TRAFFIC SIGNAL MANUAL

2018 EDITION

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CHAPTER 10 - TRAFFIC SIGNAL SOFTWARE

n/a

CHAPTER 1

INTRODUCTION

SCDOT

Traffic Signal Policy:

The SCDOT Traffic Signal Manual establishes SCDOT policy concerning traffic signals. This manual details SCDOT's standard methodology for signal review, design, installation, operation and maintenance.

Traffic signals include stop-and-go signals, flashing beacons, and railroad warning devices.

- Traffic signal studies, design, installation, operation, and maintenance shall conform to the Manual on Uniform Traffic Control Devices (MUTCD) and this SCDOT Traffic Signal Manual.
- SCDOT is responsible for the approval, design, equipment, installation, operation, maintenance, and electric current for stop and go traffic signals and flashing beacons on state maintained roadways.
- All stop and go traffic signals and flashers on the SC highway system are owned by SCDOT and operations authority is under SCDOT's jurisdiction. Any installation of traffic signal or flasher on the state's highway system must be approved by SCDOT.
- Signal operations are the responsibility of SCDOT but may be delegated to the local government within an approved Signal Maintenance Agreement. This includes ensuring communications is operational, reviewing signal timings and ensuring coordination plans are in place and operational.

Stop & Go Traffic Signal/Flashing Beacon - approval authority resides in each District.

- Studies must be conducted to determine whether a new or revised traffic signal or a flashing beacon is justified.
- Studies may be performed by SCDOT, consultants or local governments. SCDOT will review studies and the District Engineering Administrator (DEA) determines if traffic signal installations/revisions are warranted based upon the MUTCD requirements and engineering judgment.

Active Railroad Warning Devices

- The Director of Traffic Engineering will make recommendations to the SCDOT Commission for installation or upgrade of active railroad warning devices based upon a statewide ranking system.
- Active railroad warning device installations are typically federally funded, with installations prioritized utilizing a safety ranking system.
- Railroad companies will design and install railroad warning devices. SCDOT will reimburse railroad companies for design, fabrication, and installation costs.
- Active railroad warning devices are operated and maintained by the respective railroad companies, including electrical costs.

Chapter Summary :

The following is a summary of the information provided in each chapter:

Chapter 1 Introduction:
Includes Signal/flasher Installation/Revision Process/Authority, Signal Studies, References, and Inventory.

Chapter 2 Project Development:
Includes Signal Activity Types, Project Development Process, including steps to identify, program, scope, and implement signal projects.

Chapter 3 Traffic Signal Communications Network:
Describes communications efforts for signals.

Chapter 4 Traffic Signal Design:
Design includes the collection of geometric and traffic data, analysis of data, preparation of timing plans, verification of right of way, visual observation of potential utility conflicts, and preparation of signal plans. All signal design must be sealed by a South Carolina registered professional engineer (P.E.)

Chapter 5 Equipment:
Equipment describes the various signal equipment categories.

Chapter 6 Operations:
Includes signal system re-timing and operations.

Chapter 7 Construction:
includes types of signal construction, installation methods and inspections.

Chapter 8 Maintenance:
Includes maintenance duties.

Chapter 9 Railroad Preemption:
includes design and installation information for traffic signals interconnected with active Railroad Devices

Chapter 10 Traffic Signal Central Software:
Includes information concerning the various types of software for traffic signals in South Carolina.

Traffic Signal Categories:

See categories below:

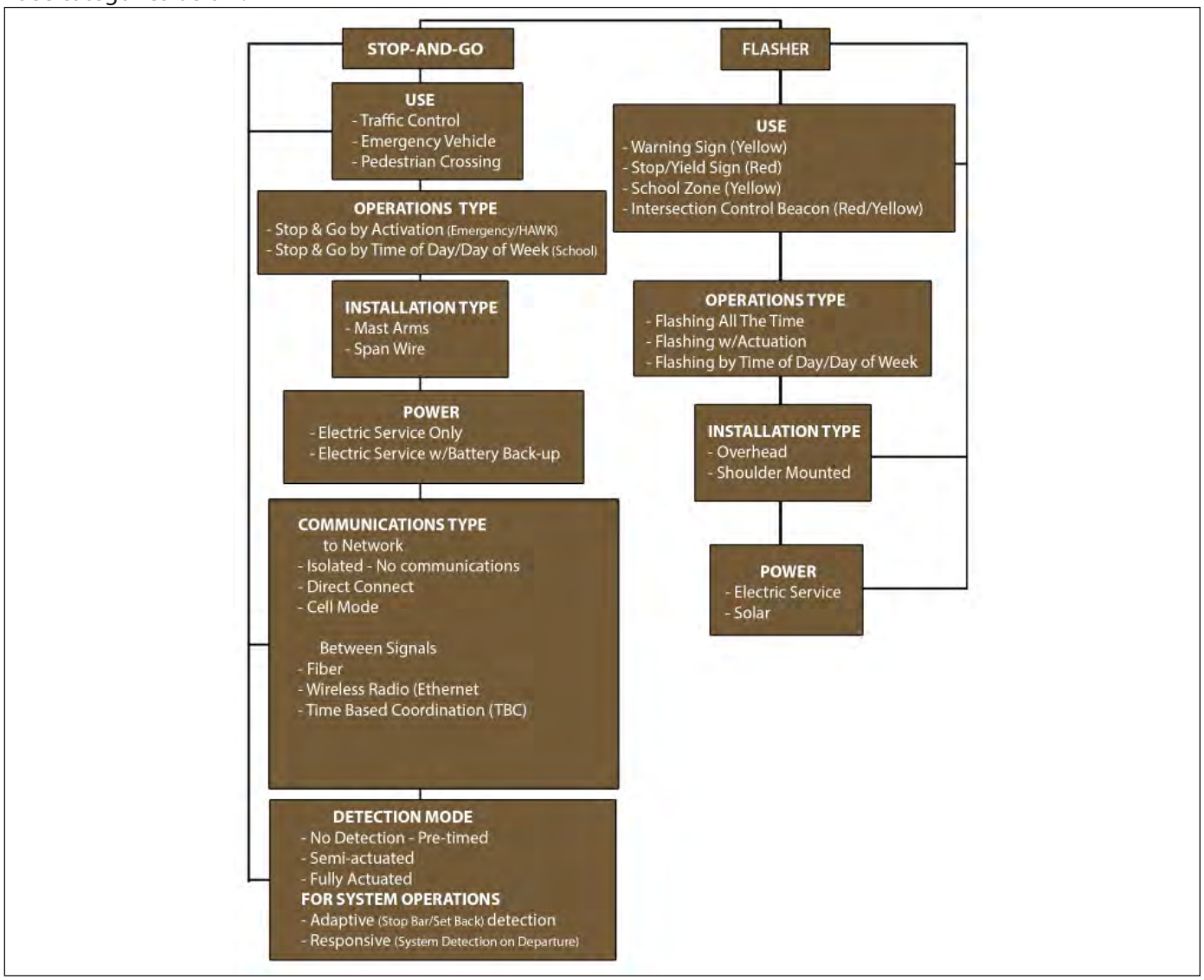


Figure 1-1
Traffic Signal Categories

Core Duties for Traffic Signal and Systems (TS&S) Unit (SCDOT Traffic Engineering -HQ)

Traffic Signals and Systems Unit within SCDOT HQ Traffic Engineering performs signal activities as shown above in **Figure 1-2.** As shown, TS&S has activities with schedules determined by others and must meet those deadlines within time frames dictated by each project. TS&S also manages Traffic Signal Program where scopes, deadlines and work activities are determined by TS&S based on funding and coordination with District personnel. In addition, TS&S provides support services to ensure statewide uniformity in design, equipment and processes for installing, operating and maintaining traffic signals.

Preconstruction Projects

Roadway Improvement Projects
for Roadway Widening, Intersection Improvement, Safety Projects, Local Option Sales Tax projects
Signal Plan Preparation including development of quantities and any specialized requirements in specifications
Signal Plan, Specification, Quantitiy Review

Traffic Engineering TS&S Activities

Support Services
provides resources to support Signal Activities
Traffic Signal Design Standards
Support Services for Signal Maintenance Staff (SCDOT, Local Government)
Traffic Signal On Call Consultant Services
On Call Signal Construction Services Contract
Signal Construction Specifications
QPL Program
Signal Materials Specifications
Signal Equipment Contracts
Research for Advanced Signal Technologies
Traffic Signal Softwares (Central Signal Software, Adaptive Software , Traffic Signal Modeling Software, Traffic Signal Inventory and Management Software)
Training for Signal Design, Project Management, Signal Software, Equipment Operation, Construction/Maintenance Activities

Traffic Engineering TS&S Projects

Type 2 Signal Activities Signal Upgrade Projects	**Type 1 Signal Activities Signal System Projects**	**Type 3 Signal Activities Communications Projects**
for Signal Upgrades or Installations	*to Install, Retime or Update Signal Systems for Corridor Management*	*to Expand, Operate or Maintain Traffic Signal Communications Networks*
***SCDOT TS&S** Manages Program*		
Project Management		
Signal Plan Preparation including development of quantities and specifications	Project Scope Development	
Review of Signal Plans/ Specifications/ Quantities prepared by consultants	Coordination with SCDOT IT Services -Network Group	
Coordination with SCDOT / Local Government Signal Staff		
Construction Support Services	Support for Signal Construction Services	
Letting Package Preparation	Review of Expenses	

Figure 1-2
Core Duties for Traffic Signal & Systems Unit

Traffic Signal Studies:

- Traffic Signal Studies should be maintained at the District Engineering Office, or at the appropriate local government office.
- The Manual on Uniform Traffic Control Devices(MUTCD) 4C has information on Highway Traffic Signals, concerning Traffic Control Signal Needs Studies. More information on Signal Studies is below:

Typical Studies:

- Traffic Signal Needs Study
- Left Turn Phase Study
- Flashing Beacon Needs Study
- Intersection Control Beacon Study
- School Zone Flasher Study
- Intersection Capacity Analysis
- Intersection Safety Study

The following includes typical information that is gathered to make a determination on the appropriate traffic control to address existing conditions.

Field Reviews

- Existing Traffic Control
- Sight distances
- Roadway alignment
- Lane configuration
- Character of area
- Signs and markings
- Adjacent driveway location and spacing
- Operational characteristics of vehicles
- Delay and Queuing Data

Observations

- Motorists Behavior
- Compliance with existing signal, signs and markings
- Traffic patterns

Accident History

- Typically 3 years
- Collision Diagram
- Type and Cause of Collision
- Time of Day/Day of week

Traffic Counts

- Directional Count Data
- Turning Movement Counts

Traffic Signal Needs Study

This study is intended to determine if a traffic signal is warranted at an unsignalized intersection. This study shall be performed in accordance with MUTCD Chapter 4C, see **Figure 1-3** below.

CHAPTER 4C. TRAFFIC CONTROL SIGNAL NEEDS STUDIES

Section 4C.01 Studies and Factors for Justifying Traffic Control Signals

Standard:

01 An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location.

02 The investigation of the need for a traffic control signal shall include an analysis of factors related to the existing operation and safety at the study location and the potential to improve these conditions, and the applicable factors contained in the following traffic signal warrants:

Warrant 1, Eight-Hour Vehicular Volume
Warrant 2, Four-Hour Vehicular Volume
Warrant 3, Peak Hour
Warrant 4, Pedestrian Volume
Warrant 5, School Crossing
Warrant 6, Coordinated Signal System
Warrant 7, Crash Experience
Warrant 8, Roadway Network
Warrant 9, Intersection Near a Grade Crossing

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Figure 1-3a
Traffic Signal Needs Study Warrants from MUTCD

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION
DISTRICT ##
TRAFFIC ENGINEERING

County: count City: city Date: date

Major Rt: Main Roadway Minor Rt: Minor Roadway

Day of Week: day Weather: weather Name: name

Type of Control: Stop Sign Speed Limit (major st) 55

Direction of Minor Street: E-W Intersection ADT - 7230 (Calc)

Number of Lanes (major st)* 1 Number of Lanes (minor st)* 1
* Each Direction

INTERSECTION VOLUME SUMMARY

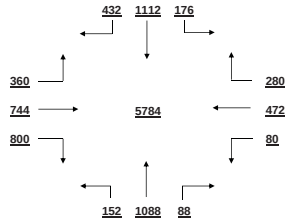
	SB - Main Roadway				NB - Main Roadway				EB- Minor Roadway				WB- Minor Roadway				Total	Total
	LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	Vol	Peds
7:00 - 7:15	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	1
7:15 - 7:30	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	3
7:30 - 7:45	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	3
7:45 - 8:00	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	2
8:00 - 8:15	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	2
8:15 - 8:30	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	0
8:30 - 8:45	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	1
8:45 - 9:00	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	1
9:00 - 9:15	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	0
9:15 - 9:30	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	0
9:30 - 9:45	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	0
9:45 - 10:00	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	0
11:00 - 11:15	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	0
11:15 - 11:30	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	0
11:30 - 11:45	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	5
11:45 - 12:00	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	1
12:00 - 12:15	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	3
12:15 - 12:30	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	3
12:30 - 12:45	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	0
12:45 - 13:00	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	0
13:00 - 13:15	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	0
14:00 - 14:15	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	1
14:15 - 14:30	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	3
14:30 - 14:45	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	3
14:45 - 15:00	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	2
16:00 - 16:15	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	2
16:15 - 16:30	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	0
16:30 - 16:45	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	1
16:45 - 17:00	2	46	11	59	1	33	2	36	4	15	7	26	15	15	25	55	176	1
17:00 - 17:15	4	35	13	52	5	32	1	38	2	18	11	31	19	25	28	72	193	0
17:15 - 17:30	10	28	18	56	8	33	3	44	2	14	9	25	4	23	33	60	185	0
17:30 - 17:45	6	30	12	48	5	38	5	48	2	12	8	22	7	30	14	51	169	0
TOTAL	176	1112	432	1720	152	1088	88	1328	80	472	280	832	360	744	800	1904	5784	38
Trucks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
School Buses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%

PAGE 1

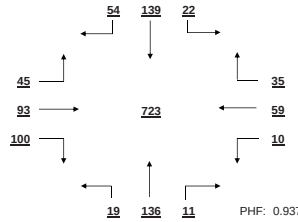
TOTAL AND PEAK HOUR VOLUME DIAGRAMS

Main Roadway AT Minor Roadway Date: date

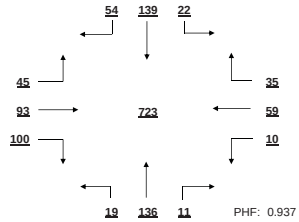
8.0 HOUR TOTAL VOLUME
FROM 7:00 TO 17:45



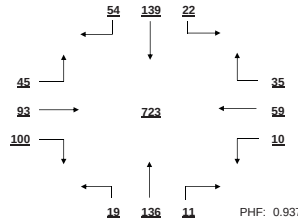
OVERALL PEAK HOUR VOLUME
FROM 7:00 TO 8:00



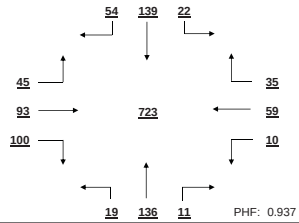
AM PEAK HOUR VOLUME (0:00-10:45)
FROM 7:00 TO 8:00



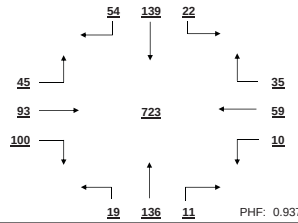
PM PEAK HOUR VOLUME (14:15-23:45)
FROM 14:15 TO 16:15



MID-DAY PEAK HOUR VOLUME (11:00-14:00)
FROM 11:00 TO 12:00



OTHER HOUR VOLUME
FROM 14:00 TO 15:00



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SIGNAL WARRANT ANALYSIS

Main Roadway AT Minor Roadway Date: date

Minor Street Volume, percent of total = 47.3%
Percent of Left Turns from Minor Street = 16.1%
Percent of Right Turns from Minor Street = 39.5%
Percent of Minor Street Right Turns to Remove from Warrant Analysis = 0%
WARRANT BASIS = **70%**

Warrant No. 1 - Vehicular Volume is met

Condition A - Minimum Vehicular Volume is met

Average Major Street % of Warrant				Average Minor Street % of Warrant			
381.0	/	350	= 109%	238.0	/	105	= 227%

Hourly percent of warrant

	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	11:00 - 12:00	12:00 - 13:00	13:00 - 14:45	14:45 - 16:45	16:45 - 17:45
Major St.	109%	109%	109%	109%	109%	109%	109%	109%
Minor St.	227%	227%	227%	227%	227%	227%	227%	227%

Condition B - Interruption to Continuous Traffic is not met

Average Major Street % of Warrant				Average Minor Street % of Warrant			
381.0	/	525	= 73%	238.0	/	53	= 453%

Hourly percent of warrant

	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	11:00 - 12:00	12:00 - 13:00	13:00 - 14:45	14:45 - 16:45	16:45 - 17:45
Major St.	73%	73%	73%	73%	73%	73%	73%	73%
Minor St.	453%	453%	453%	453%	453%	453%	453%	453%

80% Combination of Conditions A & B is not applicable

Warrant No. 2 - Four Hour Vehicular Volume is met

Hourly percent of warrant

	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	11:00 - 12:00	12:00 - 13:00	13:00 - 14:45	14:45 - 16:45	16:45 - 17:45
Minor St.	139%	139%	139%	139%	139%	139%	139%	139%

Warrant No. 3 - Peak Hour is not met

Percent of warrant			Percent of warrant		
Overall Peak Hour:	7:00 - 8:00		Higher Volume Side Street Peak Hour:	7:00 - 8:00	
Minor St.	85%		Minor St.	85%	

Warrant No. 4 - Pedestrian Volume is not met

Major Street				Minor Street			
0.0	/	100	= 0%	0.0	/	100	= 0%

Hourly percent of warrant

	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	11:00 - 12:00	12:00 - 13:00	13:00 - 14:45	14:45 - 16:45	16:45 - 17:45
Major St.	0%	0%	0%	0%	0%	0%	0%	0%
Minor St.	0%	0%	0%	0%	0%	0%	0%	0%

Warrant No. 7 - Crash Experience (Requires 3 criteria analysis by engineering)

Total Number: 17 From: 1/1/2015 to 11/1/2018
Accident Rate 1.68 per million entering vehicles

Types of Accidents	No.	/	Avg.		No.	/	Avg.
Right Angle	3	/	0.8	Rear End	6	/	1.6
Lost Control	4	/	1.0	Side Swipe	0	/	0.0
Left Turn	4	/	1.0	Other	0	/	0.0

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Figure 1-3b
Example SCDOT Traffic Count/Warrant Analysis

Left Turn Phase Study:

Left turn signal phases facilitate left -turning traffic and may improve the safety of the intersection for left turning vehicles. However, this is done at the expense of the amount of green time available for through traffic and will usually reduce the capacity of the intersection. Left turn arrows also result in longer cycle lengths, which in turn have a detrimental effect by increasing stops and delays. While phases for protected left turning vehicles are popular and commonly requested, other methods of handling left turn conflicts also need to be considered. Potential solutions may include prohibiting left turns and geometric improvements. Left turn phasing will typically be installed as a protected/permissive left turn movement if at all possible. This will keep the intersection capacity and efficiency at the highest possible operation level. The following guidelines are listed to determine whether or not a left turn phase should be considered:

A. ***Protected/Permissive -*** This phasing allows a motorist an opportunity to choose to make their turn during the protected or the permissive part of the signal phase. Left turn phase should only be considered for approaches where one or more of the following requirements are met at the signalized intersections.

1. The cross-product, one hour left turn volume times the opposing one hour through movement volume divided by the number of lanes for the opposing through movement, is greater than or equal to 50,000

$$V_{lt} * V_0 \div N_0 \geq 50{,}000$$

Where: V_{lt} = left-turn flow rate, vehicles/hour

V_0 = opposing through movement flow rate, vehicles/hour*

N_0 = number of lanes for the opposing through movement

*Opposing right turn movment flow rate should be included as necessary

Example: Main Road @ Side Road

Main Road EB peak hour (5:00pm to 6:00pm) left turn volume is 113 vph = V_{lt}

Main Road WB through peak hour (5:00pm to 6:00pm) volume is 893 vph = V_0

Main Road is a four lane roadway, therefore N_0 = 2

*Cross Product = 113 *893 ÷ 2 = 50,454*
(cross-product is greater than 50,000; therefore, the cross product warrant is satisfied.)

2. The left turn volume exceeds 125 vehicles per hour.

V_{lt} = 125 veh/h (Where: V_{lt} = left-turn flow rate, vehicles/hour)

3. Correctable crashes equals or exceeds 4 crashes in one year or 6 crashes in two years.

4. More than 2 left turn vehicles per cycle still waiting at the end of green.

5. Additional criteria, including but not limited to sight distance, speed of opposing traffic, number of left turn lanes, number of opposing through lanes, delay, the angle of the left turn and if the signal is included in a coordinated signal system should aslo be taken into consideration when evaluating requests for left turn phases.

B. ***Protected only*** - This phasing only allows a motorist to turn on the protected phase for the left turn. This option provides more safety; however, a good bit of efficiency is lost at the signal, since during low traffic times, a motorist must wait for the protected turn phase in order to make a turn.

