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None.

16. ABSTRACT

This report shows the upgrade efforts to the original Vehicle Infrastructure Integration (VII) California DSRC test-bed along El Camino Real in Palo Alto to the most current version of DSRC and to make it compliant with the latest national standards. The plan was for a direct swap of new RSE devices to replace the older RSE devices from the original VII California test-bed at 11 intersections and to add the new Road Side Equipment (RSE) installations at intersections that were not part of the original test-bed. Due to mandated changes by Federal Highway Administration (FHWA) on DSRC standards, the RSE architecture was also changed. In the end, much more software development and implementation work had to be done than was originally planned which resulted in significant delays to complete the project in time. Finally the project was completed which reflects the new FHWA DSRC standards.

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Final Report to Caltrans

Vehicle-Infrastructure Cooperation Using DSRC

Technical Agreement 65A0408
Contract 22A0486

June 2014

Summary

This project was established to upgrade the original VII California Dedicated Short Range Communications (DSRC) test-bed along El Camino Real in Palo Alto to the most current version of DSRC and to make it compliant with the latest national standards. The Intelligent Transportation System (ITS) Joint Program Office of the U.S. DOT cooperated by providing the new DSRC Roadside Equipment (RSE) devices in exchange for the earlier- generation Kapsch Roadside Equipment (RSE) devices that California sent to Florida in support of the demonstrations for the 2011 ITS World Congress. They also provided consultation on the backhaul network, Security Credentials Management System (SCMS) and interfaces with the traffic signal controllers based on the experience gained by their support contractor Leidos in the Southeast Michigan Test-bed.

The concept and plans for the project changed several times in the course of the work. The original plan was for a direct swap of new RSE devices to replace the older RSE devices from the original VII California test-bed at several of the intersections and to add the new RSE installations at intersections that were not part of the original test-bed. Figure 1 shows the map of intersections that were originally equipped with diamond symbols and the additional intersections to be newly equipped with circular symbols. Taken together, these represent eleven consecutive signalized intersections along a 2-mile section of this busy arterial (60,000 vehicles per day). With these consecutive signalized intersections all equipped, it becomes possible to test (Infrastructure to Vehicle/Vehicle to Infrastructure) I2V/V2I applications such as signal priority and eco-driving at a realistic scale.

The project became considerably more complicated when it became evident that much more was involved than swapping old radios for new radios and adding several new radios. The DSRC standards were changing significantly, as was the architecture of the entire system. New work at the national level on definition of messages such as Signal Phase and Timing (SPaT) and on the interfaces to traffic signal controllers had to be accommodated. Since California uses AB3418 rather than NTCIP protocols for communicating with its traffic signal controllers, the mapping between these protocols had to be developed as part of the project as well. In the end, much more software development and implementation work had to be done than was originally planned. A new computer had to be installed at each intersection to house application programs and to provide the interfaces among all the components. A further complication arose when it became necessary to replace all the Model 170 traffic signal controllers with Model 2070 controllers along this corridor in order to have proper software interfaces available for reading information such as SPaT messages.

The original project plan contemplated the hiring of an outside electrical contractor to do the

physical installation work of the new RSE equipment and to establish all the needed electrical power and signal connections. The specifications for that electrical installation work are included here as Attachment 1, and represent the most complete description of the physical implementation of the test-bed site. However, after so much effort had to be devoted to re-engineering the system and to software development, there were insufficient funds remaining in the project budget to cover the cost of the outside electrical contract work. Fortunately, Caltrans District 4 maintenance staff was able to do much of that work, in coordination with PATH Research and Development engineers.

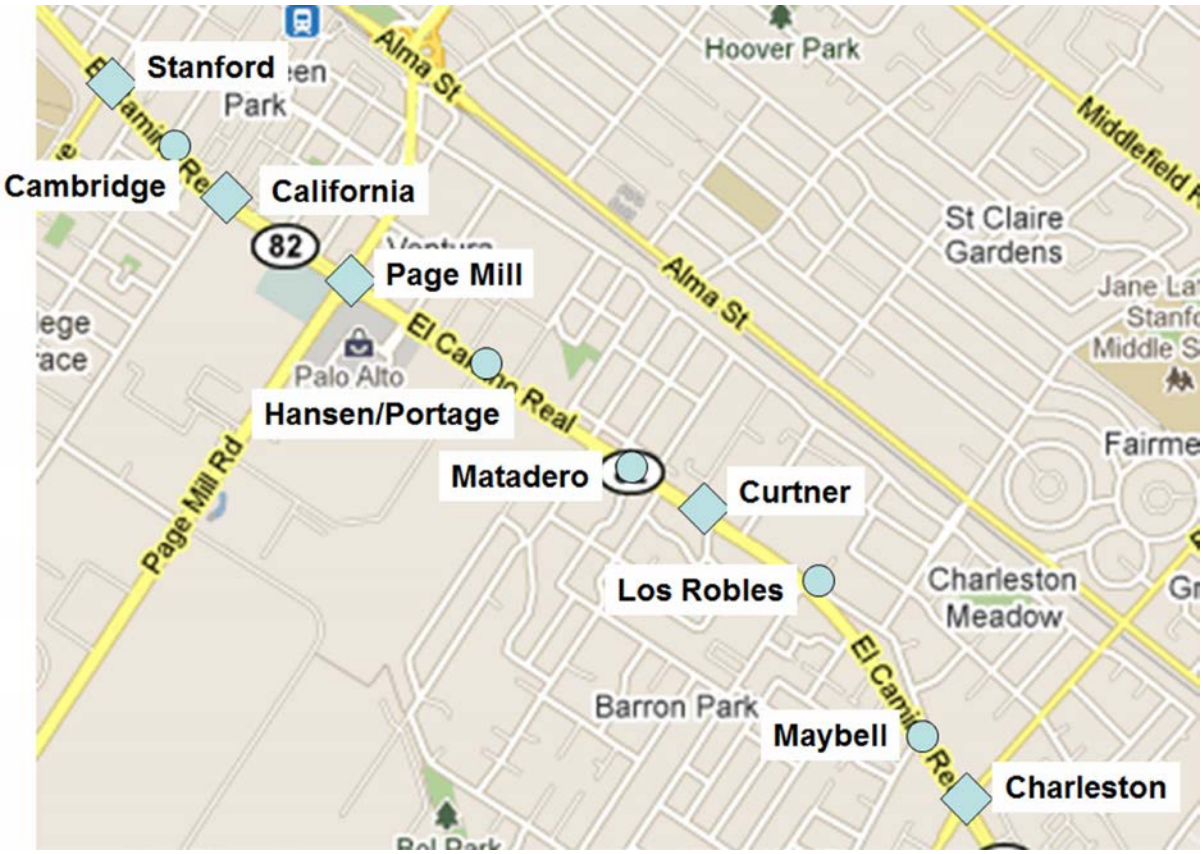


Figure 1 – Map of El Camino Real Test-bed Corridor

All of the intersections were equipped with the new DSRC RSEs and antennas and other equipment by the end of the project except for the southern-most intersection at Charleston Rd., which was still awaiting the needed support from Caltrans District 4. The District also replaced all the traffic signal controllers except for those at Charleston and Page Mill by the end of the project, with the expectation that those will follow in the near future.

Attachment 1

Solicitation of Bids for Installation of Equipment at Signalized Intersections along El Camino Real in Palo Alto

Background

The California Partners for Advanced Transportation Technology (PATH) program of the University of California, Berkeley is soliciting bids for installation of electrical equipment at specific signalized intersections along El Camino Real (SR 82) in the City of Palo Alto, California. PATH will obtain the primary permit from Caltrans District 4 for the entire job and the selected bidder must obtain the contractor's permit for both installations and lane closures during the installation period. PATH is particularly seeking licensed electrical contractors that have enough bonds to ensure all the required liabilities are met. A prior experience working with field equipment for Caltrans District 4 is preferable.

Scope of work

Figures 1.a – 1.c show generic schematics of each installation. Each installation is unique since each intersection is unique in terms of number and location of underground conduits, availability of space in the conduits, geometry and signal equipment such as the number and types of poles and mast arms. Each figure includes a list of intersections that belong to that category of installations.

