paving, structural section, concrete, drainage, sanitary sewer, and earthwork items.
- G. SIGNAL HARDWARE - Draft special provisions as part of the design submittal are to be provided to the City for review. All hardware shall be as listed in the City's

Authorized Material List. If alternate equal equipment is proposed for City consideration, said equipment technical specifications and details shall be included in the draft special provisions or submittal of Developer Improvement Plans.