A protected-only left turn phase should be considered when conditions satisfy one or more of the following criteria:

1. $V_{lt} * V_0 \div N_0 \geq 150{,}000$
2. Left turn crashes under a protected/permissive phasing equals or exceeds 5 crashes in 2 years for the proposed movement
3. Dual left turns
4. Limited sight distance will not allow permissive turns
5. Conflicting left turn paths
6. Opposing traffic is approaching in three or more lanes at speeds greater than or equal to 45 mph
7. Additional criteria such as unusal intersection geometrics or a high volume of pedestrians

Engineering judgment should be used in determining if left turn phasing will improve the overall operation of the intersection. Even if the volume warrants are met, a field review should be conducted to determine the number of vehicles waiting to turn left at the end of the phase. Consider the amount of queuing and the storage available to determine if there is adequate room to facilitate the volumes without installing the additional phase. If no safety issues are present, and sight distance and storage is adequate, give strong consideration to the effect of the additional phase on the level of service of the main traffic movements through the intersection. In addition, there are different types of left turn phasing, as shown below:

C. ***Variable Turn Modes*** - An engineering study should be completed prior to installing a variable left turn mode and/or variable right turn mode at traffic signals.

D. ***Flashing Yellow Arrow (FYA)*** - SCDOT promotes the use of flashing yellow arrow signal heads for protected permissive signal operation. FYA signal heads are also used at signals with offset left turn lanes regardless of signal phasing. More information and guidelines concerning Flashing Yellow Arrows are provided in **Chapter 4.**

Flashing Beacons:
Flashing Beacons are maintained by SCDOT and Local Government signal maintainers. Engineers should perform studies to determine if a flashing beacon should be installed in accordance with MUTCD, Chapter 4L, Flashing Beacons and Chapter 4G Traffic Control Signals for Emergency Vehicles, Chapter 7 School Zones Flashers. Engineering judgement shall also be used.

See the following figures for examples of:

Intersection Control Beacon (**Figure 1--5a,1-5b)**,

Intersection Control Beacon - All way Stop **(Figure 1-5c**)

Removal of Intersection Control Beacon (**Figure 1-6)**

Emergency Signal **(Figure 1-7**),

School Zone Flasher (**Figure 1-8, 1-9**)

Warning Beacon (**Figure 1-10)**

Stop Beacon (**Figure 1-11**)

Road Ends Beacon (**Figure 1-12**)

Left Turn Analysis
SCDOT - District Traffic Engineering

Intersection:	Street A & Street B	Street:	A
Count Date:		Left-turn Movement	Westbound
Counted By:		Number Opposing Lanes	2

Speed Limit or 85th Percentile of Opposing Traffic?	45
Is the current left turn Protected/Permitted? (Y/N)	N
Peak Hour Delay/Left Turn Vehicle?	#DIV/0!

Count Data

Time	Left Turn Volume	Opp Thru Volume	Cycle Length	Max Green	Cross Product	Left Turns Per Cycle
7:00 AM	73	1244	67	40	90812	1.4
8:00 AM	67	866	67	40	58022	1.2
11:00 AM	109	722	67	40	78698	2.0
12:00 PM	132	741	67	40	97812	2.5
4:00 PM	214	904	67	40	193456	4.0
5:00 PM	226	951	67	40	214926	4.2
Average	137	905	67	40	122288	2.5
Peak Hour	13	18	67	45	234	0.2
Peak Time	4:15 PM					

Accident History

Year	Left Turn Accidents
2000	0
2001	1
2002	0
2003	2

Guidelines for Left Turn Phase Installation

Summary of Guideline	Guideline Met?	Hours/Years
Minimum Left-turn Volume	Yes	3
Minimum Cross Product of Opposing and Left-turns	Yes	2
Minimum Number of Lefts/Cycle	Yes	4
Minimum Left-turn Volume vs. Opposing Speed Lim	Yes	6
Accident History Analysis	No	***
Minimum Left-turn Delay	#DIV/0!	#DIV/0!

Minimum Left Turn Volume							*Criteria= 120*	
Begin Time	*Percent Satisfied*							
	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	61%	56%	91%	110%	178%	188%	114%	11%

Figure 1-3c
Example Left Turn Phase Analysis (page 1)

Total Hours Met	3

Minimum Cross Product of Opposing Through and Left Turns							Criteria= 100000	
Begin				Percent Satisfied				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	91%	58%	79%	98%	193%	215%	122%	0%
Total Hours Met	2							

Minimum Number of Lefts/Cycle							Criteria= 2	
Begin				Percent Satisfied				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	68%	62%	101%	123%	199%	210%	127%	12%
Total Hours Met	4							

Minimum Left Turn Volume vs. Opposing Speed Limit							Criteria= 30	
Begin				Percent Satisfied				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	247%	227%	369%	446%	724%	764%	463%	44%
Total Hours Met	6							

Accident History Analysis			Criteria=4/1yr,6/2yrs,8/3yrs		
Year	2000	2001	2002	2003	0
Min. Met?	No	No	No	No	No
Total Years Met	0				

Minumum Left Turn Delay	Criteria= 11
Begin Time	Peak Hour
4:15 PM	#DIV/0!
Met?	#DIV/0!

This report does not constitute a recommendation, other factors and criteria should be considered.

Figure 1-3d
Example Left Turn Phase Analysis (page 2)

Task 1 Signal Studies - Level 1 (per Intersection)		
Scope of Work: A study in **Level 1 Signal Study** is required if the District Office is not sure of the types of issues associated with the intersection and needs a quick site visit, sample 15 minute counts and short report summarizing findings of the site evaluation. The results of the study will identify the problems, but may require further detailed evaluation in areas identified.		
#	**Project Tasks**	**Task Description**
1	Project Management	The ***CONSULTANT*** will manage the project to conform to the **SCDOT** requirements for monitoring and controlling the engineering budget, project schedule and invoicing procedures. The ***CONSULTANT*** shall provide project management for all of the tasks detailed below including the submission of monthly invoices and progress reports to the **SCDOT**. The ***CONSULTANT*** will assign a Project Manager to serve as the primary contact for communications with the **SCDOT**
2	Field Review	Field Review: The ***CONSULTANT*** shall visit each intersection with representatives of the **SCDOT** (if necessary) to discuss the project goals and objectives. As part of this field visit, the ***CONSULTANT*** will collect site specific information, perform 15 minute traffic counts, take digital photos of the intersections and existing signal equipment, and field check copies of the existing signal plans. The ***CONSULTANT*** will prepare a brief memo summarizing the findings of the evaluation including any concerns noted and any recommendations for improvement.
5	Traffic Signal Study: Capacity Analysis Signal Warrant Study Left turn Phase Study Safety Study	As determined in coordination with the **SCDOT**, the ***CONSULTANT*** will utilize MUTCD, &/or Highway Safety Manual, SCDOT Traffic Signal Guidelines to perform studies and to propose recommendations for improvements. The ***CONSULTANT*** will utilize Synchro to model peak periods; this will include modeling existing conditions and recommended improvements. The recommended improvements will be modeled based on a projected horizon year and growth rate coordinated with the **SCDOT**. The capacity analysis results will be provided to the **SCDOT** as part of the design submittal.
8	Report	The ***CONSULTANT*** will prepare a traffic study report detailing all data collected, analysis, performed, and study findings. Report will include concept signal plans, estimated quantities and costs for improvements (if applicable). The study periods and proposed build-out year will be developed in coordination with the **SCDOT**.

Figure 1-4a
Example Level 1 Signal Study Scope of Work (page 1)

Task 2 Signal Studies Level 2 (per Intersection)		
Scope of Work: Perform traffic engineering studies on an on- call basis. Such services will consist of conducting traffic engineering studies at specified locations to evaluate problems related to safety and/or operational efficiency, evaluate the need for the installation of traffic signal warrants and to recommend improvements. A **Level 2 Study** will provide a detailed evaluation of the intersection. The task will include obtaining traffic counts, identification of problems associated with traffic control, road geometry (turn lanes), sight distance issues, and accident data evaluation. The end product will include a signal warrant analysis and concept signal design (as warranted). Existing condition sketches and figures for any proposed modifications will also be provided.		
#	**Project Tasks**	**Task Description**
1	Project Management	The ***CONSULTANT*** will prepare traffic study design plans for each study location. Plans will be schematic in nature and will show recommended improvements including any necessary equipment, signing, signal, marking or roadway construction improvements. Plans will not be sealed and will not include ROW or Utility certification. ASSUMPTIONS: The ***CONSULTANT*** will not be responsible for providing survey services under this task. The ***CONSULTANT*** will utilize aerial photography to develop base mapping for conceptual designs. The concept study plans will be similar to 30% design plans.
2	Field Review	The ***CONSULTANT*** will calculate preliminary quantities and cost estimates for proposed countermeasures for each study utilizing pay items provided by SCDOT. The ***CONSULTANT*** will develop an excel spreadsheet for each study to show quantities required and anticipated costs. Anticipated Costs will be based on the cost estimate file provided by the **SCDOT**.
3	Data Collection – Traffic Counts	The ***CONSULTANT*** will prepare a traffic study report detailing all data collected, analysis, performed, and study findings. Report will include concept signal plans, estimated quantities and costs for improvements (if applicable). The study periods and proposed build-out year will be developed in coordination with the **SCDOT**.
4	Collision Diagram	The ***CONSULTANT*** will collect up to three (3) years of collision data from the **SCDOT** and develop collision diagrams. The ***CONSULTANT*** will coordinate with the **SCDOT** to determine the period of analysis to be performed. The ***CONSULTANT*** will summarize its findings in memo format and incorporate safety considerations into the traffic signal design.
5	Traffic Signal Study: Capacity Analysis Signal Warrant Study Left turn Phase Study	As determined in coordination with the **SCDOT**, the ***CONSULTANT*** will utilize MUTCD, &/or Highway Safety Manual, SCDOT Traffic Signal Guidelines to perform studies and to propose recommendations for improvements. The ***CONSULTANT*** will utilize Synchro to model peak periods; this will include modeling existing conditions and recommended improvements. The recommended improvements will be modeled based on a projected horizon year and growth rate coordinated with the **SCDOT**. The capacity analysis results will be provided to the **SCDOT** as part of the design submittal.
6	Schematic improvement plan preparation	The ***CONSULTANT*** will prepare traffic study design plans for each study location. Plans will be schematic in nature and will show recommended improvements including any necessary equipment, signing, signal, marking or roadway construction improvements. Plans will not be sealed and will not include ROW or Utility certification. ASSUMPTIONS: The ***CONSULTANT*** will not be responsible for providing survey services under this task. The ***CONSULTANT*** will utilize aerial photography to develop base mapping for conceptual designs. The concept study plans will be similar to 30% design plans.
7	Cost Estimate	The ***CONSULTANT*** will calculate preliminary quantities and cost estimates for proposed countermeasures for each study utilizing pay items provided by SCDOT. The ***CONSULTANT*** will develop an excel spreadsheet for each study to show quantities required and anticipated costs. Anticipated Costs will be based on the cost estimate file provided by the **SCDOT**.
8	Report	The ***CONSULTANT*** will prepare a traffic study report detailing all data collected, analysis, performed, and study findings. Report will include concept signal plans, estimated quantities and costs for improvements (if applicable). The study periods and proposed build-out year will be developed in coordination with the **SCDOT**.

Figure 1-4b
Example Level 2 Signal Study Scope of Work (page 2)

References

Below are links to other pertinent documents for traffic signals:

FHWA Standards
Manual of Uniform Traffic Control Devices (MUTCD)
Traffic Signal Timing Manual, NCHRP Report 81

Signal Definitions
Definitions can be found in
MUTCD Sections 1A.13 and 1A.14
Traffic Signal Timing Manual, 1st edition

SCDOT Engineering Directives dealing with Traffic Signals

ED 2 Fiscal Responsibilities for Traffic Signals on the State Highway System

ED 19 Manual on Uniform Traffic Control Devices (MUTCD)

ED 33 Mast Arm Policy

SCDOT Traffic Engineering Guidelines dealing with Traffic Signals
TG-1 Street Name Signs on Signal Span Wires or Mast Arms

TG-7 Flashing Yellow Arrow Signal Heads

TG-26 Pedestrian Hybrid Beacon Guideline

TG-33 Rectangular Rapid Flash Beacon
Interim approval from FHWA is required; SCDOT must approve installation under encroachment permit.
TG-35 Business Rules for Signal Shops

Other SCDOT Manuals with Signal Information
SCDOT Maintenance Manual - Chapter 38
Access & Roadside Management Standards - Chapter 8
Roadway Design Manual - Chapter 9

Traffic Signal Equipment:
Qualified Product List (QPL)
Material Specifications for Traffic Signal Equipment

SCDOT Traffic Signal Construction Specifications
Supplemental Specifications SCDOT Traffic Signal Supplemental Technical Specifications
Special Provisions Form

SCDOT Traffic Signal Standard Drawings
675-000-00 - 699-000-00

Procurement Contracts in Place
State Fiscal Accountability Authority - Procurement Services

Signal Equipment Contracts
- Signal Heads *(use search criteria 'traffic signal')*
- Pedestrian Heads *(use search criteria 'traffic signal')*
- Pedestrian Push Buttons *(use search criteria 'traffic signal')*
- Cabinet Assembly *(use search criteria 'traffic signal')*
- Solar Flashers *(use search criteria 'traffic signal')*
- Blankout Sign *(Under SCEIS Contract Search use search criteria 'blankout')*
- Signal Cable *(use search criteria 'signal cable')*
- Steel/Concrete Pole *(Under SCEIS Contract Search use search criteria 'steel pole')*
- See **Chapter 5 Equipment** for more information.

Signal Software Contracts
- **Central Traffic Signal Software** *(use search criteria 'traffic software')*

See **Chapter 10 Signal Software** for more information.

Signal Construction/Maintenance Services Contract
- Fixed Price On Call Traffic Signal contract *(Under SCEIS Contract Search use search criteria 'signal')*

See **Chapter 7 Construction** for more information.

Signal Maintenance Partners
SCDOT Signal Maintainers - see **Chapter 8 Maintenance, Figure 8-1**
Local Government Maintainers - see **Chapter 8 Maintenance**, **Figure 8-2**

Signal Reports
Number of Signals Statewide By Maintenance see **Chapter 1 Introduction, Figure 1-14**
Number of Flashers Statewide By Maintenance see **Chapter 1 Introduction, Figure 1-15**

Signal Discussion Users Group
A signal group discussion forum on sharepoint has been developed for SCDOT and local government signal shop employees that maintain, operate, construct, and design traffic signals. This forum gives the signal shop employees the opportunity to stay involved and up to date on any issues pertaining to signal systems. This is a permissions enabled website for signal maintainers.

Enchroachment Permit Process
Encroachment Permit Process
Also, see **Chapter 7 Construction** for language to include in the Special Provisions portion of the Encroachment Permit for traffic signals to be installed under encroachment permit.

Online Signal Information Applications (Permissions enabled applications):
Integrated Traffic Management System (ITMS)
Traffic Engineering Asset Management Software (Signal Inventory Software Program)

INTERSECTION CONTROL OVERHEAD BEACON EXAMPLE

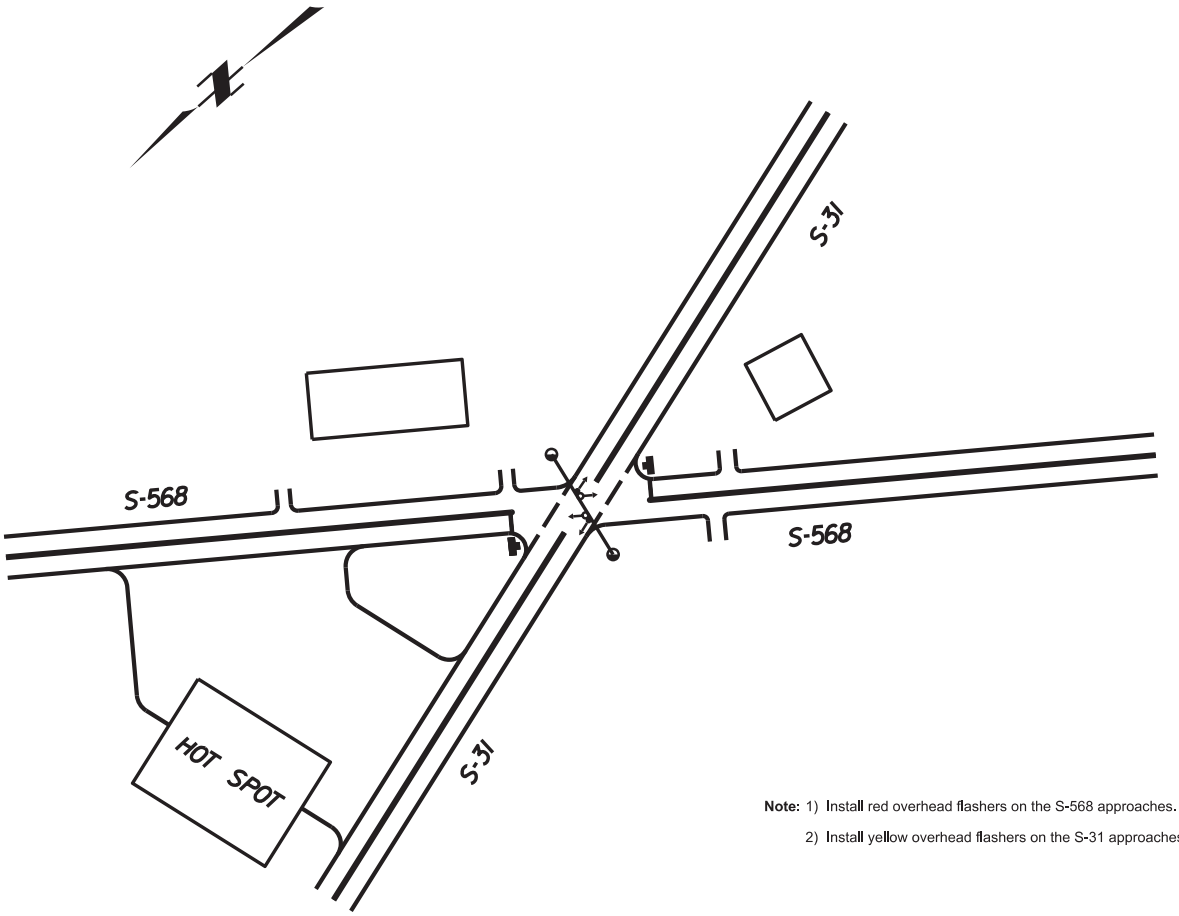
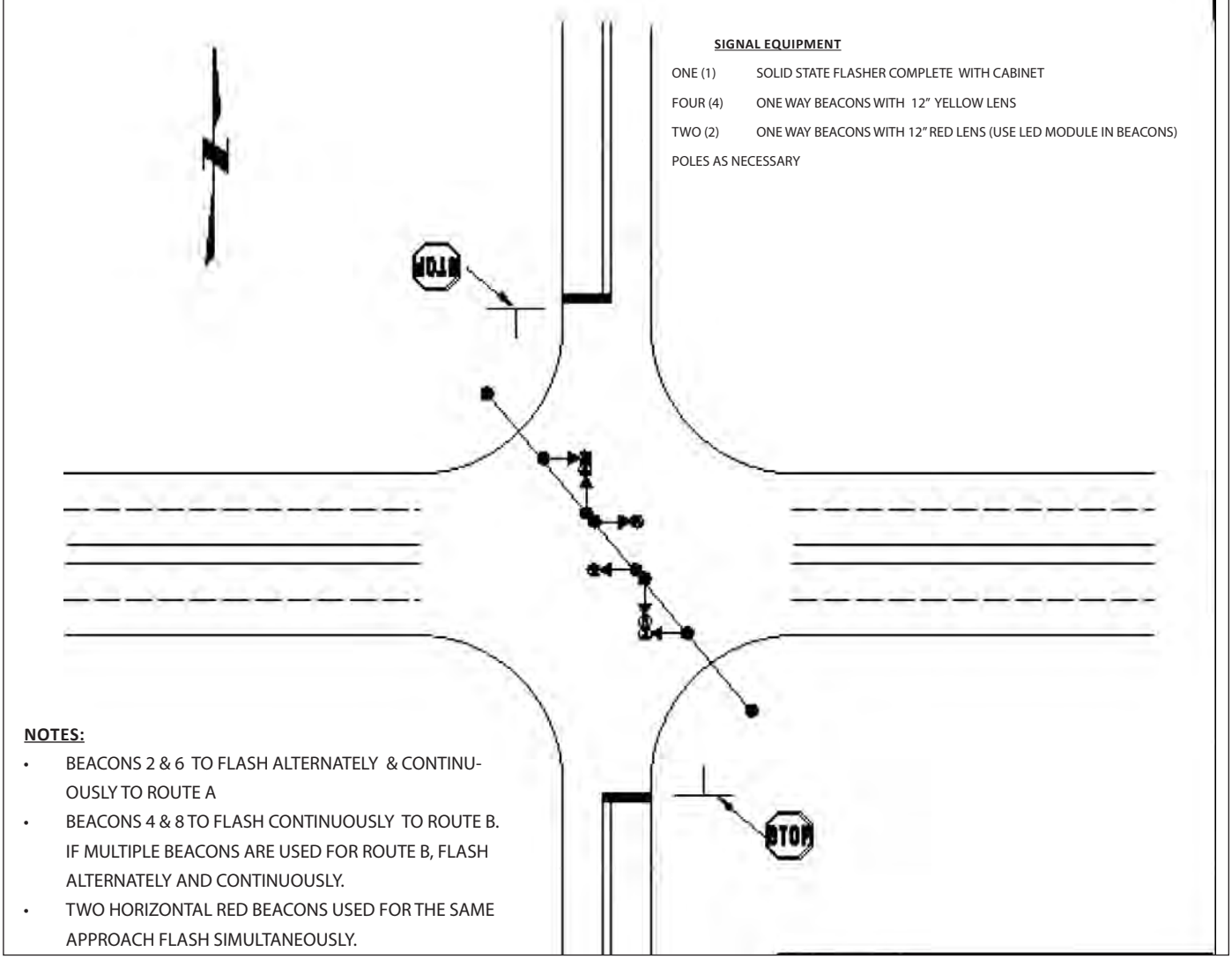