The following provides a description for each installation:

1. Procure some specified equipment (see Table 1),
2. Produce brackets to hold antennas (see Appendix A for details),
3. Attach a 2-inch flexible conduit from an opening on the host pole near the signal head to the Road Side Equipment (RSE) except for figure 1.c,
4. Attach RSE to the host pole (see Appendix B for pictures and dimensions and Appendix C for RSE mount accessories),
5. Attach antenna bracket to the mast arm,
6. Run a cable between the RSE and antenna,
7. Place antenna on the bracket attached to the mast arm,
8. Run a cable from the traffic control cabinet to the RSE through Caltrans signal conduits and the host pole and the 2-inch flexible conduit,
9. Install a 4G antenna atop of the cabinet and connect it to a 4G router inside the controller cabinet,
10. Connect all the cables including those inside the cabinet and plug in all the devices
11. Weather proof all the connections,
12. Support an end-to-end acceptance test at each site.

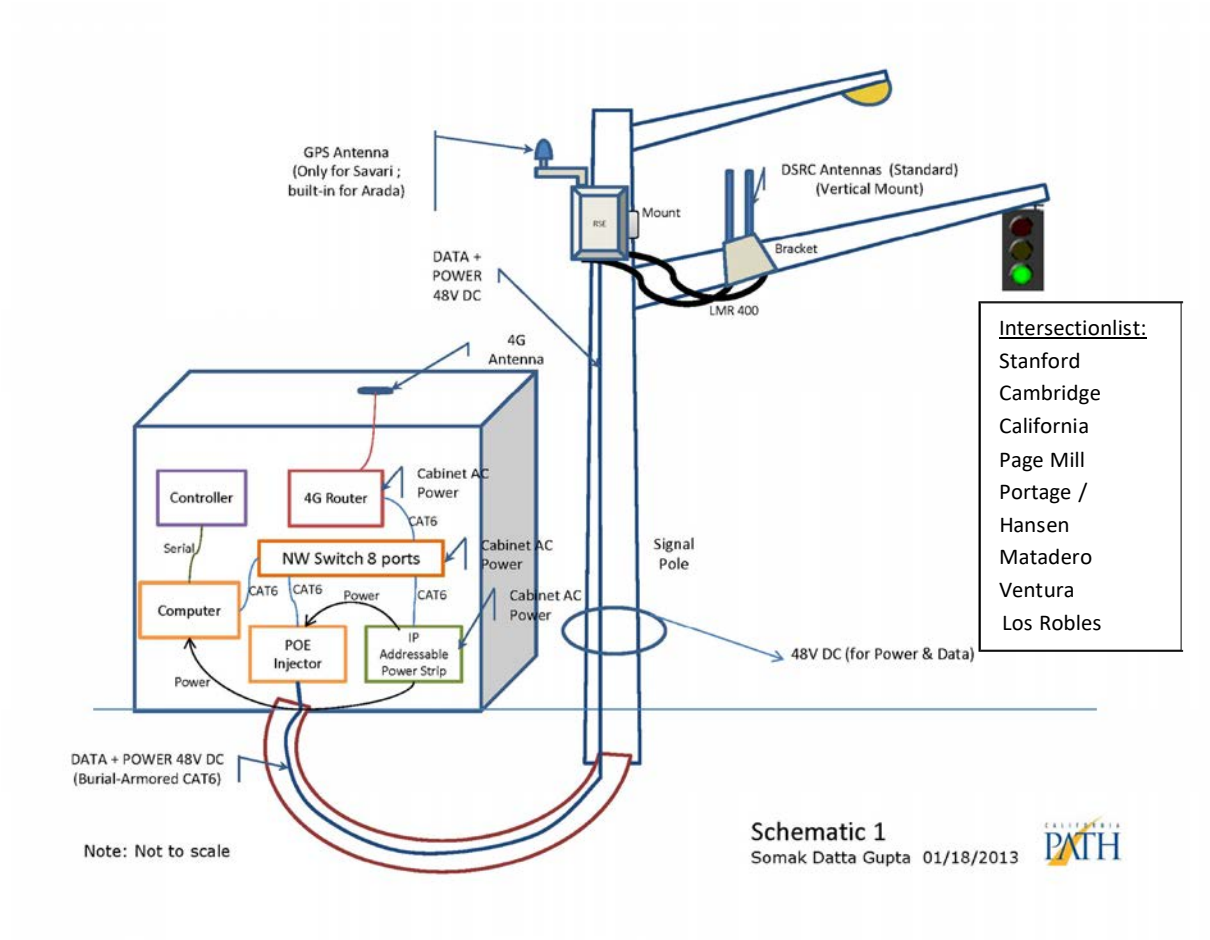


Figure 1.a

The antenna mount is the diagram is a placeholder. Details for this mast arm type installations are available in Appendix A.2 and A.3.

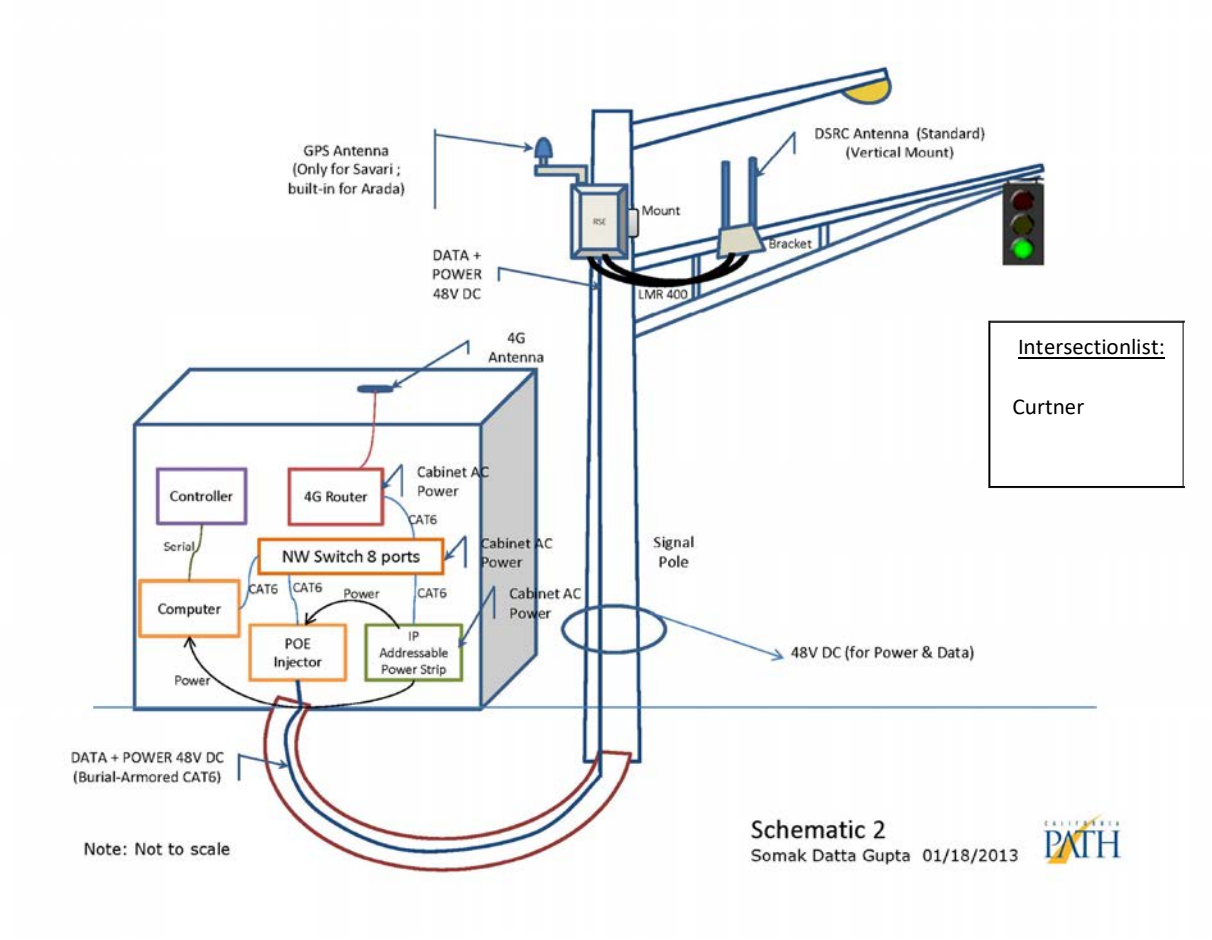


Figure 1.b

The antenna mount is the diagram is a placeholder. Details for this mast arm type installations are available in Appendix A.2 and A.3.