Figure 1-5a
Intersection Control Beacon

MULTI-LANE INTERSECTION CONTROL OVERHEAD BEACON EXAMPLE



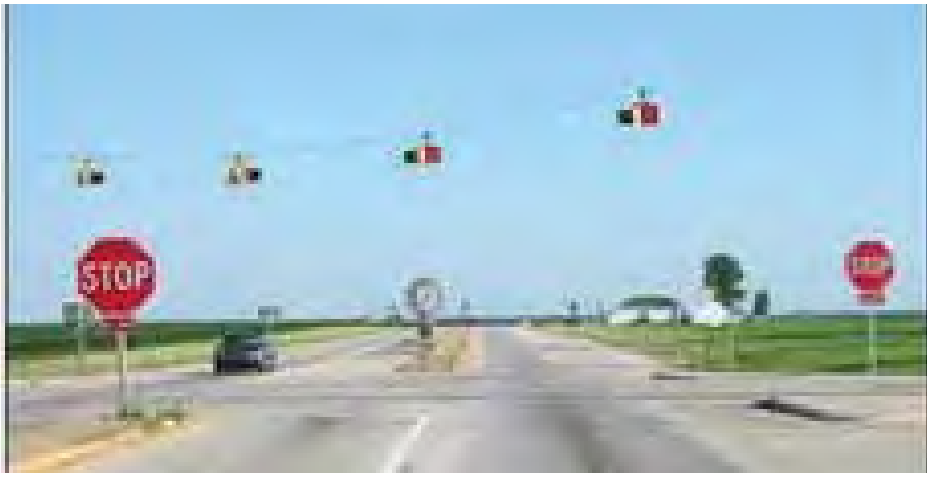


Figure 1-5b
Intersection Control Beacon - Multi-lane Roadway

INTERSECTION CONTROL OVERHEAD BEACON - ALL WAY STOP

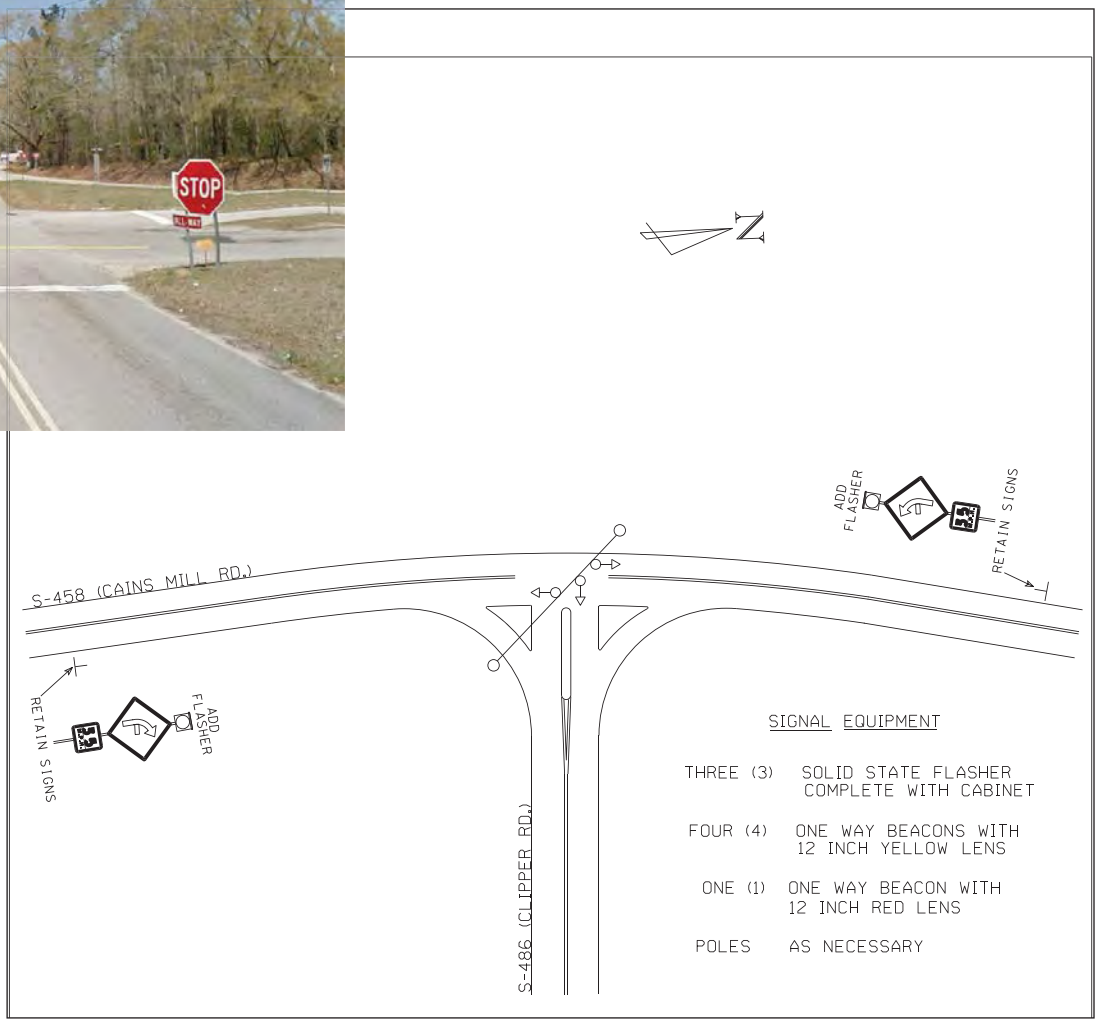


Figure 1-5c
Intersection Control Beacon- All way stop

REMOVAL OF INTERSECTION CONTROL BEACONS

Below is an example plan detailing the removal of overhead intersection control beacons.

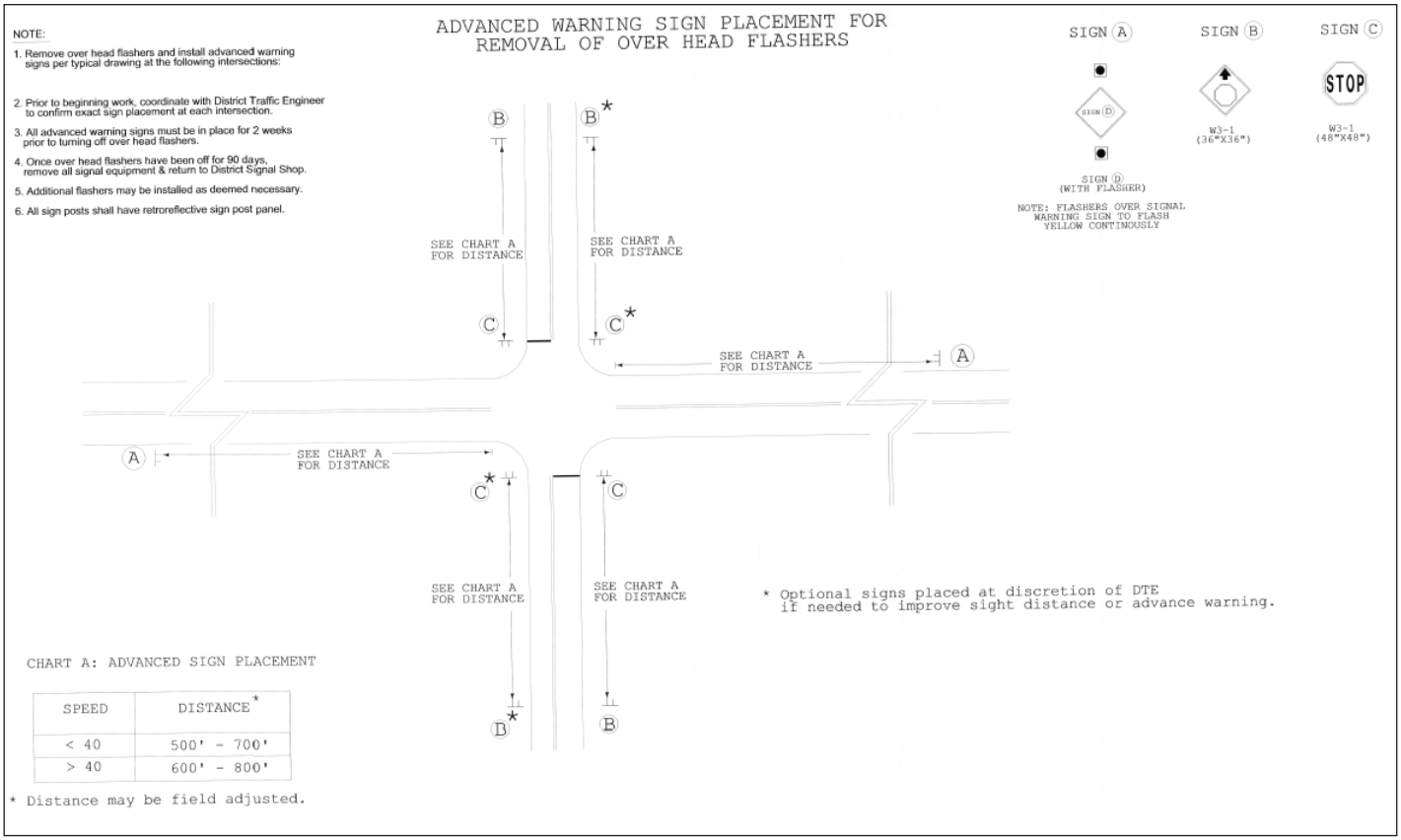
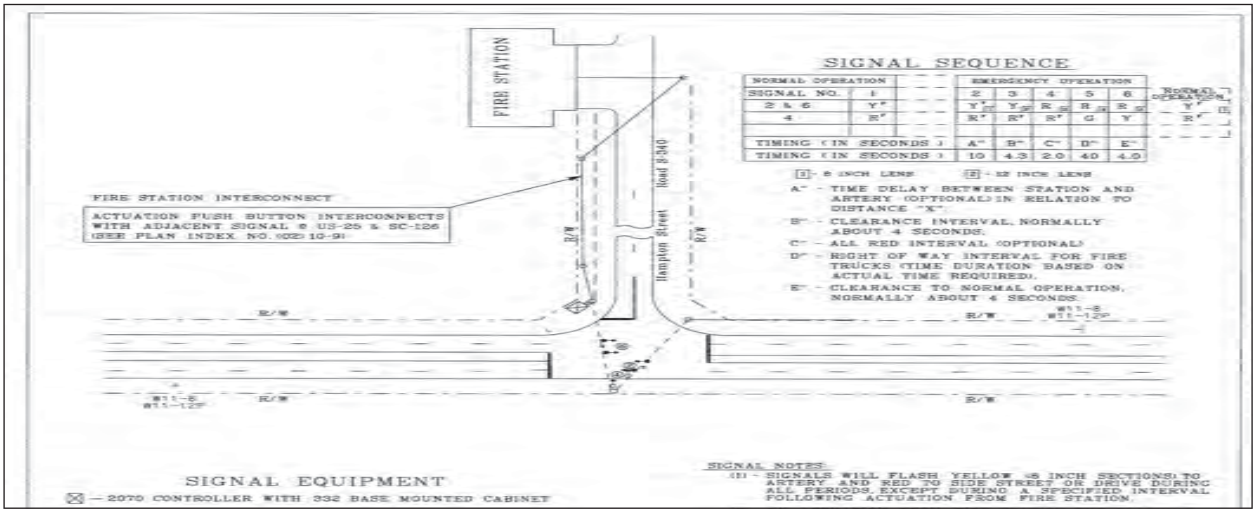


Figure 1-6
Removal of Intersection Control Beacon



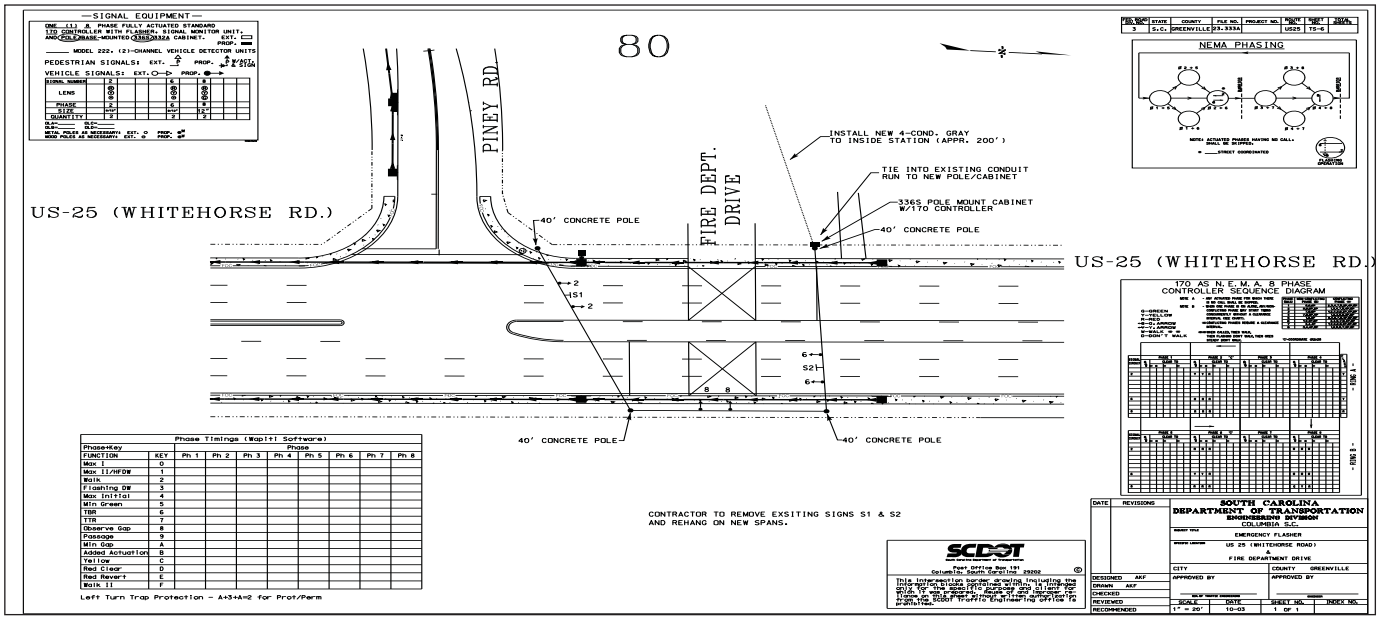


Figure 1-7
Emergency Signal

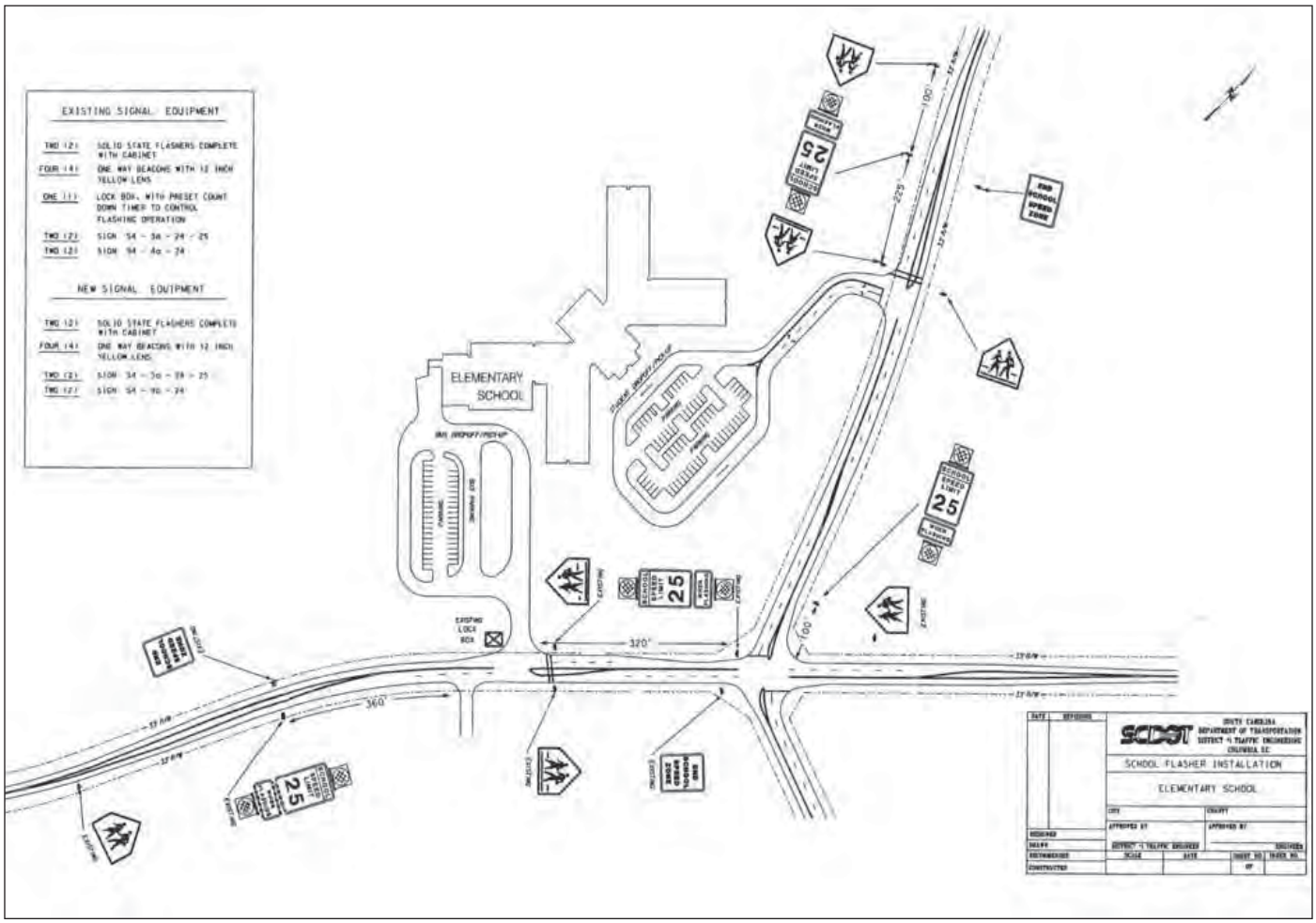


Figure 1-8
School Zone Flasher - Shoulder Mounted Beacons

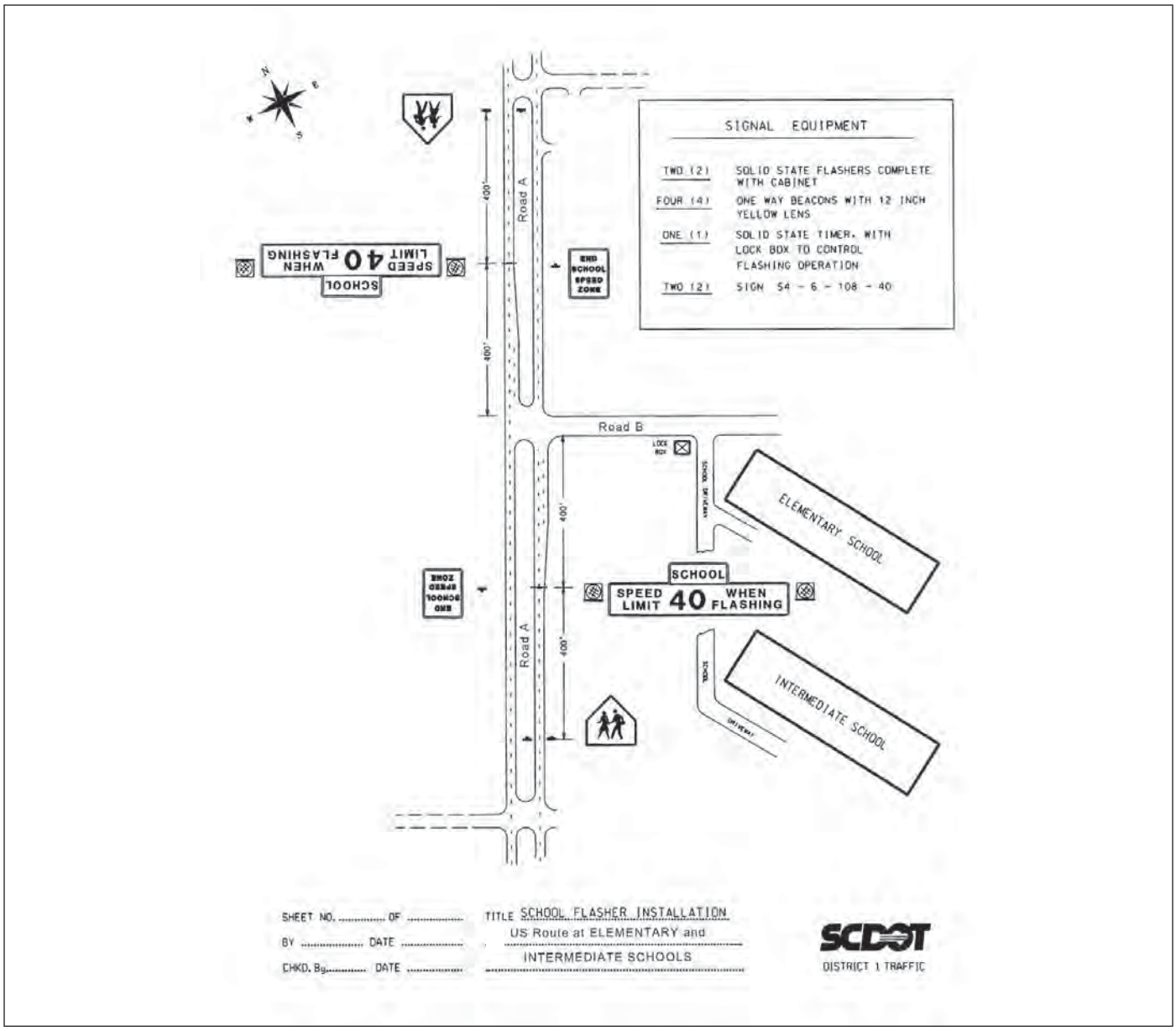
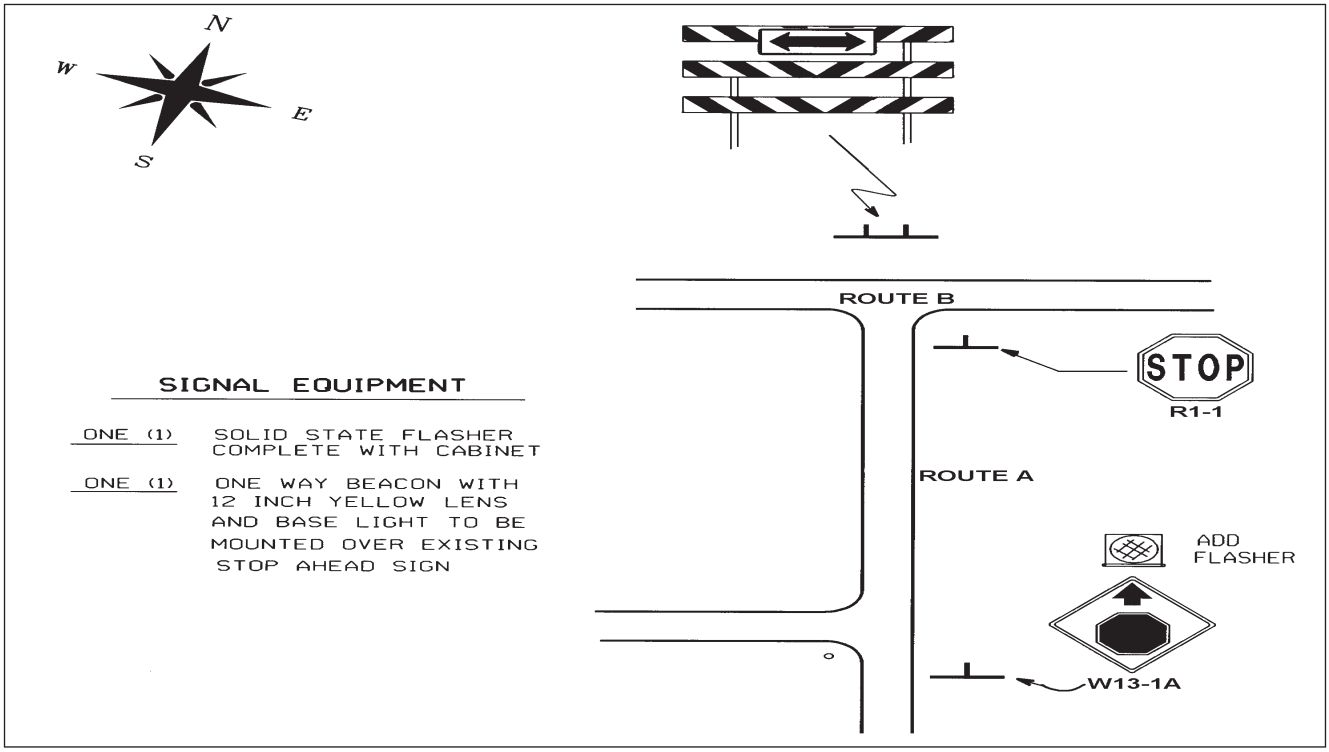


Figure 1-9
School Zone Flasher - Overhead Beacons

WARNING BEACON EXAMPLE

The flasher/beacon may be attached to the advanced warning sign depending on sight distance and engineering judgement on a case by case bases as shown below.



NOTE:

IN CASES WITH DUAL STOP SIGNS, DUAL STOP AHEAD SIGNS, OR BOTH; THE FLASHER SHOULD BE INSTALLED OVER THE SIGN LOCATED ON THE RIGHT HAND SIDE OF THE ROAD OR BOTH DEPENDING ON ENGINEERING JUDGMENT.

Figure 1-10
Warning Beacon

Typically the stop flasher/beacon is attached to the stop sign as shown below.

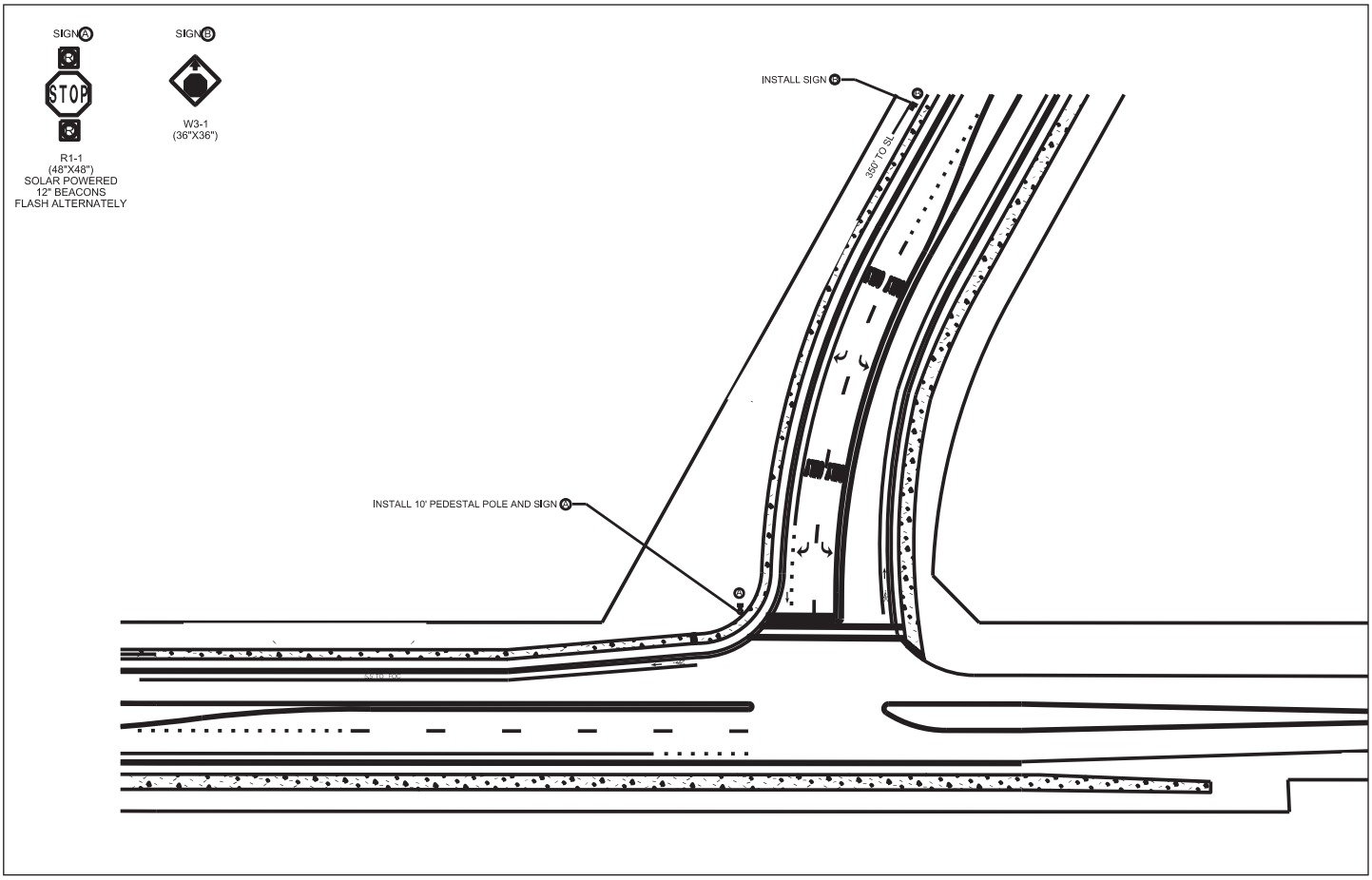


Figure 1-11
Stop Beacon

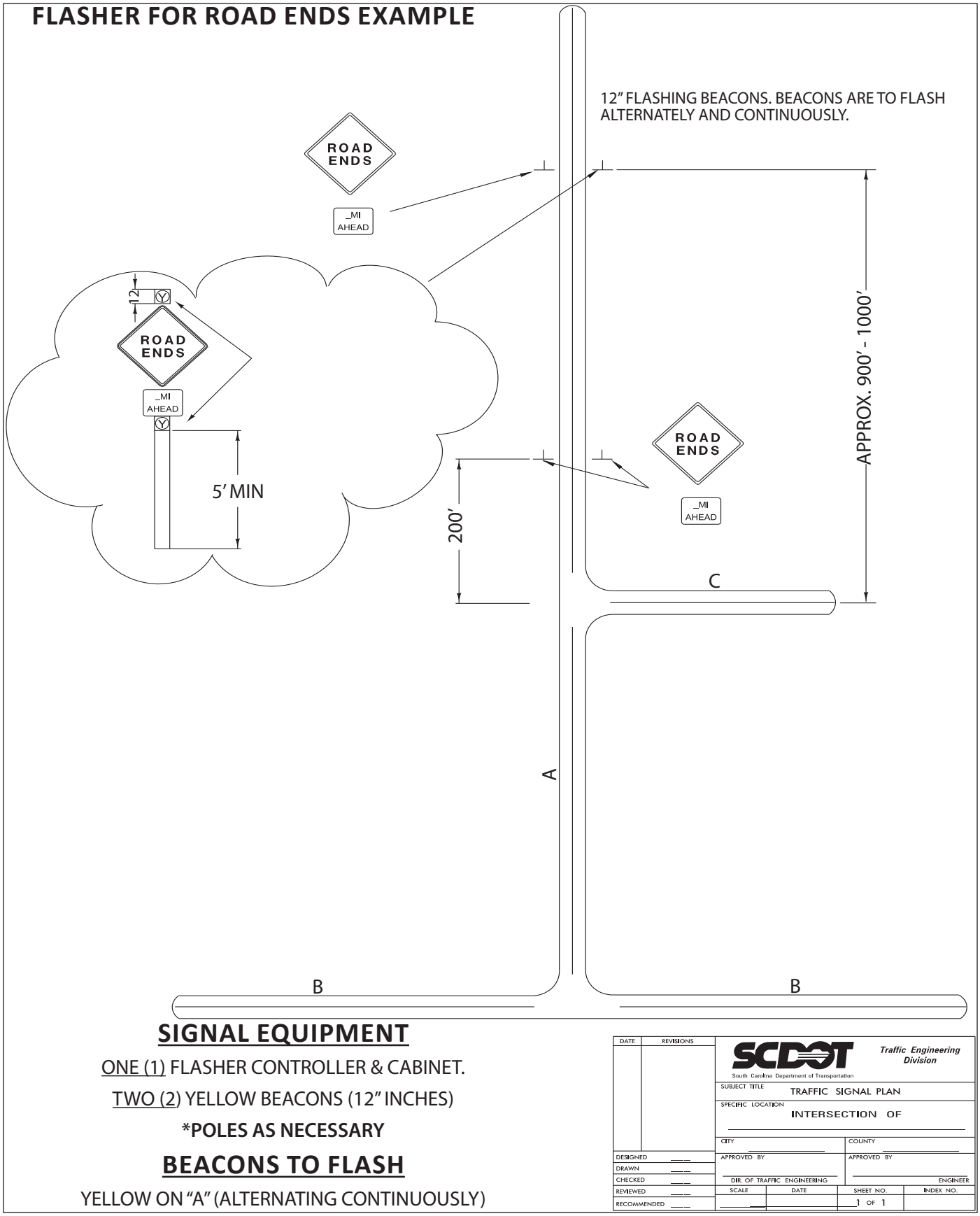


Figure 1-12
Road Ends Warning Beacon

Traffic Signal Inventory

The Director of Traffic Engineering is responsible for providing a traffic signal management tool to inventory and house pertinent stop & go signal and flashing beacon information. The TEAMS (Traffic Engineering Asset Management Software) program is available for use by both SCDOT signal maintainers and local government signal maintainers as a web-based program.

The districts and local governments participating in the signal maintenance agreement program are responsible for maintaining and updating inventory data in TEAMS for the stop and go traffic signals and flashing beacons.

Railroad Device Inventory – The Railroad Division of Traffic Engineering will maintain a statewide inventory of active railroad warning devices.

TEAMS (Traffic Engineering Asset Management Software)

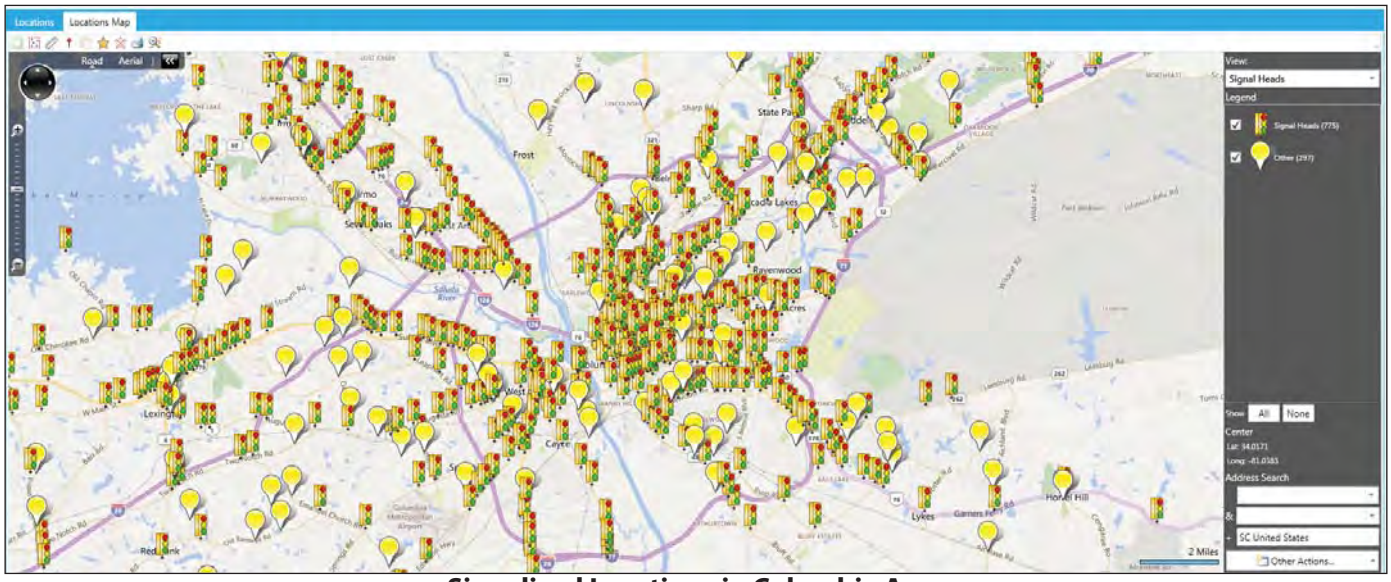
To comply with the ACT 114 requirement to rank projects needs in order of priority, SCDOT obtained software license for a comprehensive Traffic Signal Management Tool, called TEAMS in the fall of 2010.

- ***TEAMS*** - The TEAMS software consists of a web based inventory, preventative maintenance, troubleshooting, and work management software application that shares data with Integrated Transportation Management System (ITMS). TEAMS was developed with Microsoft Visual Studio 2013 and utilizes Microsoft's IIS Server. It is an N-tier web application utilizing Microsoft .NET 4.5.2, Silverlight, and web services in a Microsoft SQL Server 2012 environment.
- ***TEAMSLite*** - TEAMSLite is an HTML5 web application for mobile devices such as the iPad, Android Tablets, and Windows Surface Tablets. TEAMSLite is a field technician's version of TEAMS, and, as such, has some, but not all of the capability of the full version.
- ***TEAMS Off-Line*** - TEAMS Off-Line enables users to perform maintenance, inventory, inspections, etc. while disconnected from the internet. When the user returns to the office or any location with internet connectivity, the system can be brought back on-line allowing modifications to be synchronized with the TEAMS service. This capability is essential for users working in areas where there is limited internet availability. This version of the tool runs on Windows laptops or tablets such as the Windows 8 Pro devices.

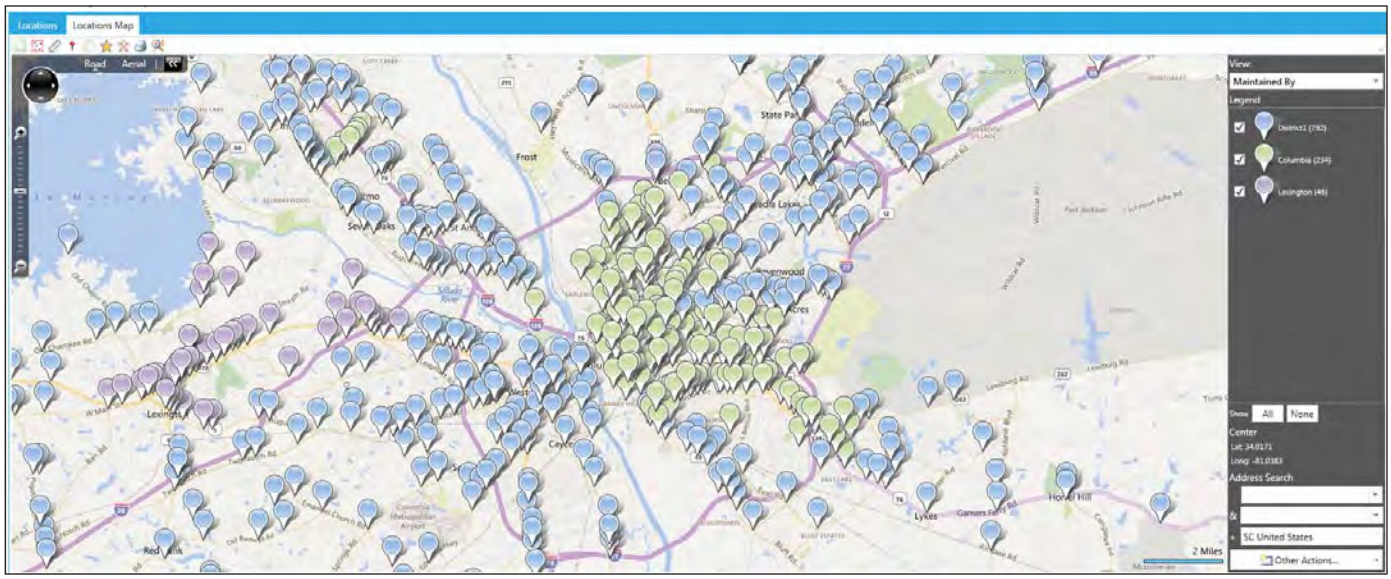
Signal Inventory History

On-site reviews and inventories were conducted in 2010-2011 to populate the TEAMS database. Signal Maintainers populated TEAMS with flasher information and signal system information.