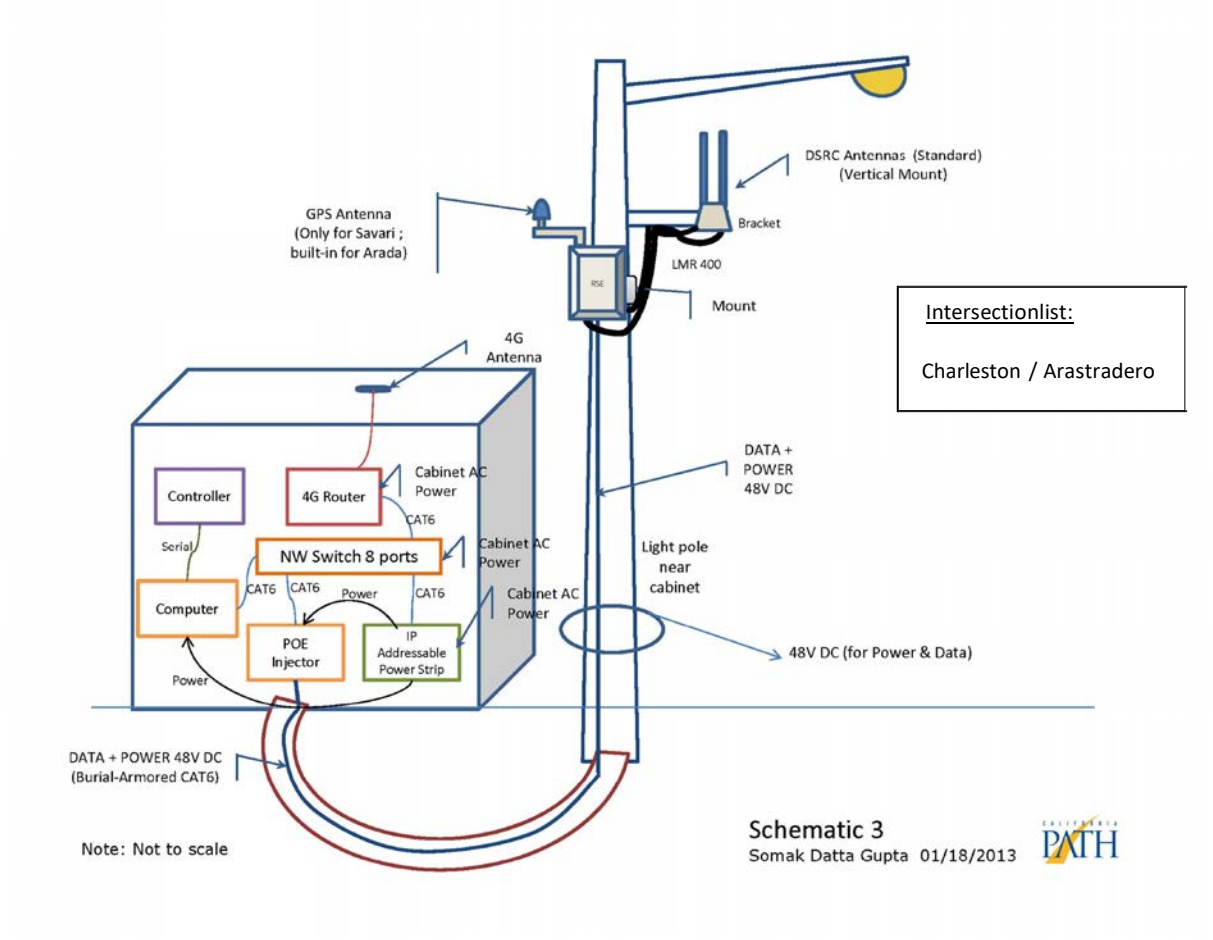


Figure 1.c

The antenna mount is the diagram is a placeholder. Details for this light pole type installations are available in Appendix A.1 and A.3.

List of signalized intersections

The following are the intersections to be equipped. The bidder is required to submit a bid for installation of RSEs at the first 5 locations on the list and then provide options for addition of each of the next 6 intersections. All of the intersections are in the city of Palo Alto, California, along El Camino Real.

1. Stanford
2. Cambridge
3. California
4. Page Mill
5. Portage / Hansen
6. Matadero
7. Curtner
8. Ventura
9. Los Robles
10. Maybell
11. Charleston / Arastradero

List of Equipment

All of the following equipment with stated specification, lengths, and quantities will be provided by the contractor for each installation.

Table – 1 Equipment needed for each installation

Description of Equipment	Quantities
Pre-fab LMR 400 cable with N-Type Male and N-Type Female connectors	20-ft long
Cat-6 cable	4 (5-ft long)
Bracket for mounting DSRC antenna on the mast arm or light pole	1
Strapping metal bands to attach RSE to the host pole	As needed
Band strapping saddle brackets for antenna mounts	As needed
Serial cable and its connectors	1 (8-ft each)
Burial armored cat-6 cable and its connectors (Superior Essex – Part Number: 04-001-64)	Variable length (see the aerial photograph of each site)
Network switch with 8 ports Black Box LBH600A-P- Long-term operating: -40 to +167° F (-40 to +75° C)	1
IP addressable power switch Synaccess Networks, Inc. : NP-02 2 Switchable Outlets	1
Surge Protected power strip (6 outlets)	1
Public Safety Cellular 3G 4G LTE Low-Profile Dome Antenna w/Bolt-Mount(Example supplier: http://www.antennagear.net/servlet/the-1190/Public-Safety-Cellular-4G/Detail)	1
TNC-Female-to-SMA-Male RF Adapter for the 4G antenna	1

Note: All of RSE, GPS antenna, DSRC antenna and 4G antennas, 4G router and computer will be furnished by California PATH to the contractor. Power Over Ethernet (POE) injector is included in the RSE package already.

Installation details for each intersection

The following Google aerial pictures provide a visual for the location of each component of installation at selected intersections.

This document contains layout information for installation of RSEs along El Camino Real (ECR) in Palo Alto, California.

NOTES:

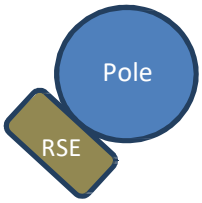
- The following abbreviations are used in the document:

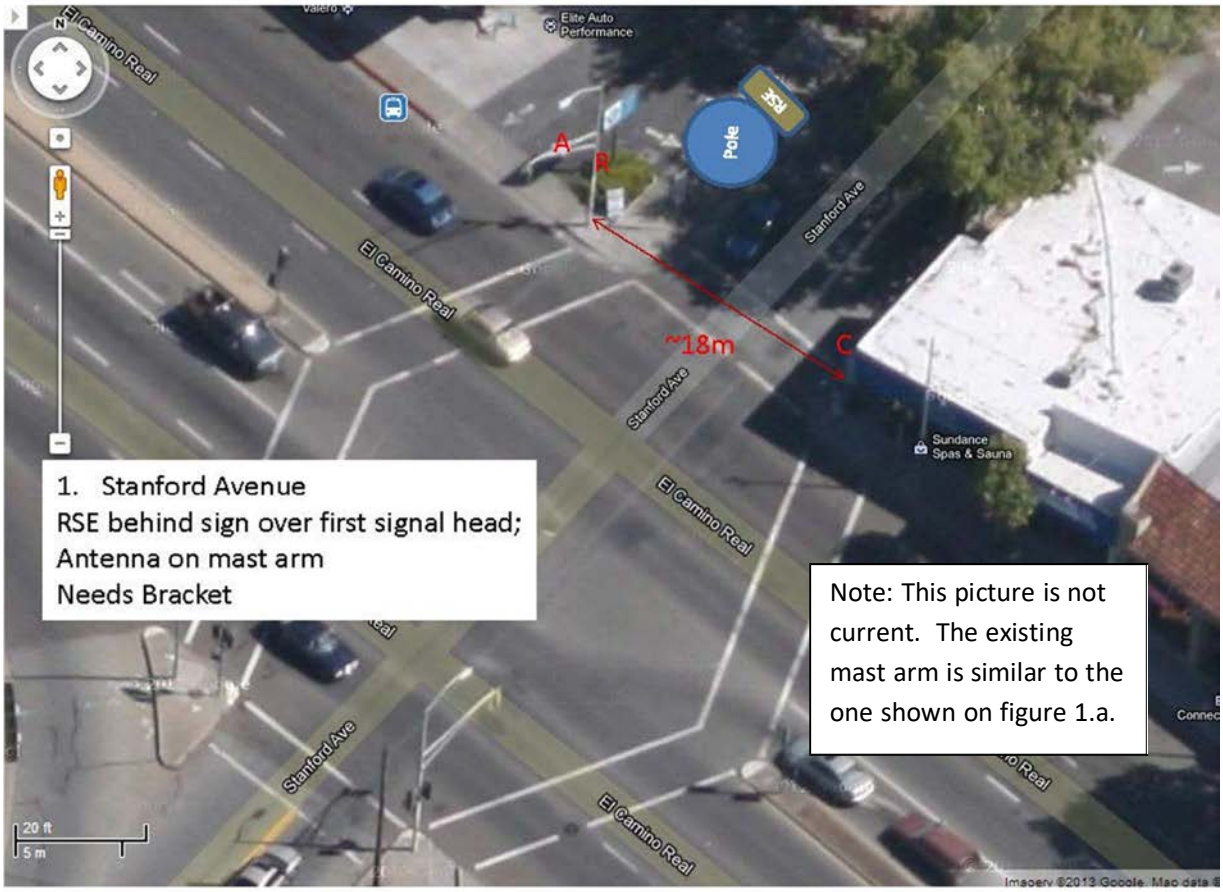
  C = Cabinet, R = Road Side Equipment (RSE) and A = Antenna

- Unless specified, the location denoted by Option 1 should be used.

- Antennas on light poles are mounted on the vertical pole using a bracket at a height of at least 18 feet.

- Further, the relative positioning of the RSE with respect to the pole it is being attaché to, as seen in the top view parallel to ECR, is illustrated on the photo of each intersection by diagrams like this:




El Camino Real
Elite Auto Performance
RSE
Pole
A
B
C
~18m
Stanford Ave
El Camino Real
Stanford Ave
Sundance Spas & Sauna
El Camino Real
Stanford Ave
El Camino Real
20 ft
5 m
1. Stanford Avenue
RSE behind sign over first signal head;
Antenna on mast arm
Needs Bracket
Note: This picture is not current. The existing mast arm is similar to the one shown on figure 1.a.


N
El Camino Real
El Camino Real
Cambridge Ave
Cambridge Ave
Cambridge Ave
El Camino Real
Cambridge Ave
C
R
A
~8m
Pole
RSE
Jack In the Box
20 ft
5 m
2. Cambridge Avenue
RSE goes above mast arm;
Antenna on mast arm
Needs Bracket
©2013 Google. Map data ©


3. California Avenue
RSE goes above mast arm;
Antenna between street sign and on the mast arm;
Does not need Bracket
El Camino Real
S California Ave
Baywide Funding Corporation
A
R
~10m
C
Pole
RSE
20 ft
5 m
Imagery ©2013 Google, Map data ©

4. Page Mill road

Option 1(to be used):

RSE goes above mast arm on the vertical

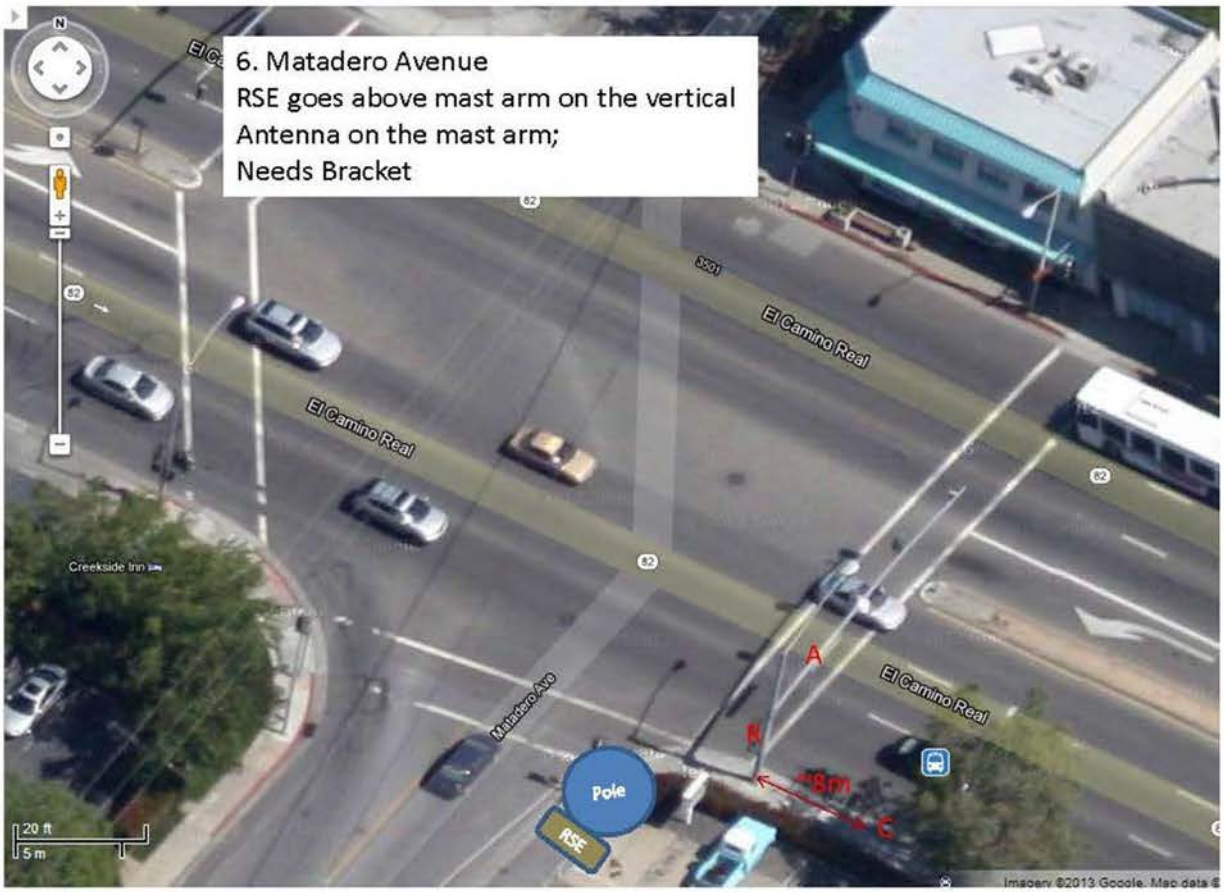
Antenna on the mast arm;