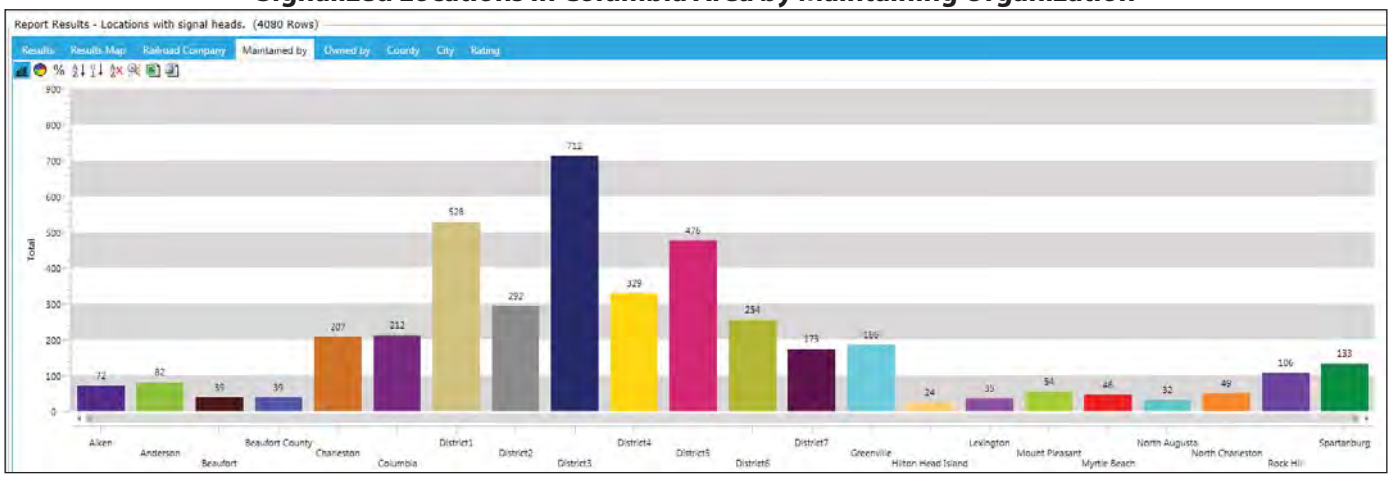
- TEAMS is an on-line application, accessible from any location via user name and password and an internet connection. TEAMS has an offline version for remote locations, providing the users cache the offline locations in advance. TEAMS also has a tablet version. Signal maintainers utilize air cards and laptops to operate and update TEAMS when changes are made to signals or when Preventative Maintenance activities occur.
- TEAMS is currently used:
    - as a storage location for signal plans, re-timing data and other pertinent information,
    - as a tool to recommend funding levels for signal maintenance, capital improvements for signal rebuilds, and for signal operations work,
    - as the mobile application to perform Preventative Maintenance reviews,
    - to identify the location of signal systems and the pertinent communications equipment associated with these systems,
    - to verify billing from power companies,
    - TEAMS data via ITMS can be used to scope signal work required within other projects (widening, resurfacing, safety, enhancements)
    - to create Standard reports and ad-hoc reports
    - as a warehouse for equipment not in use
    - for guest users



Signalized Locations in Columbia Area



Signalized Locations in Columbia Area by Maintaining Organization



Signalized Locations in SC by Maintaining Orgnization
Figure 1-13
Example TEAMS Information

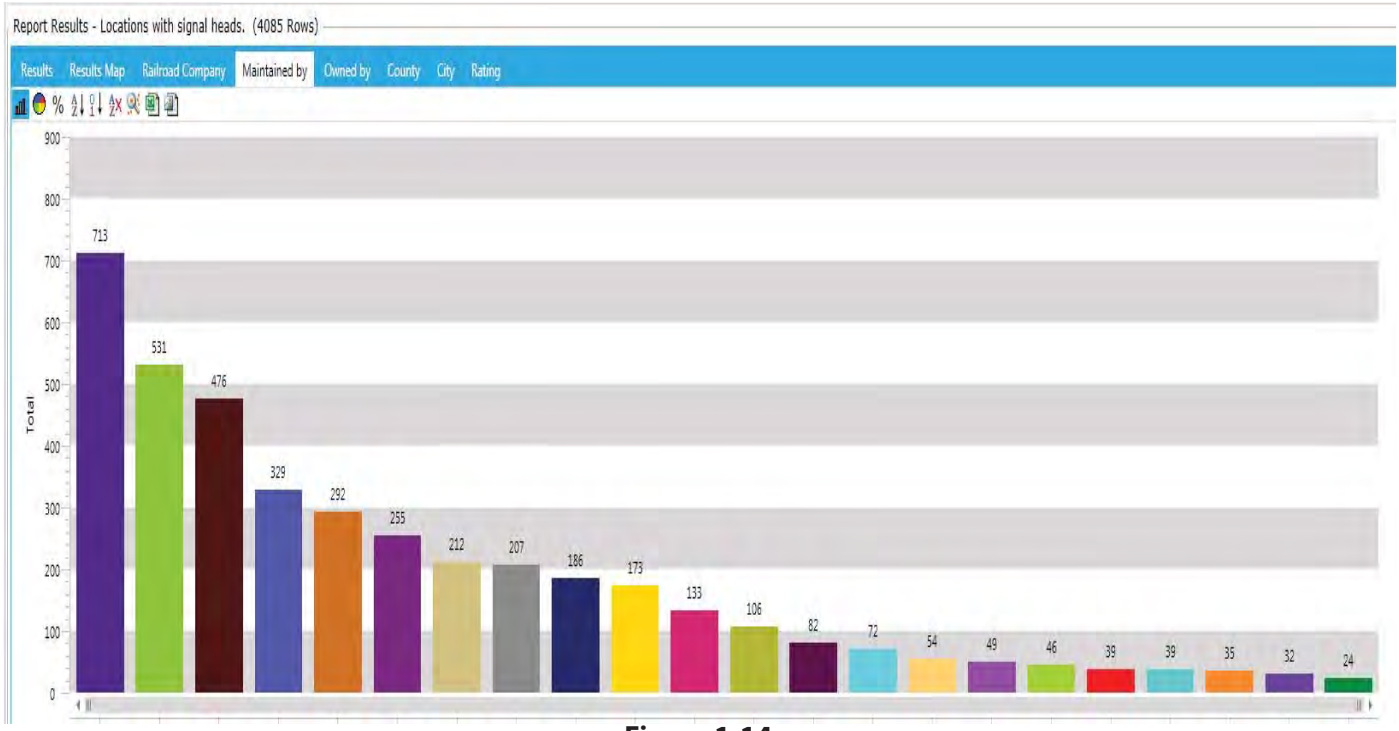


Figure 1-14
Number of Signals Statewide (by Maintaining Agency)
as of December 2018

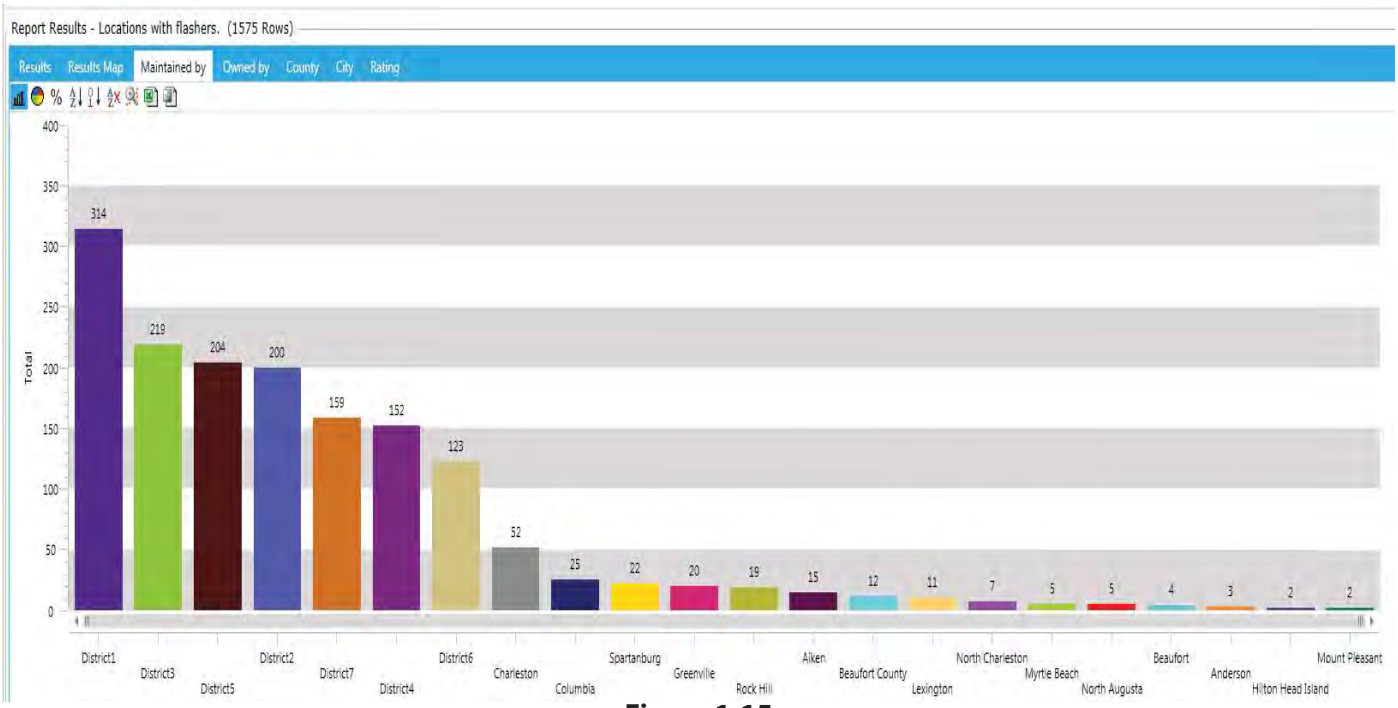


Figure 1-15
Number of Signals Statewide (by Maintaining Agency)
as of December 2018

CHAPTER 2

TRAFFIC SIGNAL PROJECT DEVELOPMENT

SCDOT

This chapter focuses on the management of the Traffic Signal Program. The TS&S Project Development Process is described below.

Signal Upgrade Program

The first step in developing a Signal Upgrade Program is to develop a statewide signal ranking process. This ranking provides a list of signals that are eligible for upgrade based on condition, traffic volumes and interstate proximity.

Signal Ranking

The statewide signal ranking process was implemented in 2013 based on the following information:

- Age of Equipment
- Proximity of Interstate
- Average Daily Traffic Volume

The Age of Equipment and Proximity of Interstate information was obtained from the Traffic Signal Inventory program, TEAMS . The AADT was obtained from ITMS. Flasher locations were not ranked.

Points were given to each location based on the following criteria:

Age of Equipment –

Age of Controller (in years) = AGE points

Age of Cabinet (in years) = AGE points

Proximity of Interstate – If a location is at a ramp = 2 points, otherwise = 0 points

Average Daily Traffic Volume – > 12,000 AADT = 2 points, otherwise = 0 points

Based on these factors, a statewide ranking has been developed. It was determined that, because the life cycle of a signal is 15 years, any signal with more than 15 points is a candidate for a rebuild.

For planning purposes, a 15-year life cycle is SCDOT's target for controller/cabling signal equipment replacement; 7.5 years for signal head replacements, and 30 years for signal support replacements. These are target life cycles for signals; however signal equipment may be older than 15 years and still in good operating shape. These life cycles are established as a planning tool for establishing needed funding. Based on these targets, SCDOT's signal upgrade program funding would exceed $22M annually.

Using the point system ranking, each District Traffic Engineer determines which signals are to be included in the annual Traffic Signal Upgrade project.

New signals are top priority and may be included in the project, if scheduling of project fits the signal installation schedule. New signals are often installed with state funds by on call contractors, since new signals are generally installed as soon as possible and cannot be subject to the possibility of delayed lettings and awards.

New Signal Systems are eligible for funding based on District justification. Signal systems are projects that include providing communications and special timings to operate signals that are in close proximity, generally on high volume arterials.

For Signal Upgrades (Rebuilds), District staff should include all the signals within their jurisdiction that are owned by SCDOT, including both SCDOT maintained and local government maintained signals. Close coordination with local government signal staff is necessary to ensure signals are appropriately chosen for upgrades.

Districts may chose signals that are not the highest ranking signals based on the following reasons:

- District staff has more specific knowledge of faulty or deteriorated signal equipment, which includes wiring, poles, or other equipment that is not considered in the ranking methodology; in this case there may be justification for including signals with less than 15 points.
- District staff may have a signal that requires more maintenance than normal due to poorly placed signal equipment; in this case there may be justification for including that signal in a project with less than 15 points.

- If an eligible signal is chosen and is part of an existing signal system or adjacent to a signal system, the District may provide justification for including improvements along the entire signal system as needed.
- Districts may include upgrades to flasher locations based on the condition of the equipment.

District staff may bypass high-ranking signals based on the following criteria:

- Railroad, utility or right of way issues are present that would add undue costs to the upgrade and require a lengthier project design.
- There is an upcoming project anticipated that will impact the signal.
- A resurfacing project is planned that will impact the signal detection.
- The signal may be considered for removal based on changes in side street traffic volumes.

In 2013, out of 3,942 signalized locations, there were 2,275 candidates with over 15 points, meeting the criteria for signal upgrades. The top 981 ranking candidate locations had 24 points or more.

Signal Funding

Funding for the Signal Upgrade Program is identified in the Statewide Transportation Improvement Program (STIP) and has been approximately $8M annually. Signal Upgrade Funding is allocated per district by percentage based on the number of signals in the district. This Signal Upgrade Program has been federally funded until 2016, but is currently state funded. Federal and state funds have different requirements for obligation and letting. TS&S Signal Program Managers will coordinate with Preconstruct ion Management to appropriately plan and schedule signal projects.

Preliminary Scoping

After determining the signals to be included in the project, HQ and District Signal staff should meet to preliminary scope this work. This meeting should determine the type of signal project activities. Signal projects may include a combination of Signal Activity Types. The Signal Activity Types are defined below and described in more detail later in this document.

Type 1 Signal Activities - Traffic Signal System Re-timing/Operational Improvements

Type 1 signal activities include any of the following timing improvements:

- **Time Of Day Re-timing** to include
  - Traffic count
  - Labor for re-timing by consultants/SCDOT
- **Responsive Re-timing** to include
  - Traffic counts
  - Labor for re-timing by consultants/SCDOT
  - Installation of additional detection
  - Performance Measuring devices (origin destination, travel time devices)
  - Operations tools (Traffic monitoring cameras)
- **Adaptive Re-timing** for systems maintained by SCDOT include
  - Adaptive Software services including software, detection design, implementation
  - Installation of additional detection
  - Performance Measuring devices (origin destination, travel time devices)
  - Operations tools (Traffic monitoring cameras)

Type 2 Signal Activities - Traffic Signal Upgrades

Type 2 signal activities include:

- New Installation
- Signal Rebuilds
- Signal Equipment Upgrades, such as adding pedestrian treatments, flashing yellow arrows;

Type 3 Signal Activities - Traffic Signal Communications Network Projects

Type 3 signal activities is typically implemented at signal system signals or isolated signals that require remote monitoring. Type 3 activities include all work necessary to place traffic signals on the communications network and can include the following:

- Design/testing/implementation
- Installation of communications between signals (fiber optic cable, wireless communications, and if necessary support poles, electric service, ITS cabinet, conduit, cable),
- Connecting to the Communication Network (cell modems, direct connect via network fiber), network devices (switches, server, firewalls)
- Performance Measuring devices (origin destination, travel time devices)
- Operations tools (Traffic monitoring cameras)
- This work may also include ensuring the Traffic Signal Network continues to operate properly.

The Signal Activity designation will assist in determining how the project will be implemented. Decisions will be made concerning who will perform Project Management, Engineering, Operations activities, how the Field Implementation will occur and if SCDOT will provide any Equipment or Software. Typical scopes and a discussion of project methodology is discussed in later in this document under "Types of Signal Activities". A general description is below:

- Type 1 and 3 Signal Projects can be implemented through the use of the On Call Signal Services and On Call ITS Services contracts. Type 1 and Type 3 Signal Projects utilize SCDOT staff and/or consultants to perform Project Management/Engineering/Operation activities, such as re-timing, field scoping, design, issuing work orders, field inspection. No work will occur outside the SCDOT right of way.
- Type 2 Signal Projects funded with federal dollars must be let to construction. Type 2 Signal Projects funded with state dollars may be let to construction or constructed utilizing On Call Signal Construction Services contract. Type 2 Signal Projects utilize SCDOT staff and/or consultants to perform Project Management/ Engineering/Operation activities, such as signal design, field scoping, letting package preparation.

STIP

The SCDOT Signal office will prepare and modify a rolling two-year plan of individual signal projects. A list of these projects will be provided to the Planning office that includes anticipated program amounts within each MPO area. The SCDOT Planning office will coordinate with the MPOs for inclusion of these projects in the relevant TIP. Modifications and adjustments to this plan will be routed to the Planning office on a regular interval in order to ensure consistency between the TIPs, STIP and programmed amounts. In addition, Lump Sum reports can be accessed through the eSTIP application to provide greater transparency to individual projects programmed against the lump sum STIP values. The list will be provided to the MPO's for inclusion in their TIPs.

Field Scoping

Scoping should address potential right of way or utility impacts, as well as signal design issues. Obtain right of way information prior to field scoping. This scoping process will provide improved scheduling and estimates during the final stages of the project development process.

- Utilities marked prior to field scoping; right of way staked prior to field scoping.
- Field scoping to include SCDOT staff and consultant design staff (HQ Traffic Engineering, District Signal Staff and/or District Utility Coordinator)
- A standard scoping form is shown in **Figure 2-1a,b**. This form should be kept in the project file to ensure concerns discussed during the scoping meeting are addressed prior to construction authorization.
- A field check list is shown in **Figure 2-2a-e**. The field checklist should ensure a thorough field review.

Utility Coordination:

The scoping will determine if attachment agreements or relocations are needed. Signal plans are not surveyed plans and are schematic in nature. The poles are not based on stationing and offsets. The base signal plan is generated from roadway plans, but utility locations are not identified on signal plans. When signal upgrade projects are developed, the design of said plans is based on utility locates and field visits with the signal maintainers to identify what poles need replacing based on height and type. SCDOT has been in the process of replacing all wood signal poles with steel or concrete signal poles for the past 10 years. Many existing signals attach to shared use poles and SCDOT prefers to attach to its own poles and to get off shared use poles. This is not always possible due to limited right of way. Ideally each signal should have 4 steel poles, one on each quadrant to make a box span for the signal heads. If a utility issue arises during construction that was not identified during scoping, this utility issue can generally be addressed by moving the pole, eliminating the pole replacement and reusing the existing pole, or installing a new pole on an existing foundation.

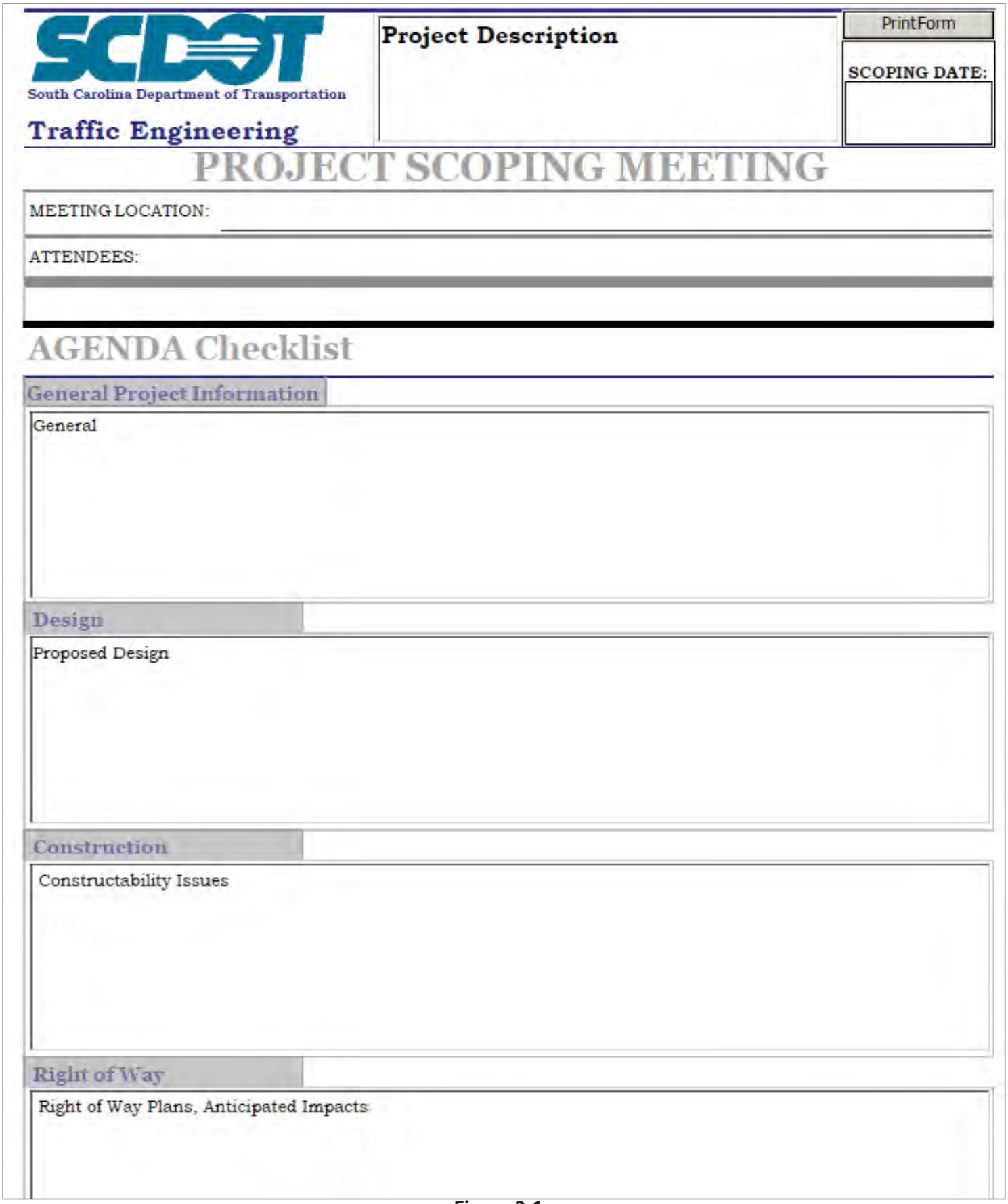
If there are utility conflicts identified during construction, the signal pole locations can be moved as the span wire does not have to be perpendicular to the roadway, as the signal heads can be adjusted for visibility. In many cases, if utility issues (overhead or underground) make installation of a new pole adjacent to an existing pole, unfeasible, we can simply reuse the existing pole. If a taller pole is needed, we can mount the taller pole on the existing foundation- as our foundation for steel poles is uniform for 28' or 32' steel poles. SCDOT prefers installing a new foundation, as that makes it easier to construct, but we do have that option if we can verify the existing foundation meets current specifications.

- During scoping, if any of the existing poles do not meet current electrical safety standards due to spacing and there is no room for a new pole, SCDOT will pursue obtaining a utility agreement to address those issues.
- If the existing signal is attached to a shared use pole and must re-use that pole instead of installing a signal pole, SCDOT will coordinate with that utility company during construction, as it is not a new attachment.
- Any new attachments to shared use poles will be identified during design and attachment agreements must be obtained prior to construction letting to be eligible for federal funding.

Federal funding will pay for utility expenses if they are addressed prior to the letting and any needed utility agreements will be in place prior to the letting.

If no utility conflicts are anticipated and options (relocation, re-using existing support pole, re-using foundation, reduction of work) are available to avoid unforeseen utility issues, the District signal staff will provide this information to HQ along with concurrence from District construction or utility personnel. Either the Director of Traffic Engineering or the State Utility Engineer will sign the utility certification as indicated below:

1. Based on the unique nature of signal projects and the flexibility to avoid utilities during construction, the utility certification can be signed by the Director of Traffic Engineering. However a comment will need to be added to the certification that "any additional costs or delays due to utility conflict during construction will be deemed federal-aid nonparticipating".
2. The State Utility Engineer can sign the certification, if all of the SCDOT Utility Departmentrequirements are met.



South Carolina Department of Transportation

Traffic Engineering

Project Description

Print Form

SCOPING DATE:

PROJECT SCOPING MEETING

MEETING LOCATION:

ATTENDEES:

AGENDA Checklist

General Project Information

General

Design

Proposed Design

Construction

Constructability Issues

Right of Way

Right of Way Plans, Anticipated Impacts

Figure 2-1a
Example Scoping Documentation (page 1)

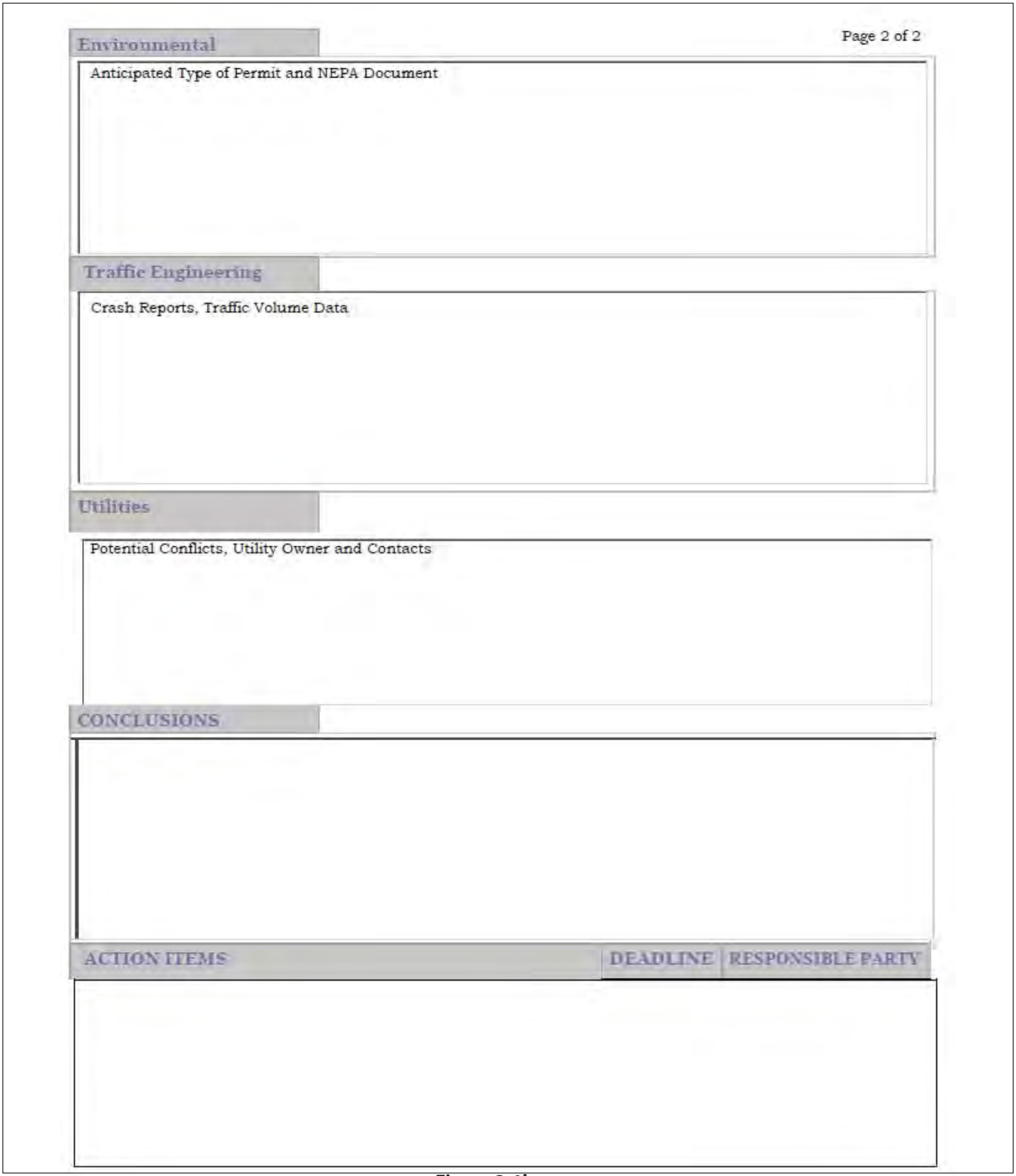


Figure 2-1b
Example Scoping Documentation (page 2)

Scoping - Signal Design / Field Review

		NE Quadrant 1	NW Quadrant 2	SE Quadrant 3	SW Quadrant 4
Right of Way	**Business / Landmark**				
	Existing *Note available r/w per Quadrant*				
	Proposed *Will additional r/w be needed*				
		NE Quadrant 1	**NW Quadrant 2**	**SE Quadrant 3**	**SW Quadrant 4**
Utilities	**Business / Landmark**				
	Existing *Note any issues with overhead or under ground utilities, as it relates to signal supports, span wire, mast arms, signal heads, and conduit; List and note on plan, utility company and types of utilities marked and observed*				
	Proposed *Ensure District Traffic, Construction, and Utility personnel are involved in reviews/ design decisions*				
	Are utilities marked during review?		Will attachment agreement be required? Will utility relocation be required?		

		NE Quadrant 1				NW Quadrant 2				SE Quadrant 3				SW Quadrant 4			
	Business / Landmark																
Signal Supports	**Existing** *Identify any issues with re-using existing poles, including necessary clearnance issues, height, maintenance, ADA issues* *If mast arms exist, identify who owns and maintains mast arms*	UTILITY				UTILITY				UTILITY				UTILITY			
		WOOD				WOOD				WOOD				WOOD			
		STEEL				STEEL				STEEL				STEEL			
		CONCRETE				CONCRETE				CONCRETE				CONCRETE			
		SINGLE MAST ARM				SINGLE MAST ARM				SINGLE MAST ARM				SINGLE MAST ARM			
		DUAL MAST ARM				DUAL MAST ARM				DUAL MAST ARM				DUAL MAST ARM			
	Proposed *IDENTIFY WHAT POLES ARE RE-USED, BY TYPE AND QUADRANT* *(IF RE-USING SHARED USE, COORDINATE W/ UTILITY DURING CONSTRUCTION)* IF MAST ARMS ARE PROPOSED, ARE THEY THE MOST FEASIBLE OPTION,; SEE CHAPTER 4 FOR MORE INFORMATION	Re-use	New	Height	Type	Re-use	New	Height	Type	Re-use	New	Height	Type	Re-use	New	Height	Type
					U				U				U				U
					W				W				W				W
					S				S				S				S
					C				C				C				C
					SM				SM				SM				SM
					DM				DM				DM				DM

	Type	Existing	Proposed	More info on Proposed
Span Wire	Box			**Re-use existing span wire?** (If re-using, existing span and replacing signal heads adjacent to existing signal heads, ensure span can accomodate both existing heads and new heads (bagged) during construction
	Modified Box			
	Other			**Replace existing span wire?** (If re-attaching to existing poles, ensure poles can accomodate both existing span and new span during construction)
	Identify any issues with existing span configuration that need correction			

Figure 2-2a
Example Scoping Documentation (page 1)

	Type/Location	Existing	Proposed	More info on Proposed	
Signal Cabinet	Quadrant			Re-use Existing cabinet	
	332 base mounted			Re-use Existing Cabinet Foundation, Install New Cabinet	
	336 base mounted			Install 2070 Controller / conflict monitor in Existing Cabinet	
	336 pole mounted			Install new cabinet & foundation	
	other type/ mounting			Install new cabinet on pole	
Electric Service	*Mounting location*				
	New Service or Modify Existing Service				
	Pedestal Mounting				
Grounding	*Ensure Traffic Signal Cabinet, Poles, ecetera are properly grounded.*				

	Type	Existing	Proposed	
Electric Cable *(The condition of the existing cable should be determined by signal maintenance staff)*		**Condition (Good, Replace)**	**Use all new cable**	**Re-use existing cable**
	Signal Head Cable (Black)			
	Pedestrian Head Cable (Black)			
	Detection Cable (Grey)			
	Pedestrian Button Cable (Grey)			

	Type	Existing	Proposed
Splice Box	Splice Box *Note location and size of existing on plans*		
	17x30x26		
	13x24x18		

	Type	Existing	Proposed
Pedestrian Treatments *(The designer must determine if pedestrian paths exist and/ or if typical pedestrian traffic should be expected, see Chapter 4)*	Are sidewalks present? If so, what quadrants?		
	Is curb and gutter present or shoulder section.		
	Are curb ramps in place? If so, describe condition and if DWS is in place)		
	Do channelized islands exist for right turn movement? Determine if pedestrian treatment should be placed in islands or if stop bar should be relocated to include right turn movement in signal operation.		
	Do medians impact pedestrian movement? If so, ensure modifications to median are included.		
	Are pedestrian buttons in place? What phases?		
	Are pedestrian heads in place? - What phases?		
	Are crosswalk markings in place?		
	Should existing crosswalk markings be removed or relocated?		
	Should pedestrian phase be exclusvie?		
	What signs are needed to address pedestrian issues?		
	Does two phase pedestrian crossing exist? Should two phase crossing be utilized?		

Figure 2-2b
Example Scoping Documentation (page 2)

		Existing												
	Type	1	2	3	4	5	6	7	8	other	OLA	OLB	OLC	OLD
Signal Heads	Note phases and number of signal heads													
	RYG 													
	RAYAYA- FYA permissive 													
	RAYAYAGA-FYA prot/permissive 													
	5 Section left turn 													
	RARAYAGA protected left turn 													
	RAYAGA protected left turn 													
	5 section right turn 													
	RYGGA-thru/left split phase 													
	RYAGA - split 													
	backplates													
	mast arm signal head mounting?													

		Proposed												
	Type	1	2	3	4	5	6	7	8	other	OLA	OLB	OLC	OLD
Signal Heads	Note phases and number of signal heads													
	RYG 													
	RAYAYA - FYA permissive 													
	RAYAYAGA-FYA prot/permissive 													
	5 Section left turn prot/permissive 													
	RARAYAGA- protected left turn 													
	RAYAGA protected left turn 													
	5 section right turn 													
	RYGGA- thru/left split phase 													
	RYAGA- split 													
	New backplates with reflective border?													
	Mast arm signal head mounting required?													
	Replace all signal heads or re-use?													
	If reusing heads, rewire or leave existing signal cable in place?													

Figure 2-2c
Example Scoping Documentation (page 3)

	Type	Proposed
Remove and Salvage	List items that will be removed/ disposed	
	List items that will be removed/delivered to signal shop	
	List # pole foundations to be removed 18" below grade	

	Type	Existing												
		1	2	3	4	5	6	7	8	other	OLA	OLB	OLC	OLD
Vehicle Detection	**Inductive Loop Detection**													
	Note phases													
	size (6x6, 6x10, 6x20, 6x30)													
	location (setback, stop bar)													
	quadrupole?, other													
	Video Detection Camera													
	Note phases													
	Mounting location / Number of Cameras													
	Single or Dual Processor													
	Wireless Detection													
	Note phases													
	detection zone size *(1 sensor=6x6, 2 sensors=6x10 or 6x20,3 sensors= 6x30)*													
	location (setback, stop bar)													
	Mounting location of Receiver													
	Mounting location of Antenna													
	Mounting location of repeaters													
	Type of System Existing													
	Radar Detection													
	Note phases													
	detection zone size *(1 sensor=6x6, 2 sensors=6x10 or 6x20,3 sensors= 6x30)*													
	location (setback, stop bar)													
	Mounting location of radar(s)													

Figure 2-2d
Example Scoping Documentation (page 4)

	Type	Proposed												
		1	2	3	4	5	6	7	8	other	OLA	OLB	OLC	OLD
	Inductive Loop Detection													
	Note phases													
	size (6x6, 6x10, 6x20, 6x30)													
	location (setback, stop bar)													
	quadrupole?, other													
	Reuse existing loops?													
	If re-using existing loops, new homerun or reconnect at cabinet?													
	For new setback loops, homerun is overhead on messenger or underground in conduit													
	Video Detection Camera													
	Note phases													
	Mounting location / Number of Cameras													
Vehicle Detection	Single or Dual Processor													
	Wireless Detection													
	Note phases													
	detection zone size *(1 sensor=6x6, 2 sensors=6x10 or 6x20,3 sensors= 6x30)*													
	location (setback, stop bar)													
	Mounting location of Receiver													
	Mounting location of Antenna													
	Mounting location of repeaters													
	Type of System Existing													
	Radar Detection													
	Note phases													
	detection zone size *(1 sensor=6x6, 2 sensors=6x10 or 6x20,3 sensors= 6x30)*													
	location (setback, stop bar)													
	Mounting location of radar(s)													

Figure 2-2e
Example Field Scoping Checklist (page 5)

Rail Road Coordination:
The scoping will determine if a normal right of entry permit is required or something more complex. Signal contracts include special provisions that address contractor responsibility for obtaining Rail Road permits (see attached), insurance and flagging.

- If the signal work is more complex than obtaining a simple right of entry permit (such as spanning over the Railroad or requiring conduit under the Railroad), SCDOT will perform initial reviews and coordination with the Railroad to determine what type of permit is required and what information is needed for the permit. This information will be included in the contract.
- If the signal work includes adding interconnection between the Railroad warning devices and the traffic signal for preemption, SCDOT will obtain this agreement from the Railroad prior to construction obligation.

Programming

Funding will be programmed by TS&S following a preliminary project scoping meeting. Cost estimates for engineering and implementation will be based on typical unit costs for design and signal upgrades.

- Signal Project Titles will generally include Signal Work Type, Location, Signal Activity Type and the word 'signal'.
- Signal projects will invoke the 100% Safety toggle option on the Details screen in FMIS Projects Module Project

Phases will be programmed as shown in **Figure 2-3**.

<table>
<tr><th></th><th>Type 1</th><th>Type 2</th><th>Type 3</th></tr>
<tr><td>Project Management /Engineering /Operations</td><td rowspan="3">Other Phase – Improvement Type 44 Other</td><td>Preliminary Engineering Phase – Improvement Type 15 Preliminary Engineering</td><td rowspan="3">Other Phase – Improvement Type 44 Other</td></tr>
<tr><td>Field Implementation</td><td>Road Construction Phase – Improvement Type 21 Safety
Engineering and Inspection Phase – Improvement Type 17 Construction Engineering
Utility Phase – Improvement Type 43 Utilities
Right of Way Phase – Improvement Type 16</td></tr>
<tr><td>Equipment/Software</td><td>Road Construction Phase – Improvement Type 44 Other</td></tr>
</table>

Figure 2-3
Programming by Signal Activities

Procurement
The following details the procurement metod for the various signal activities.

Type 1 Signal Activities - Signal System Projects

Project Management/Engineering/Operations

Project management and engineering services are provided by SCDOT staff and/or SCDOT On-Call Traffic Signal Consultant Contract (RFP selection) and SCDOT On-Call Traffic Count Contract. Examples of the necessary engineerring include signal re-timing, preparation of signal plans, traffic counts, quantities and cost estimates as well as verification of right of way and utility coordination.

Equipment/Software provided by SCDOT

Type 1 signal activities may require purchase of the following equipment/software by SCDOT upon issuing a Public interest Finding.

- *Network devices* necessary to place the traffic signal on the Traffic Signal Communications network are furnished by SCDOT IT Services. These network devixes are on state contract and may include Traffic Monitoring cameras. Wireless Broadband (WBB Radios) Radios, Network Equipment (Ethernet switches, routers, security), Cellular Communications, Leased Line Circuits. Network Equipment and cellular communications witll be configured by IT Services
- *Adaptive signal software and licenses* - SCDOT will furnish and install adaptive signal software and license via SCDOT's software and equipment state procurement contract.

Field Installation

Type 1 signal activities may require installation of equipment. The SCDOT staff or SCDOT On-Call Contractor Signal Services *(Fixed Price On Call Traffic Signal Services)* will be used to install equipment.

Examples of this work include:

- *Added detection* for operations of adaptive or responsive signal systems. This detection may include installation of inductive loops, wireless detection, video detection or radar detection.
    - Inductive loops require saw-cutting and installation of loop wire, electrical cable, conduit, splice boxes, messenger wire. Contractors will furnish and install all necessary wire and matreials necessary for inductive loops.
    - Wireless detection requires installation of flush mounted sensors within the roadway as well as equipment in the signal cabinet and overhead receivers. Cables must be installed from the receivers to the cabinet. Contractors will furnish and install wireless detection systems.
    - Video detection requires installation of equipment in the cabinet as well as cameras on signal poles. Cables must be installed from the cameras to the cabinet. Contractors will furnish and install video detection cameras.
    - Radar detection requires installation of equipment in the cabinet as well as radars on signal poles. Cables must be installed from the radar to the cabinet. Contractors will furnish and install radar detection.
- *Performance measuring devices* (Short Range Radio Device Detector) - These devices measure travel times in an ongoing bases based on blue tooth technology. The devicies require equipment in the cabinet and the radio detectors installed on signal poles, with cable connecting the devices and the signal cabinet. Contractors will furnish and install the performance and measuring devices.
- *Traffic monitoring cameras* may be needed for optimum signal operations, providing traffic engineers remote visual access to identify issues and make needed operational changes. Traffic monitoring cameras reuire installation of equipment in the cabinet as well as TM cameras on Signal poles. Cables must be installed from the cameras to the cabinet. Contractors will install traffic monitoring cameras provided by SCDOT.

Type 2 Signal Activities - Upgrades or New Installations of Traffic Signals

Construction Improvements (as identified by FHWA)

Type 2 signal activities includes design and construction improvements including installation of new cabinet assemblies, controllers, signal heads, detection, signal support poles, all necessary electric cable and conduit.

Project Management/Engineering /Operations
Project management and engineering services are provided by SCDOT staff and/ or by SCDOT On-Call Traffic Signal Consultant Contract (RFP selection). Examples of the necessary engineering include; signal design, preparation of letting package, right of way identification and utility coordination.

If Type 1 and /or Type 3 signal activities are included in the scope of the signal project along with Type 2 signal activities, SCDOT may utilize SCDOT On-Call Traffic Signal *Consultant* Contract to provide signal retimng and communications design services. SCDOT On-Call IT Services Contract (B-line, State procurement) may provide the following services; communications design, configuration, testing, implementation, troubleshooting.

Equiment provided by SCDOT
If Type 1 and /or Type 3 Signal Activites are included in the scope of the Type 2 Signal project, SCDOT will provide the following equipment equipment/software upon issuing a Public Interest Finding. These activities are programed as Road Construction Phase - Improvement Activity 44 Other.

- *Network* devices necessary to place the traffic signal on the Traffic Signal Communications network are furnished by SCDOT IT Services. These network devices are on state contract and may include Traffic Monitoring cameras. Wireless Broadband (WBB Radios) Radios, Network Equipment (Ethernet switch, routers, security), Cellular Communications, Leased Line Circuits. Network Equipment and cellular communications will be configured by IT Services.
- *Adaptive signal software and licenses* - SCDOT will furnish and install adaptive signal software and license via SCDOT's software and equipment state procurement contract.

Type 3 Signal Activities - Traffic Signal Communications Network Projects

Project Management/Engineering/Operations

Project Management and Engineering activities are provided by SCDOT staff, SCDOT On-Call Traffic Signa Consultant Contract and/or SCDOT On-Call IT Services Contract (B-line, State procurement). Engineering activities includes communications design.

SCDOT On-Call IT Services Contract (B-line, State procurement) may be utilized to provide the following services; communications design, configuration, testing, implementation, troubleshooting. Utility coordination activities and right of way identification are also necessary activities for project implementation. Coordination with District and local government signal maintainers and signal engineers is required to determine full scope of project.

Equipment provided by SCDOT
Type 3 signal activities may require purchase of the following equipmen/software by SCDOT upon issuing a Public Interest Finding.

- *Network devices* necessary to place the traffic signal on the Traffic Signal Communications network are furnished by SCDOT IT Services. These network devices are on state contract and may include Traffic Monitoring cameras, Wireless Broadband (WBB Radios) Radios, Network Equipment (Ethernet switches, routers, security), Cellular Communications, Leased Line Circuits. Network Equipment and cellular communications will be configured by IT Services.

Field Installation
Type 3 signal activities may require installation of equipment. The SCDOT On-Call Contractor Signal Services *(FIXED PRICE ON CALL TRAFFIC SIGNAL)* can be used to install equipment.

- *Fiber optic cable and connections* provide communications between signals and to the Traffic Signal Communications Network. Fiber may be installed overhead on messenger wire or underground in

conduit. Fiber installation requires splicing to the signal cabinets. Furnish and install pay items may include messenger wire, fiber cable, fiber interconnect center, factory terminated patch panel, conduit, splice boxes, possibly wood or steel poles. *Contractors will furnish and install all materials and equipment.*

- *Traffic monitoring cameras* may be needed for optimum signal operations, providing traffic engineers remote visual access to identify issues and make needed operational changes. Traffic monitoring cameras require installation of equipment in the cabinet as well as TM cameras on signal poles. Cables must be installed from the cameras to the cabinet. *Contractors will install traffic monitoring cameras provided by SCDOT.*
- *Wireless Broadband (WBB Ethernet) Radios* provide point to point communications as an alternative to fiber communications. Radios require installation of equpment in the cabinet as well as radios on signal poles. Cables must be installed from the radios to the cabinet.

  When these radios are installed between signals additional equipment is needed, such as cabinet enclosure, electric service/meter and possibly a signal pole. *Contractors will furnish and install all materials and equipment except the raidos. Contractors will install radios provided by SCDOT.*

Figure 2-4 summarizes procurment methods described above within a chart format.