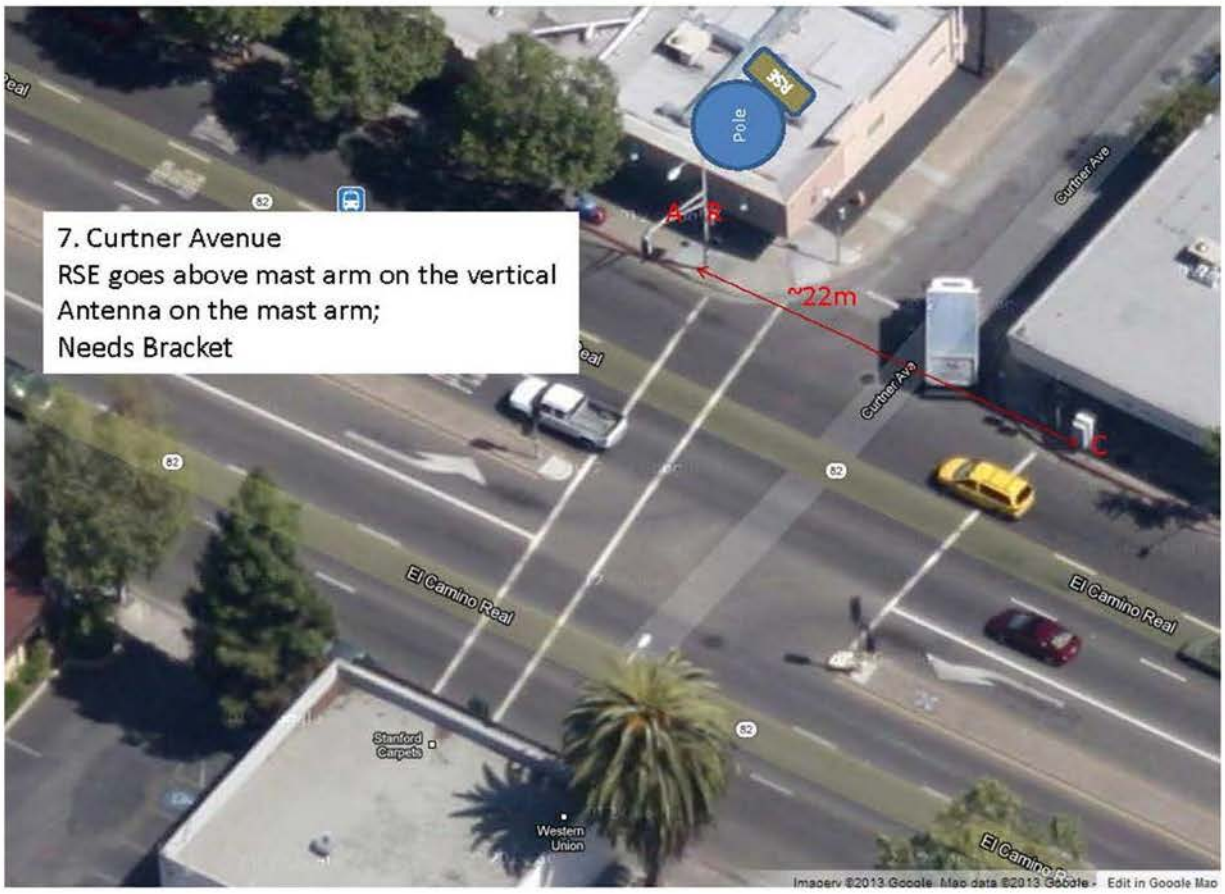
Does not need Bracket

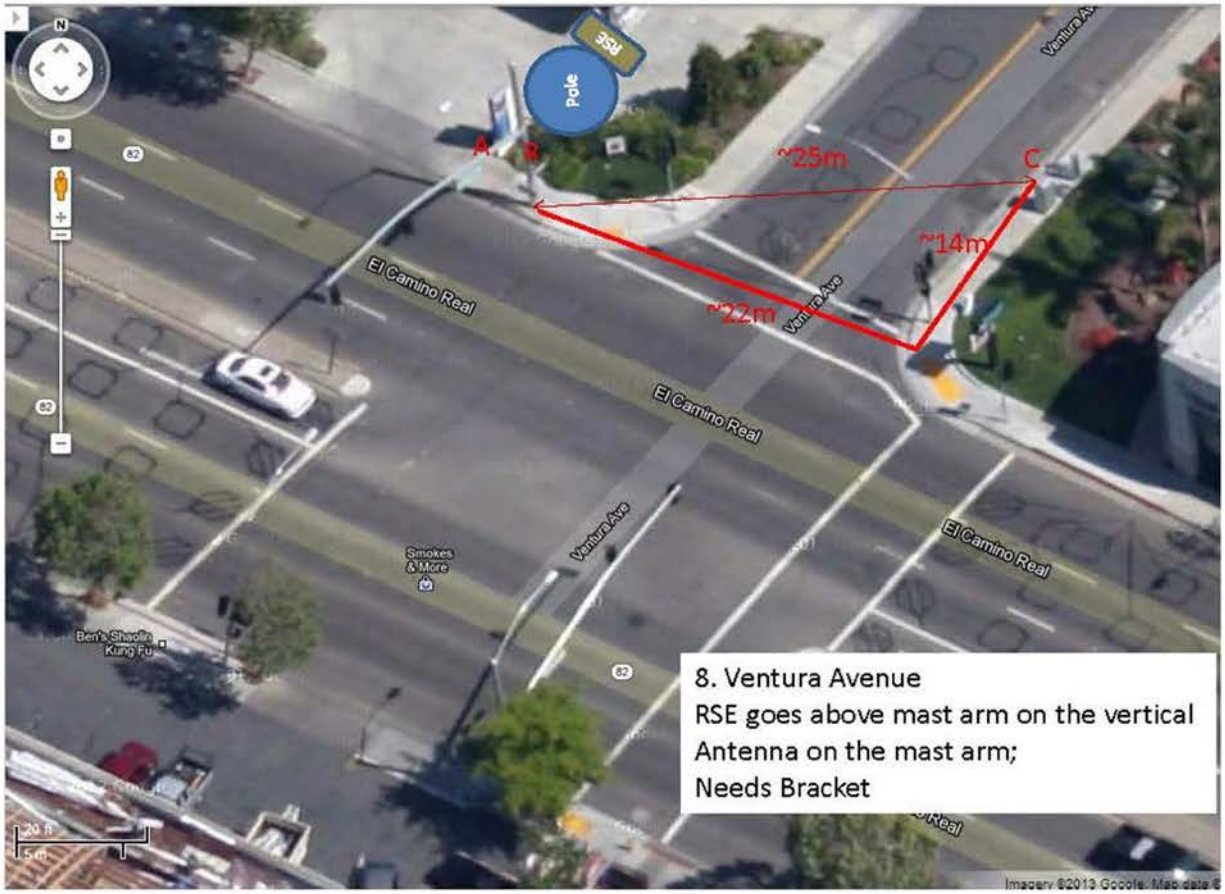
Option 2:

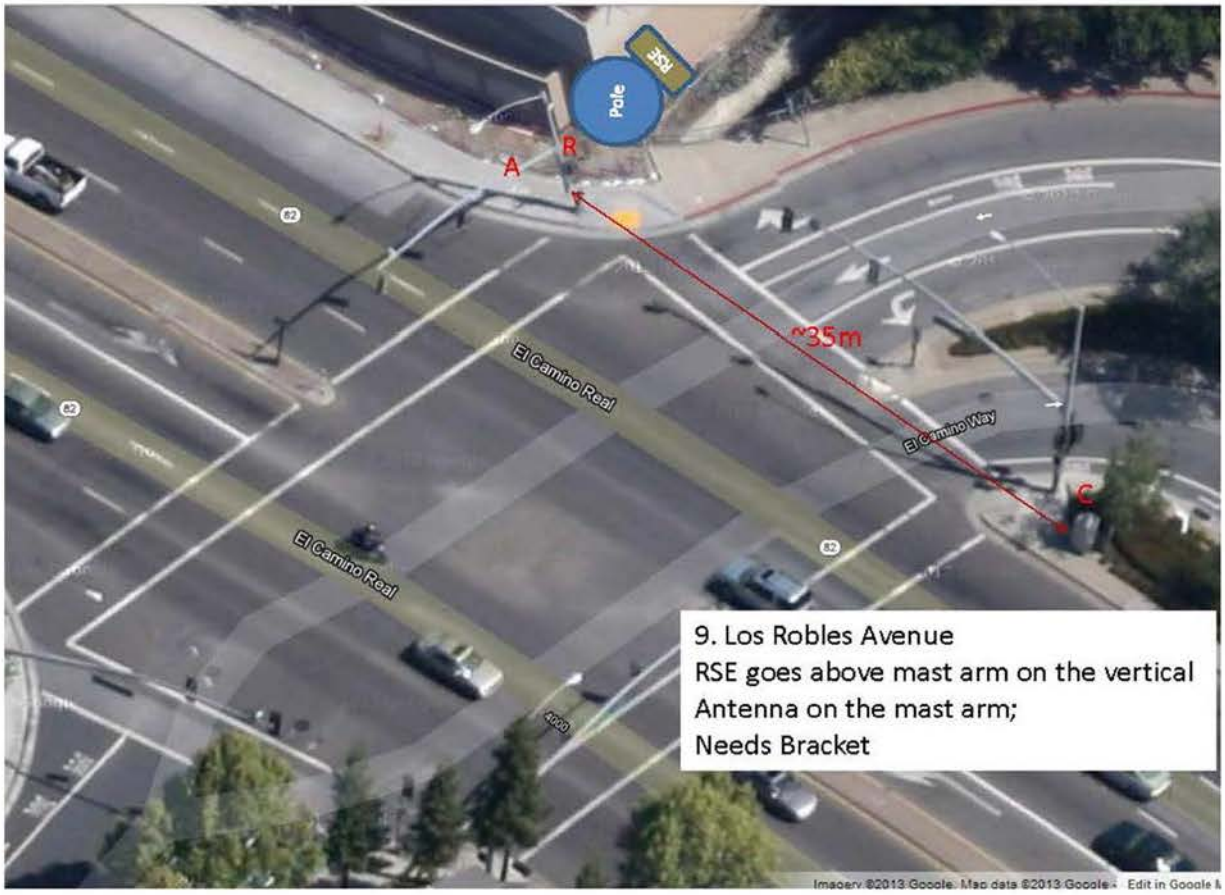
Needs Bracket and add small arm


We Fix Macs
Portage Ave
El Camino Real
El Camino Real
El Camino Real
Super 8 Palo Alto Stanford
RSE
Pole
C
A
R
~8m
5. Portage/Hansen
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket

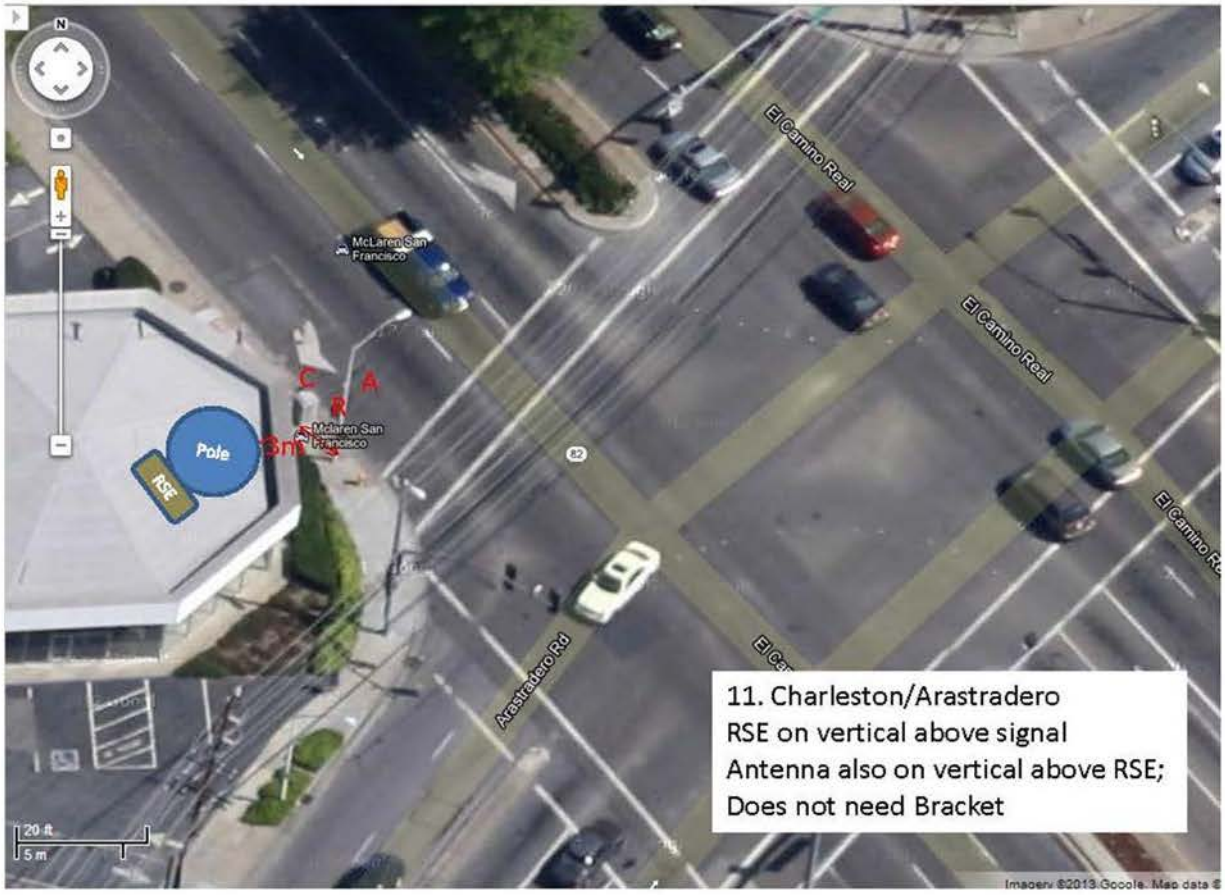

6. Matadero Avenue
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket
El Camino Real
El Camino Real
Creekside Inn
Matadero Ave
Pole
RSE
A
B
C
~8m
20 ft
5 m


7. Curtner Avenue
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket
RSE
Pole
A
B
~22m
C
Curtner Ave
Curtner Ave
El Camino Real
El Camino Real
Stanford Carpets
Western Union
Imagery ©2013 Google Map data ©2013 Google
Edit in Google Map


RSE
Pole
A
B
C
~25m
~14m
~22m
El Camino Real
Ventura Ave
Smokes & More
Ben's Shaolin Kung Fu
8. Ventura Avenue
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket


RSE
Pole
A
B
~35m
El Camino Real
El Camino Way
C
El Camino Real
9. Los Robles Avenue
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket
Imagery ©2013 Google, Map data ©2013 Google - Edit in Google M


10. Maybell Avenue
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket
El Camino Real
Maybell Ave
Pole
RSE
C
~8m
B
A
20 ft
5 m


El Camino Real
El Camino Real
McLaren San Francisco
C
R
A
Mclaren San Francisco
3m
Pole
RSE
82
Arastradero Rd
11. Charleston/Arastradero
RSE on vertical above signal
Antenna also on vertical above RSE;
Does not need Bracket
20 ft
5 m

Time Frame and Schedule of installations

The selected bidder is expected to perform the work between 06/15/2013 and 08/31/2013. These dates are contingent on Caltrans testing and approval of the installation at the first site. The specific schedule for work at each intersection will be established in consultation with PATH and Caltrans District 4, which will be represented on-site during the work and will be conducting acceptance testing at the completion of each installation. The first installation will be at an intersection determined jointly by UC and Caltrans. After the first installation is completed, Caltrans will require a waiting period of a few weeks to ensure that there has been no interference with normal traffic signal operations before authorizing work on the additional intersections.

Conditional termination of contract

If after the first installation, Caltrans District-4 is not satisfied, then PATH reserves the right to terminate the contract with the contractor compensated for the cost of the first installation.

Contractors are to submit bids as follows:

Base bid is to include sites 1 through 5

Alternate bids to be provided:

Alt #1: Site 6

Alt #2: Site 7

Alt #3: Site 8

Alt #4: Site 9

Alt #5: Site 10

Alt #6: Site 11

The basis of award will be based on base bid amount. Alternates should be priced as if they will be added to the base bid as opposed to individual, stand-alone projects.