TYPES OF SIGNAL PROJECT ACTIVITIES			
Type	**Type 1**	**Type 2**	**Type 3**
Activity Description, Funding Info	**Operational Improvements (Traffic Signal System Improvements, Traffic Signal Timing / Retiming)** ($500k annually PMO, Variable funding annually MPO, Interstate)	**Traffic Signals Upgrades/ New Signals (appx $8M annually PMO)**	**Traffic Signal Communications Network** (appx $1M annually PMO, Variable funding annually MPO)
Typical Scope	Retiming improvements are 1 of 3 types: **Time of Day (TOD), Responsive or Adaptive**; If signals are not on a communications network, TOD retiming efforts are not as effective, as they are difficult to monitor/ operate. Implementation of these timing systems may also include implementation of Traffic Signal Communications Network. **TOD Retiming** typically includes traffic counts/ consultant or SCDOT retiming efforts; Responsive and Adaptive Signal Systems require signals to be on a Communications Network. Implementation of these timing systems may include implementation of Traffic Signal Communications Network. **Responsive Retiming** typically includes traffic counts/ consultant or SCDOT retiming efforts, installation of additional detection if needed, and may include installation of origin destination devices and traffic monitoring cameras; **Adaptive Retiming** for systems maintained by SCDOT includes procurement of local controller software to communicate with SCDOT Owned Central Adaptive Software (Synchro Green), installation of additional detection, installation of origin destination devices, and may include installation of traffic monitoring cameras. Adaptive Retiming for systems maintained by local government - (if Synchro Green adaptive is utilized the scope is the same as for SCDOT maintained systems; if another adaptive retiming system is used, the system may be furnished and installed via construction contract.)	This work typically includes installation of new cabinet assemblies, signal heads, detection, signal support poles, all necessary electric cable and conduit.	This work is typically implemented at signal system signals or isolated signals that require monitoring. Communications Network Projects include all work necessary to place traffic signals on the communications network and can include the following: design of network by network services personnel, installation of communications between signals (fiber optic cable, wireless communications, installation of support poles, electric service, ITS cabinet, conduit, cable), communications to the network (cell modems, direct connect via network fiber) , network devices (switches, server, firewalls), communications devices for monitoring traffic (Pan Tilt Zoon (PTZ) cameras, origin-destination (OD) devices). This work may also include ensuring the Traffic Signal Communications Network continues to operate properly.
Project Management /Engineering /Operations	Engineering services provided by SCDOT labor or consultants, via on call consultant work order contract and on call count contract. ***P2S*** *Other Phase- Improvement Type 44 Other*	Engineering services provided by SCDOT labor or consultants, via on call consultant work order contract. ***P2S*** *Preliminary Engineering Phase-Improvement Type 15 Preliminary Engineering*	Engineering services provided by SCDOT labor, consultants via on call consultant work order contract, or on call ITS services contract. ***P2S*** *Other Phase- Improvement Type 44 Other*
Field Installation	Type 1 Implementation of detection and origin/destination devices are furnished and installed by on call signal contractor. ***P2S*** *Other Phase- Improvement Type 44 Other*	All signal improvements are implemented by low bid contractor via letting. All signal equipment is furnished and installed by contractor; SCDOT provides integration services to test and program the cabinet, controller & conflict monitor. ***P2S*** *Road Construction Phase- Improvement Type 21 Safety* *Engineering and Inspection Phase- Improvement Type 17 Construction Engineering* Utility Phase – Improvement Type 43 Utilities Right of Way Phase – Improvement Type 16	Type 3 Implementation is by on by on call signal contractor, SCDOT labor or on call ITS Services contract. Furnish & Install items by on call contractor would include fiber optic cable, Fiber interconnect Center / Fiber Patch Panel, support poles, electric service, ITS cabinet, conduit, cable. ***P2S*** *Other Phase- Improvement Type 44 Other*
Equipment provided by SCDOT	Adaptive local software is procured by SCDOT and implemented by vendor. If Type 3 Signal Activities are included, SCDOT may provide network devices for installation by contractor, including Traffic Monitoring cameras, Wireless Broadband (WBB Radios) Radios, Network Equipment (Ethernet switches, routers, security), Cellular Communications, Leased Line Circuits. ***P2S*** *Other Phase- Improvement Type 44 Other*	If Type 1 Signal Activities are required, SCDOT may provide Adaptive software licenses. If Type 3 Signal Activities are included, SCDOT may provide network devices for installation by contractor, including Traffic Monitoring cameras, Wireless Broadband (WBB Radios) Radios, Network Equipment (Ethernet switches, routers, security), Cellular Communications, Leased Line Circuits. ***P2S*** *Road Construction Phase- Improvement Type 44 Other*	Network devices are provided by SCDOT IT Services [including Traffic Monitoring cameras, Wireless Broadband (WBB Radios) Radios, Network Equipment (Ethernet switches, routers, security), Cellular Communications, Leased Line Circuits] and installed by on call signal contractor, SCDOT labor or on call ITS Services. SCDOT configures all network devices. ***P2S*** *Other Phase- Improvement Type 44 Other*

Figure 2-4
Procurement by Signal Activity

Public Interest Findings

SCDOT provides a Public Interest Finding for equipment and software provided by SCDOT within Type 1 and Type 3 Signal Activities.

SCDOT submits the following justification for the exclusive purchase and installation of state supplied Network equipment for Type 1 and Type 3 Signal Activities including; Traffic Monitoring cameras, Wireless Broadband (WBB Radios) Radios, Ethernet switches and cell modems. Ethernet switches and cell modems will be configured by IT Services.

As of January 2017, SCDOT owns 4093 traffic signals statewide. SCDOT maintains 2768 signals and local governments maintain 1325 signals under a Signal Maintenance Agreement with SCDOT. About half of these signals are in some type of signal system, meaning communications to the traffic signal is required for optimal operation.

Type 1 Signal Activities include installation of advanced technologies for traffic management. These advanced technologies require reliable communications to traffic signals. In 2010, SCDOT began the implementation of a highly secure end-to-end network architecture to optimize communication links and mobility services for traffic signal systems maintained by SCDOT. This infrastructure provides SCDOT with the necessary digital pathways to support new and emerging advanced technologies including traffic adaptive signal systems, traffic monitoring cameras, travel time detection devices, and Vehicle to Insfastructure (V21) communications.

In an effor to provide consistent network security for traffic signal systems statewide, regional traffic operations/ management and infrastructure that ensures advanced technologies can be utilized to improve traffic, SCDOT is crating a shared network infrastructure for local government partners that maintain our traffic signals (Traffic Signal Co-Location Network). This Co-Location network will provide SCDOT with a truly statewide communications netowrk that will allow end-to-end visibility for traffic signal system within the state of SC. Othe benefits to the Co-Location Network include uniform signal software updates and information storage, greater traffic operations support for local governments, and greater accessibility for SCDOT via traffic monitoring cameras on locally maintained signal systems.

SCDOT Network Services working with ATT and Cisco Systems have designed a network topology that will allow for secure multi-jurisdictional access statewide. The network provided a multipath backbone with true business continuity for the traffic engineering signals infrastructure.

It will support existing and emerging technologies such as 4G and 5G cellular, 10G backbone infrastructure and advanced firewall/security protection using next generation firewalls. This infrastructure will allow SCDOT TE to continue to expand and allow South Carolina to keep pace with the ever evolving transportation technologies of V21, Smart City, and autonomous vehicles.

1. SCDOT is currently operating a Traffic Signal Communications Network, designed, implemented and operated by IT Services at SCDOT. This network has been designed for statewide operations.
2. SCDOT procures the following Network equipment in accordance with Statewide Procurement Contracts (see following chart):
    a. Traffic Monitoring Cameras
    b. Wireless Broadband (WBB) Radios
    c. Network Equipment (Ethernet switches, routers, security)
    d. Cellular Communications, Leased Line Circuits
3. Since these Network devices are IP addressable and being connected to the SCDOT network, SCDOT Network Services are responsible for ensuring equipment and software meets SCDOT security protocols. SCDOT maintained signals reside on SCDOT network and use of these devices has been tested and approved by SCDOT Network Services to reside on the network. Due to the ability to operate traffic signal equipment remotely, security is at the forefront of concern.
4. Each of these devices has software that currently resides on the network. SCDOT IT Services has been trained to operate and configure these devices. SCDOT has access to replacement parts and equipment repairs, therefore there is less of a learning curve for SCDOT staff to operate and install these devices.

5. SCDOT will receive savings by not having to purchase multiple replacement parts for each network device.
6. Procurement of these Network Devices includes vendor support and warranty, which makes it more beneficial for SCDOT to purchase directly from the vendor.
7. Contractors are not currently qualified to configure and integrate any Network devices. Contractors can install video detection cameras and Wireless Broadband Radios that have been configured by IT Services. Ethernet Switches and Cell modems must be installed by SCDOT staff.

With this agreement, it is SCDOT's intent to continue to procure this equipment for the foreseeable future as validated by SCDOT IT Services and SCDOT Traffic Engineering staff. Pursuant to agreement execution, SCDOT will continue to procure these products off of state procurement contracts in future projects.

Letting Package

If the Signal Project is to be let to construction, the following information should be packaged and provided to the Letting Preparation office in accordance with SCDOT scheduling (See **Chapter 4** for additional information):

- Signal Plan Set including Cover Sheet, Quantity Sheet and Signal Plans
    - Plans should be sealed consistently, meaning they all have electronic seals or they all are signed by hand; if they are signed by hand, the Letting Preparation Office requires the original sealed plans.
- Pay item quantities and cost estimates
- Traffic Signal Special Provisions, Traffic Signal Special Provisions for Maintenance of Traffic, Railroad Special Provisions (if applicable)
    - The SCDOT Traffic Signal Supplemental Technical Specifications have been approved by FHWA and are automatically included in all construction projects where traffic signals are included.

CHAPTER 3

TRAFFIC SIGNAL COMMUNICATIONS NETWORK

SCDOT

Traffic Signal Communication Types

Traffic Signal Communications activities are classified as Type 3 Signal Activities.

Traffic Signal Communications has changed over the past 10 years to include the following types:

- *Time based coordinated* – no communications between signals. The signals are not physically connected, but instead use the internal clock to time the coordination. Although this is the least costly method, drifting can occur, resulting in the signals being out of sync, and requiring a visit to each signal to make timing adjustments. Signals served from different power sources have a greater tendency to drift.

  Any signal not connected to adjacent signal can get out of sync resulting in reduced progression. In addition, without being on SCDOT network, the signal clocks can drift resulting in going into and out of coordination late or early.

- *Interconnected no communication* – signals have communications between signals but are not connected to SCDOT network. Signals are connected using hard wire, in the form of a copper interconnect, serial radio or fiber optic cable. Typically the most critical signal within the system is established as the master controller, from which changes to the other signals can be made.

  These types of systems are not easily managed, reviewed and operated. Changes must be made in the field and without communications, no remote viewing can occur.

- *Interconnected with communications* – signals have communications between each other and to the network ; There are 3 types of communications to these signals:
  - Dial up- can be implemented on copper or fiber communications- slow, obsolete and being replaced
  - Serial – can be implemented on copper, serial radio or fiber communications- generally interconnected directly into signal server;
  - Ethernet - signals are on a Communications Network provided by SCDOT and IP addressed. Constant communications with signal equipment is available.

Since 2010, SCDOT has been converting all signal system communications to Ethernet and connecting these signal systems to the SCDOT Communications Network.

SCDOT Communications Network

The SCDOT Communications Network is ultimately the responsibility of SCDOT IT Services, (Network Services) Some of the tasks involved in operating the SCDOT network include design, installation, security, operations, updates, and maintenance. The SCDOT network is interdependent on fiber installed, operated and maintained by signal maintainers and ITS maintainers; these users rely on the Backbone Network operated and maintained by IT Network Services.

The HQ Backbone network supports the following 3 networks:
SCDOT Business Communications Network – Network Services (IT Services) installs, operates and maintains communications network serving all SCDOT offices statewide. Part of this network pathway follows the ITS Communications Network and then along the interstate as well as ...

Integrated Traffic System (ITS) Communications Network – ITS (Traffic Engineering) installs, operates and maintains fiber along the interstates as well as the hubs that provide pathways to the business network and to the signal communications network. Federal funding is obtained through a statewide program, and Metropolitan Planning Organization programs as well as individual projects for specific interstate upgrades.

Traffic Signal Communications Network
There are two networks for Traffic Signals:

- ***SCDOT Network for SCDOT-maintained signals***
  SCDOT maintained signals within systems are connected to the SCDOT Network by direct fiber, wireless or cellular communications. Selected isolated signals are connected to the SCDOT Signal Network by limited data cellular communications.

- ***Co-location Network for SCDOT-owned signals maintained by local governments via Signal Maintenance Agreements***
  Local government maintained signals within systems are connected to the Co-Location Network by direct fiber, wireless or cellular communications. Selected isolated signals are connected to the Co-Location Signal Network by limited data cellular communications. The Co-Location Network was developed by SCDOT working with ATT and Cisco Systems to design a network topology that will allow for secure multi-jurisdictional access statewide. The network provides a multi-path backbone with true business continuity for the traffic engineering signals infrastructure.

The benefits of the Traffic Signal Communications Network are:

- Replaces obsolete dial-up technology
- Enables instant, online access to signal systems from any location that has internet access
- Allows installation of real-time video for monitoring operations
- Facilitates performance-measuring technology
- Can reduce unnecessary trips to remote locations
- Allows adaptive signal technology to be implemented
- Facilitates the Traffic Signal Software upgrade to virtual servers (better backup and security than physical servers in 7 districts)
- It will support existing and emerging technologies such as 4G and 5G cellular, 10G backbone infrastructure, advanced firewall/security protection using next generation firewalls.
- This infrastructure will allow SCDOT Traffic Engineering to continue to expand and allow South Carolina to keep pace with the ever-evolving transportation technologies of V2I, Smart City, and autonomous vehicles.

In addition to the above, the benefits of the Traffic Signal Co-Location Communications Network are:

- Provides SCDOT access to locally maintained signal systems,
- Provides opportunity for regional traffic operations and management
- Provides consistent network security protocols statewide
- Provides a statewide communications network that provides end-to-end visibility for traffic signal systems
- Provides uniform signal software updates for signal software
- Provides secure and standard signal data and information storage
- Provides SCDOT a better opportunity for increased traffic operations support to local governments
- Provides SCDOT better accessibility to traffic monitoring cameras on locally maintained signal systems.
- Provides local government with access to a signal network maintained, operated and installed with SCDOT funding. Local government IT staff are not required to maintain the signal network.

Prior to implementing the Co-Location Network, a Memorandum of Understanding (MOU)must be executed by both SCDOT and the Local Government, detailing the project, funding and responsibilities. Included in this MOU is a security protocol agreement and a fiber sharing agreement .

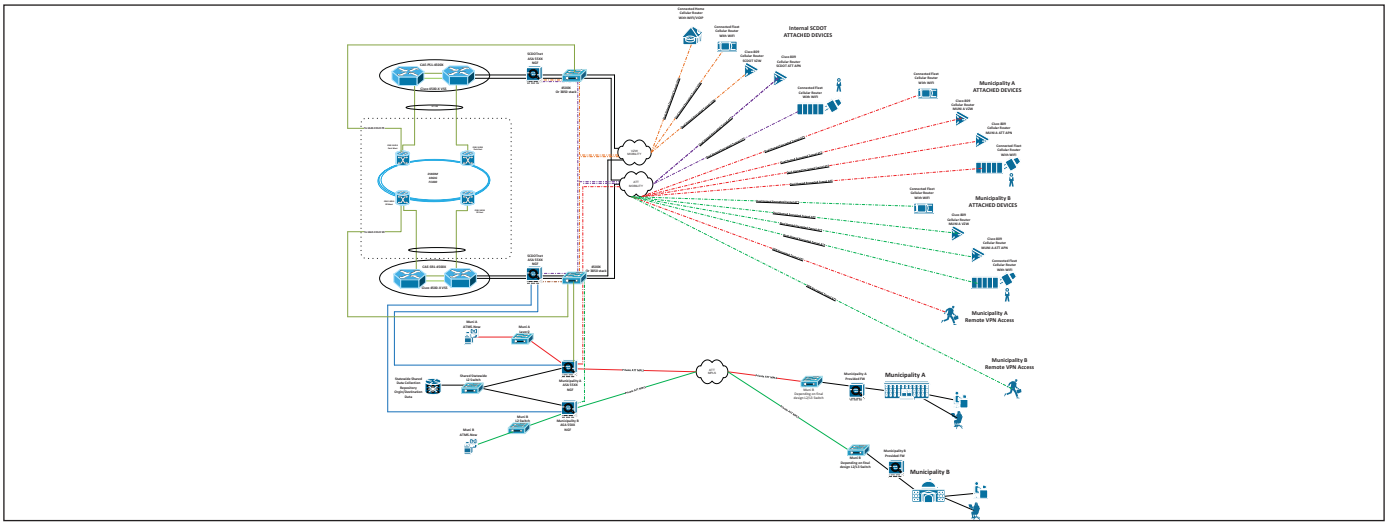


Figure 3-1
Example Co-Location Network

Traffic Signal Communications Network Project:

- Planning/Design tasks needed to effectively expand network
- Identify state of existing fiber through Optical Time Domain Reflectometer testing
- Design network to accommodate needed tools such as real time signal operations & management, Pan Tilt Zoom monitoring cameras, adaptive, and Origin-Destination devices
- Identify network needs for accommodating the traffic signal communications network

Expansion tasks projected:

- Installation of fiber or wireless communications
- Installation of Ethernet equipment such as switches, and cell modems by IT Services staff
- Installation of Co-Location Networks

Operations tasks projected to sustain peak system performance:

- Provide ongoing training for signal systems operations
- Add operations tools to network, including PTZ monitoring cameras, adaptive, and Origin/Destination devices
- Upgrade existing communications equipment to meet industry standards
- Reconfigure existing devices to meet changing security protocols
- Identify and troubleshoot communication interruptions to assure peak performance
- Maintain communications (fiber/ fiber splices, wireless communications) in operating order
- Obtain needed equipment to expand and perform on-going communications operation
- Funds recurring costs for Co-Location Network and Traffic Signal Network

Communications Network Implementation

When using Federal funds, FHWA has approved using competitively-bid-on-call procurement services contracts to expand the Traffic Signal Communications Network by installing fiber or wireless communications to add signals to this network. See **Chapter 2** for information in developing and implementing Communications projects (Type 3 Signal Activities).

Funding

The following funding sources have been used for the Traffic Signal Communications Network:

- MPO/COG funding - Federal funds
- SCDOT Program Funds - Federal or State funds
- SCDOT Roadway projects including safety projects, roadway projects- Federal or State funds
- Local Option Sales Tax (LOST)- local funds
- County Transportation Committee (CTC) funds - state funds
- Encroachment Permit - private funds

Funding Eligibility

The capital and operating costs for traffic and traveler information monitoring, management, and control facilities and programs are eligible under National Highway Performance Program (NHPP) and Surface Transportation Program (STP). Federal Highway Administration Operations guidance provides examples of eligible operating costs and expenses.

- In order to assure continuous operation, costs associated with maintaining these systems are necessary operating expenses for traffic monitoring, management, and control facilities and programs provide their intended functions. Examples of these maintenance costs include system maintenance activities to assure peak performance (preventive computer maintenance) and replacement of defective or damaged computer components and other traffic management system hardware (including street-side hardware).
- With a greater shift toward applying technology to addressing transportation needs, a broader life-cycle view of transportation operations is warranted that includes all activities related to sustaining system performance.

Based on this guidance, the following items are eligible for federal funds:

- Expanding and upgrading the traffic signal communication network
- Operations of the network to sustain system performance
- Trouble-shooting and repairing communications issues to assure peak performance

SCDOT Security Protocols

Network Security is a important to preserve the integrity of SCDOT's network. SCDOT's security protocols are established by SCDOT IT Services. SCDOT's security protocol is applicable to any devices attached to SCDOT network or Co-Location network.

SCDOT Duties for Traffic Signal Communications Network

Legal

- Prepares Co-Location and Fiber sharing agreements

Network Services

- Provides project approval from State IT Planning
- Provides network design architecture in accordance to industry standards
- Provides network IP addressing for networkable components. (Note: Network Services is the sole administrator of all IP addresses residing on the SCDOT network)
- Provides testing and verifies configuration requirement standards
- Provides detailed work plans along with updated field 'as built' drawings for each system implemented. Provide file location and access to district personnel assigned to maintenance of systems
- Provides OTDR Test for SCDOT owned fiber prior to installation and provides test result documentation to district
- Provides training to districts/statewide staff during initial system installations
- Provides system monitoring access for assigned district/statewide support staff
- Provides tel-alert to technical staff where available, i.e. email, cell phone, text, etc.
- Provides Service Documents for phone support direct to the Network Operation Center during normal work hours or emergency third level support after hours
- Provides equipment for Ethernet connections, including current and future specifications, software updates, and spares
- Provides IT vendor maintenance and maintains vendor maintenance contracts
- Provides SCDOT IT purchase approvals through approved equipment contracts
- Orders and maintains circuits needed for remote system location
- Provides private secure cellular service where designed
- Provides network security along with rules and regulations
- Will set up and maintain a virtual central signal software system

Information Security

- Provides network security protocols
- Assists in reviewing network equipment to meet security protocols
- Develops agreement language for Co-Location Networks to address security responsibilities

Traffic Management -Intelligent Transportation Systems (ITS)

- Provide dark fiber at interchanges to a point of presence (POP)
- Ensures fiber connections are maintained and operational from fiber on interstate to POP
- Provides fiber sharing opportunities for local government Co-Location networks
- Hosts traffic monitoring cameras at signals on Pal Guide for emergency responder access only

Traffic Signals & Systems (TS&S)

- Manages Traffic Signal Communications Network projects, including annual operations and maintenance projects, expansion projects and Co-Location projects
- Coordinates with District and Local Government Signal staff for project implementation
- Develops statewide plan for Traffic Signal Communications Network and how it can be utilized to manage and operate signals, including how to utilize new technologies
- Provides troubleshooting for signal software
- Provides first line of assistance to district personnel for problem solving

District Traffic Engineers/Signal Superintendents/Local Government Signal Maintainers with Co-Location

- Operates signal systems communications including replacing switches as needed with annual Traffic Signal Communications Network funding managed by TS&S
- Monitors systems monthly ensuring communications is active
- Ensures communications (fiber and/or wireless) is maintained with annual Traffic Signal Communications Network funding managed by TS&S

Co-Location Servers

There are a variety of software applications housed on the Co-Location Network, for ease of accessibility among SCDOT and local government signal staff. The following is a list of categories of these softwares:

- Central Traffic Signal Software
- Adaptive Software
- Traffic Monitoring Camera Software
- Origin Destination Software

Other softwares may be added as advanced technologies are added, such as Connected Vehicle Technologies.