Bidding schedule:

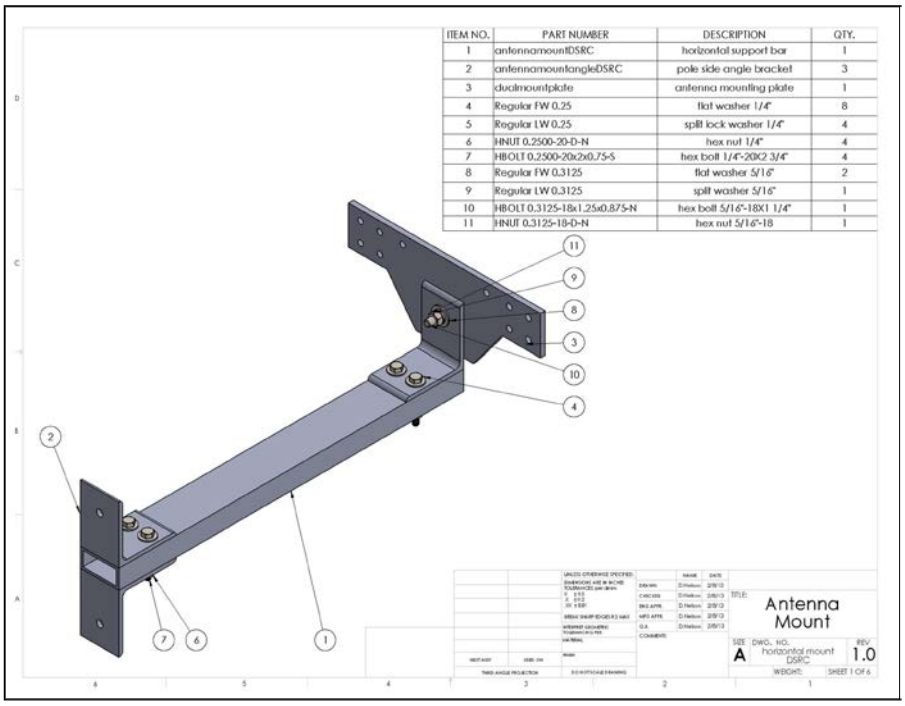
Information packets sent out:	5/20/13
Site visit:	Between 5/20/13 and 5/31/13
Bids due:	6/7/13
Contract award:	6/9/13

We have attached a sample of the UC brief form contract for your information. Please note the following:

1. A payment bond is required on any contract $25,000 or over before the contract can be fully executed
2. A certificate of insurance will be required before the contract is fully executed.

Appendix A: Design Specifications for DSRC Antenna Bracket(s)

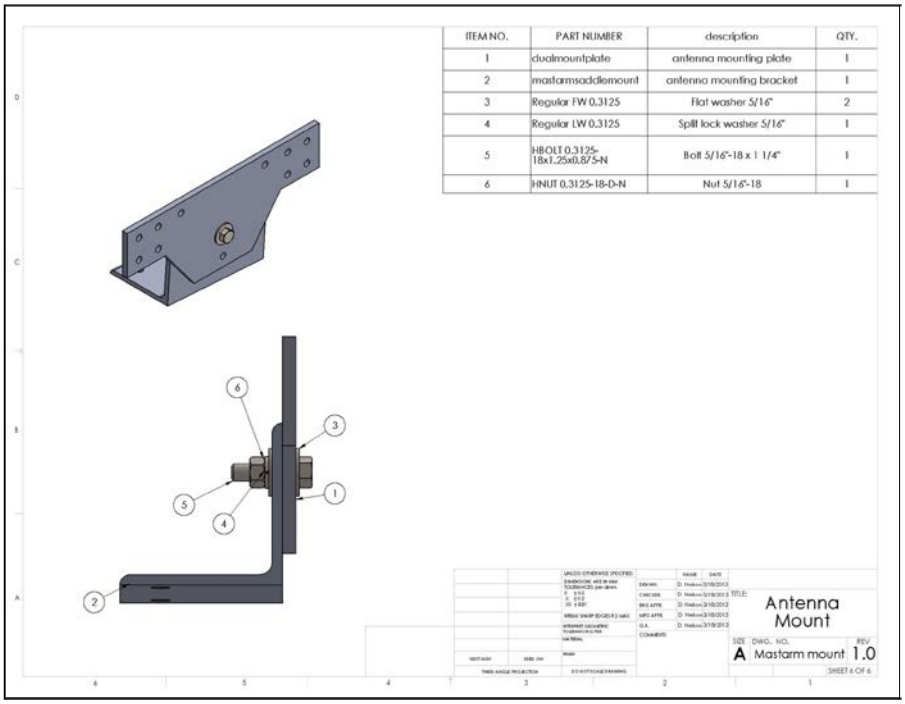
A1: Pole Mount:



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	antennamountDSRC	horizontal support bar	1
2	antennamountangleDSRC	pole side angle bracket	3
3	dualmountplate	antenna mounting plate	1
4	Regular FW 0.25	flat washer 1/4"	8
5	Regular LW 0.25	split lock washer 1/4"	4
6	HNUT 0.2500-20-D-N	hex nut 1/4"	4
7	HBOLT 0.2500-20x2x0.75-S	hex bolt 1/4"-20X2 3/4"	4
8	Regular FW 0.3125	flat washer 5/16"	2
9	Regular LW 0.3125	split washer 5/16"	1
10	HBOLT 0.3125-18x1.25x0.875-N	hex bolt 5/16"-18X1 1/4"	1
11	HNUT 0.3125-18-D-N	hex nut 5/16"-18	1

Antenna Mount

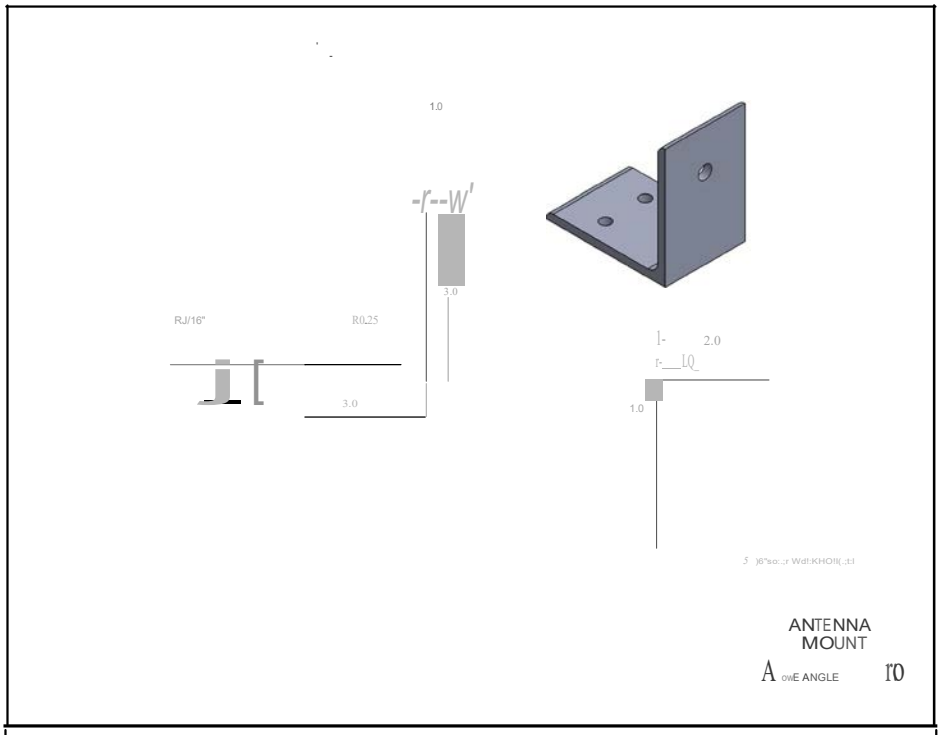
A2: Mast Arm Mount:

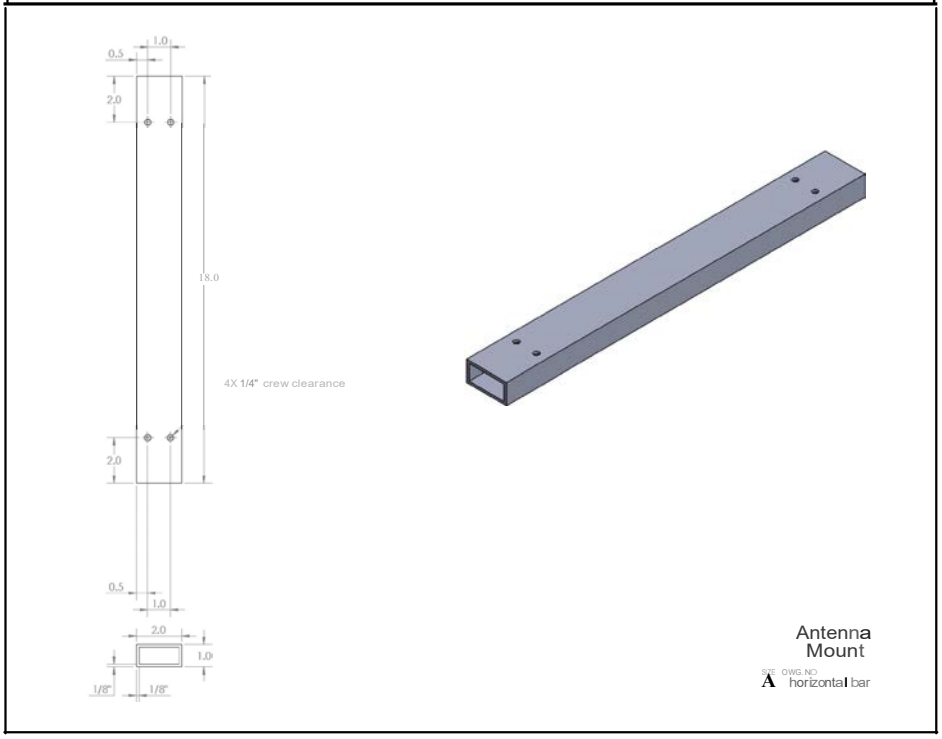


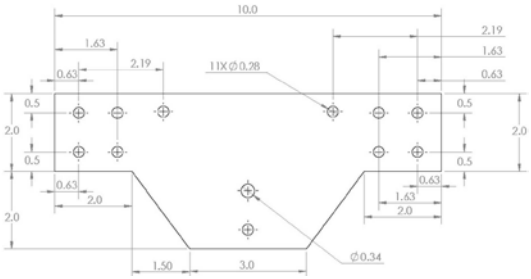
ITEM NO.	PART NUMBER	description	QTY.
1	dualmountplate	antenna mounting plate	1
2	mastarmsaddlemount	antenna mounting bracket	1
3	Regular FW 0.3125	Flat washer 5/16"	2
4	Regular LW 0.3125	Split lock washer 5/16"	1
5	HBOLT 0.3125-18x1.25x0.875-N	Bolt 5/16"-18 x 1 1/4"	1
6	HNUT 0.3125-18-D-N	Nut 5/16"-18	1

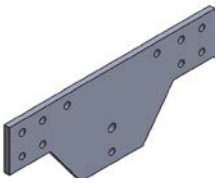
Antenna Mount

A3: Antenna Mount Assembly Part Details:



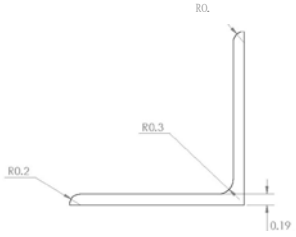



10.0
1.63
2.19
0.63
11X ∅0.28
0.5
2.0
0.5
0.63
2.0
2.0
1.50
3.0
∅0.34
2.19
1.63
0.63
0.5
2.0
0.5
0.63
1.63
2.0

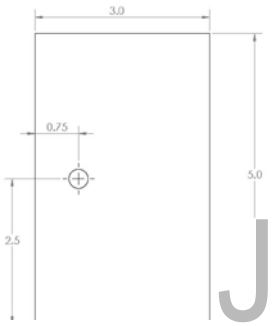


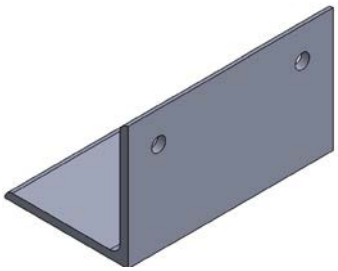

0.25
10.0

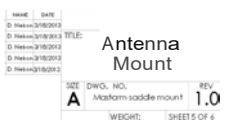

Antenna Mount
A
Dual Mount Plate
1.0


R0.
0.75
R0.3
R0.2
0.19


3X ∅0.34


3.0
0.75
5.0
2.5




Antenna
Mount
A
Mastarm saddle mount
1.0

Appendix B: Pictures and dimensions of Road Side Equipment (RSE)

Arada RSE:

Dimensions: 9 ¼” (L) x 9 ¼” (H) x 3” (D)

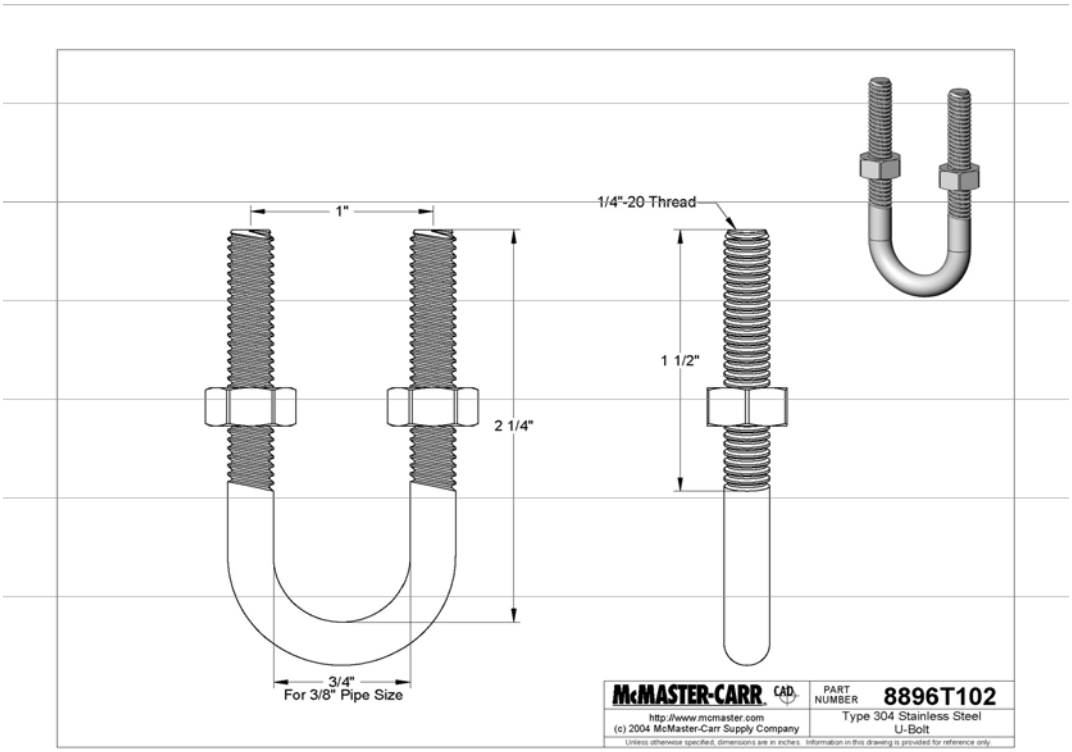
Savari RSE:

Dimension: 8" (L) x 8 1/2"(H) x 2 3/4" (D)

Appendix C: Design Specifications for Savari and Arada DSRC RSE Mounting Accessories

There are some accessories required to secure the antennas to the the Pole Mount and the Mast Arm Mount. They are listed below as needed by the different brand of RSEs.

Arada: U-Bolts (Part # - McMaster-Carr 8896T102) – 4 per site, 2 per antenna



Savari: Mobile mark mounts (Part # - ECO-MK) – 2 per site, 1 per antenna