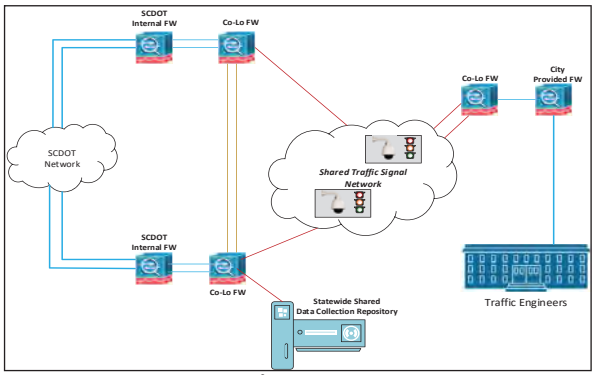


Figure 3-2
Co-Location Servers

Traffic Signal Communications Between Traffic Signals

Fiber

Fiber communication is used to physically connect adjacent traffic signals and can also be used to directly connect signals with the SCDOT network. Fiber can be installed overhead or underground in conduit. Overhead fiber installations utilize messenger wire strung between utility poles or our SCDOT poles. All fiber installations shall be on SCDOT right-of-way. Attachments to utility poles must be in accordance with joint use agreements. Overhead fiber costs are between $3 - $5 per linear foot while underground fiber costs $18 - $25 per linear foot.

Fiber pay items and specifications can be found Section(s) 677-3,677-4, 677-6, SC-M-675 Traffic Signals, Supplemental Technical Specifications.

State equipment contracts for fiber cable and appurtenances are maintained by SCDOT Network Services.

Fiber Communications Design / installation

Communications plans shall be drawn at a scale not smaller than 1" = 100', [1000'] including identifying overhead and underground installations. Overhead installations will indicate pole numbers for shared use poles or new poles to be installed. Plans shall indicate existing r/w information. Right of way information can be obtained from SCDOT roadway plan library. All communication equipment will be designed within existing right-of-way. Underground installations shall indicate conduit size and type and locations of junction boxes. Cabinet locations for signals to be interconnected shall be shown. Communications plans will include fiber routes and sizes, devices, and necessary quantities.

If fiber run designs include shared use utility poles, SCDOT will obtain submit attachment request to appropriate utility company to determine if this is a viable option attach to the poles. Utility attachment agreements will detail responsibilities for make ready work and costs.

The following is a list of tasks included in designing Fiber Communications plans:

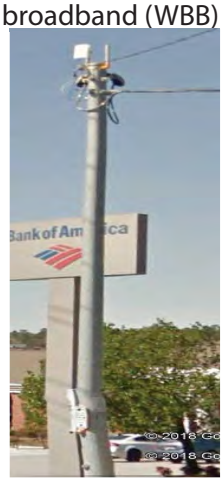
- Creation of System Base Map
- Field Review
- Utility Coordination
- Identification of Installation Locations
- Design and Plan Preparation
- Cost Estimate and Specifications

Fiber installation is a Type 3 Signal Activity, therefore installation can be procured through a construction letting or on by work order using the On Call Signal Construction contract, regardless of funding (federal, state).

Installation of fiber within letting typically requires fiber communications plans. Installation of fiber using On Call Signal Construction contract typically require strip map plans. Strip map plans do not include as much detail and the contractor typically coordinates with utility companies. SCDOT District Signal staff submits attachment requests.

Wireless Communication

Wireless communication is used to connect adjacent traffic signals with radio waves. Wireless broadband (WBB) equipment is installed at the top of signal poles in a manner to achieve the best reception between signals. In areas where communication gaps exist, due to curves or other barriers a wireless communications "bridge" may be installed to connect these gaps. The bridge would consist of WBB equipment plus electric service and equipment in a splice cabinet. Wireless communication should be considered as a viable option in areas where fiber can-not be installed overhead.



Wireless Broad Band (WBB)

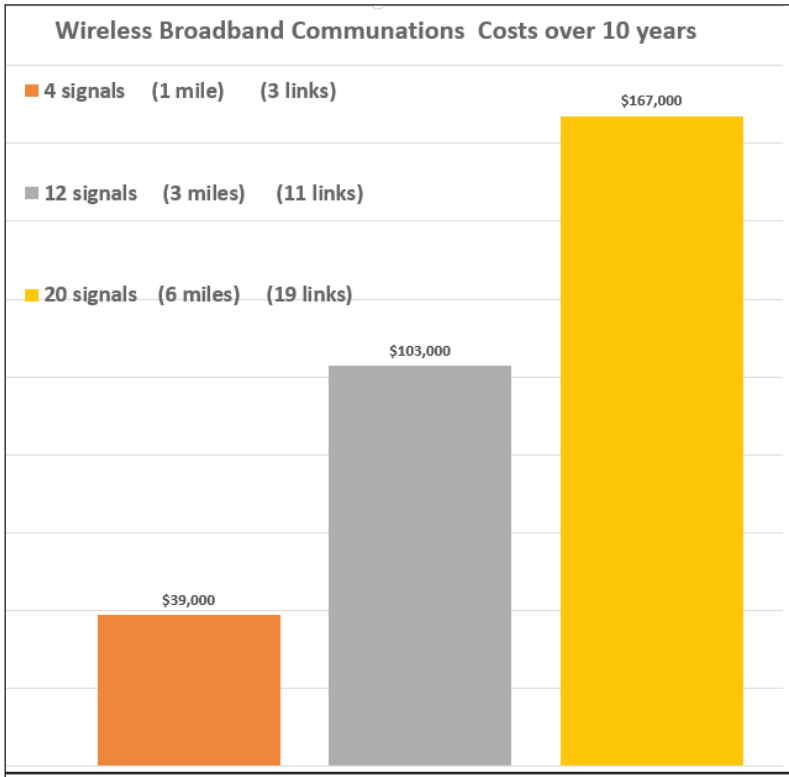
Wireless communication links including two WBB radios costs approximately $3000 per link. Installation of this link, including work at two signals is approximately $800.

Wireless communications pay items and specifications can be found in Section 677-7, SC-M-675 Traffic Signals, Supplemental Technical Specifications.

State equipment contracts for wireless communications equipment and appurtenances are maintained by SCDOT Network Services. This equipment resides on SCDOT network and is provided by SCDOT for installation by contractors.

Fiber vs. Wireless Communications

A comparison should be performed to determine what type of communications should be installed between signals. **Figures 3-3a, 3-3b,and 3-3c** give some comparison on installation costs, installation time and complexity, and annual costs.



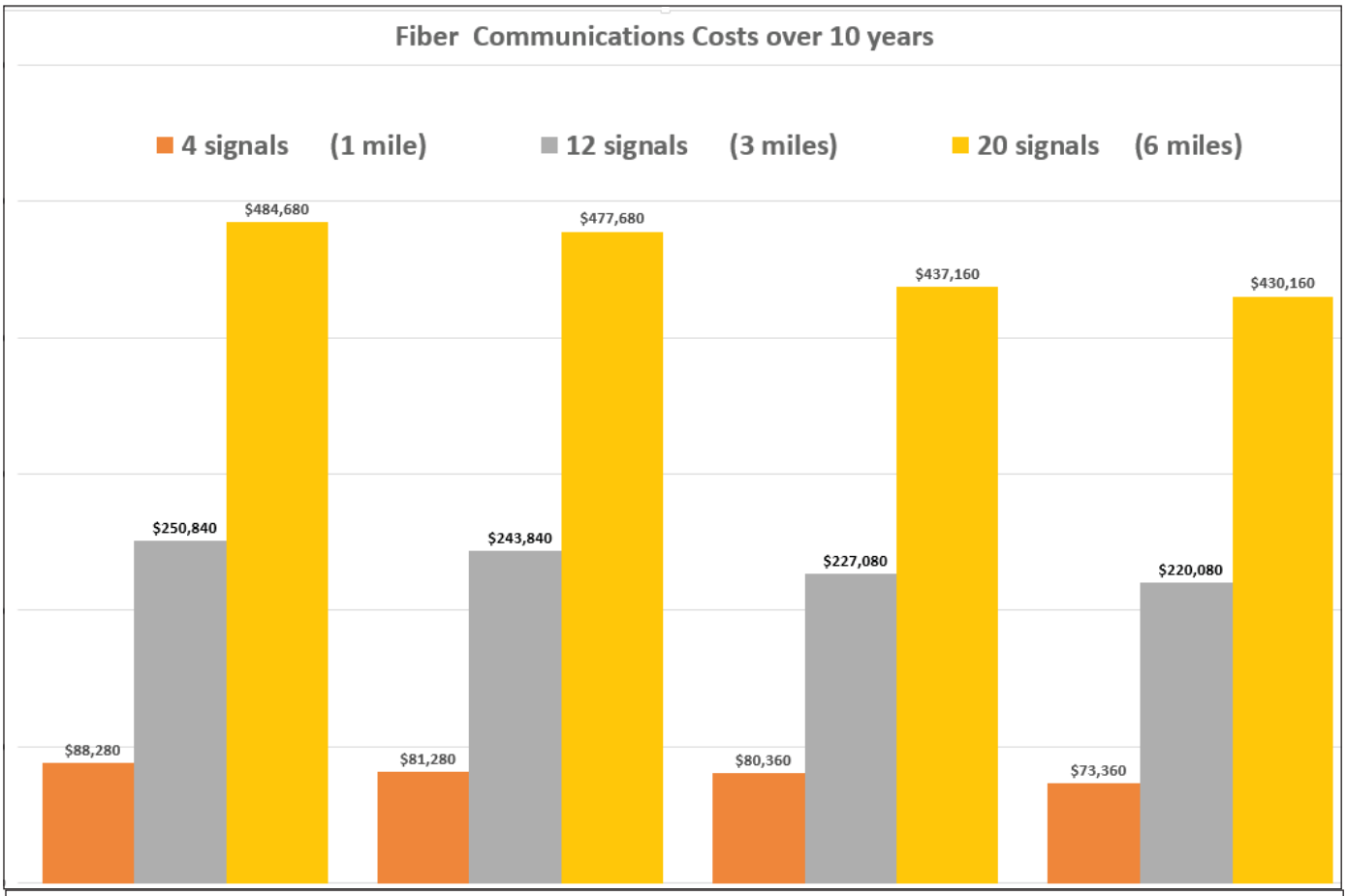
Wireless Broadband Communications-10 year costs	F&I Cost per signal	*4 signals (1 mile) (3 links)*	*12 signals (3 miles) (11 links)*	*20 signals (6 miles) (19 links)*
WBB radios (per link - 2 radios)	$5,000	$20,000	$60,000	$100,000
Assumed Life cycle 7 years- replace 1 time with signal staff	*$3,000*	*$12,000*	*$36,000*	*$60,000*
cell communications - 1 per system	$2,000	$2,000	$2,000	$2,000
Annual cost over 10 years	$5,000	$5,000	$5,000	$5,000
WBB, cell, replacement cost		**$39,000**	**$103,000**	**$167,000**

assumptions- no additional links required to address line of sight issues

Figure 3-3a
Example Communications Comparison of Costs- WBB

Although a number of factors (can SCDOT use utility poles for fiber, is sight distance between signals available for radio communications) influence what is the best most viable form of communications, in general, fiber communications is more viable where signals are closely spaced over distances less than 3 miles. In addition, using cellular communications to access signals may be the most feasible option.

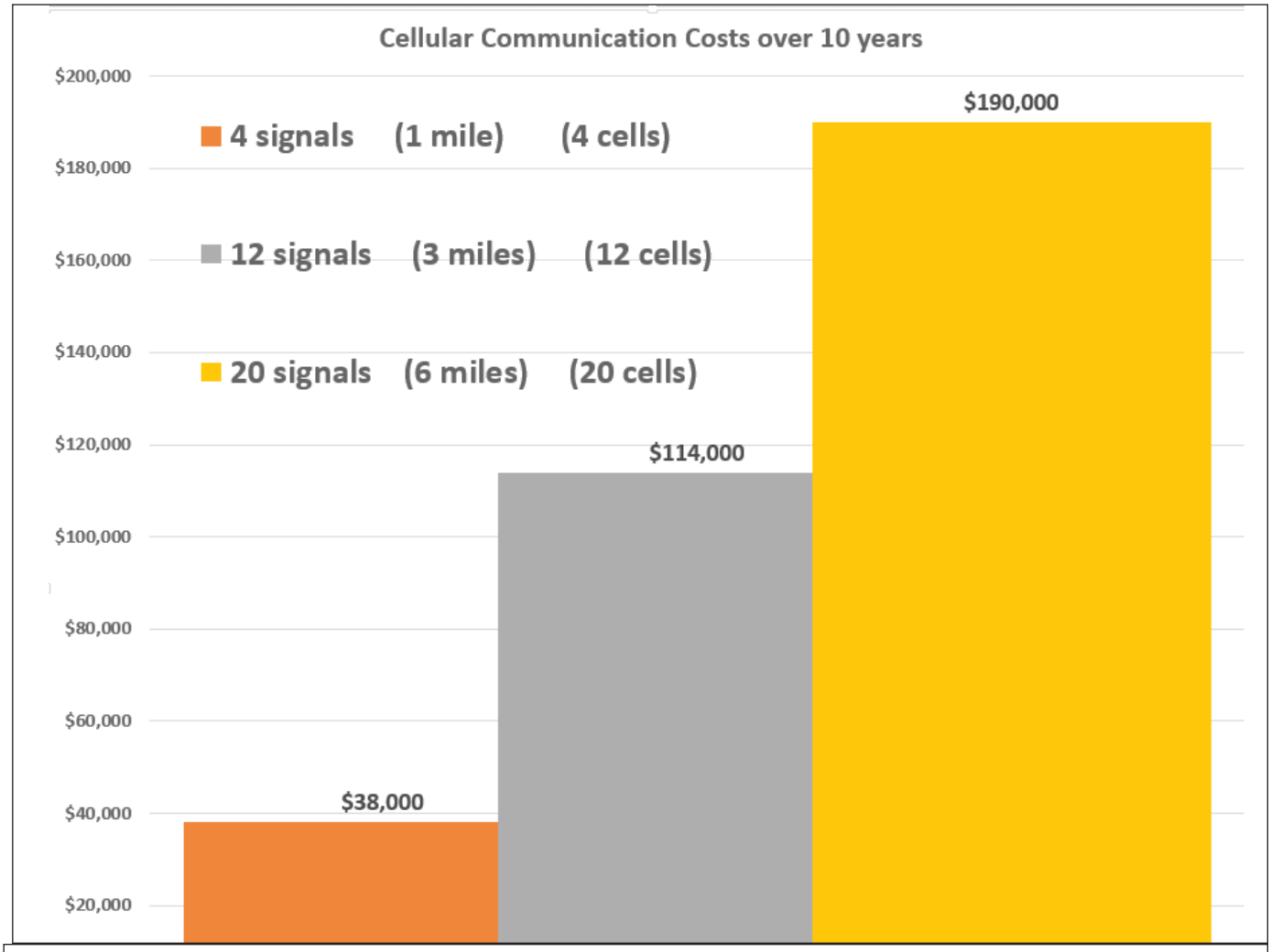
Fiber communications still gives the largest capacity for communications for advanced systems and traffic monitoring cameras, however technology advances make wireless and cellular communications an acceptable alternative. In some cases, wireless communications with a cell modem connection to the network is the most viable option.



Fiber Communications-10 year costs	F&I Cost per LF	*4 signals (1 mile)*	*12 signals (3 miles)*	*20 signals (6 miles)*
Fiber Optic Cable per LF	$5	$26,400	$79,200	$158,400
Fiber Splice per signal	$2,000	$8,000	$24,000	$40,000
Wood poles each (appx 500 spacing)	*$750*	*$7,920*	*$23,760*	*$47,520*
Messenger cable per LF	*$7*	*$36,960*	*$110,880*	*$221,760*
fiber maintenance (assumed $500 per signal per year)	*$500*	*$2,000*	*$6,000*	*$10,000*
cell communications - 1 per system	$2,000	$2,000	$2,000	$2,000
Annual cell cost over 10 years	$5,000	$5,000	$5,000	$5,000
Fiber, poles, cell, maintenance		**$88.280**	**$250.840**	**$484.680**
direct connect to ITS or Network (w/o cell costs)		***$81,280***	***$243,840***	***$477,680***
w/o installing poles - using utiltiy poles		***$80,360***	***$227,080***	***$437,160***
direct connect (w/o cell), using utility poles (w/o installing poles)		***$73,360***	***$220,080***	***$430,160***

Although using utility poles is less expensive, coordination with utility companies can be time consuming and poles may be too full to use.

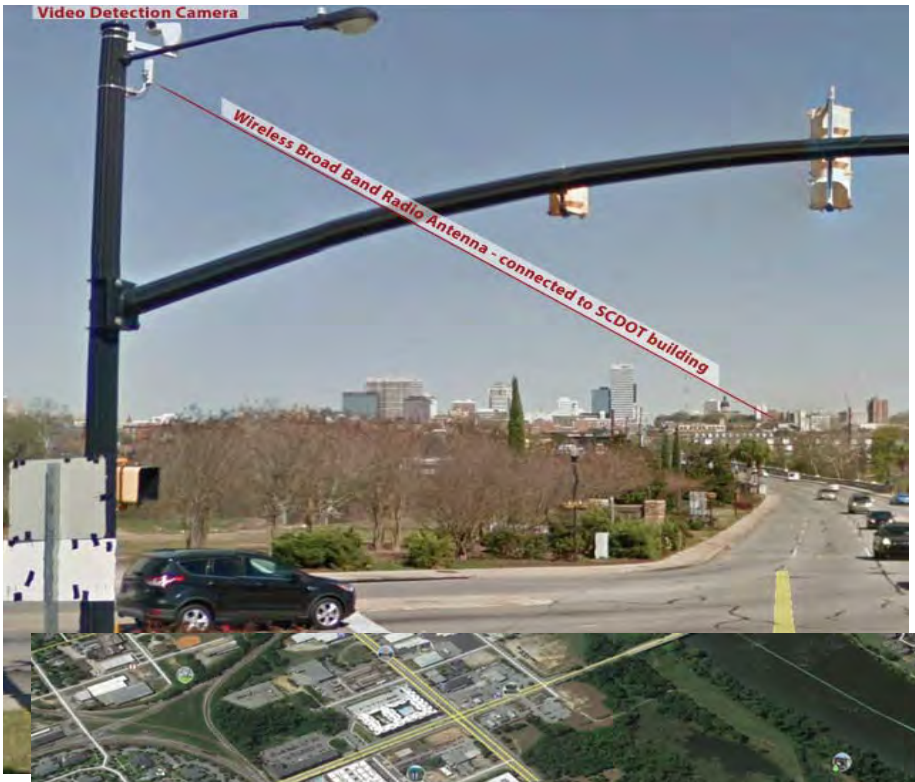
Figure 3-3b
Example Communications Comparison of Costs- Fiber



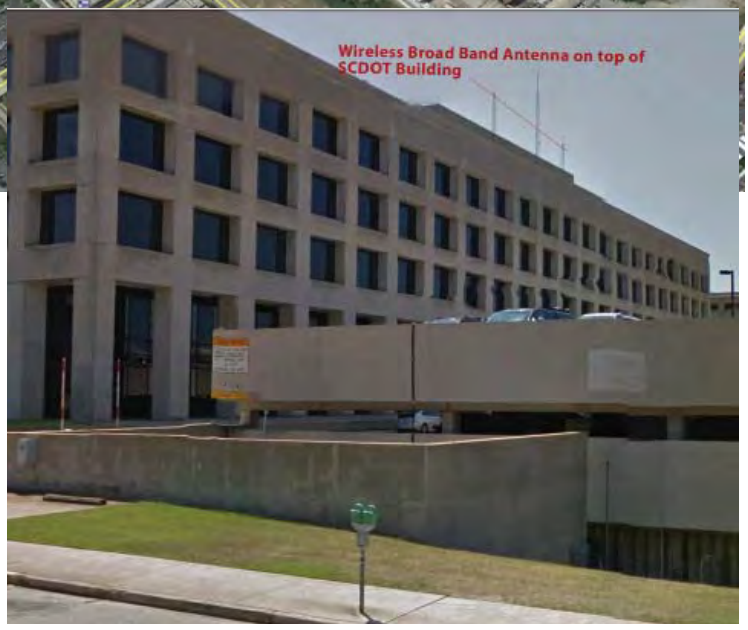
Cellular Communications-10 year costs	F&I Cost per signal	*4 signals (1 mile) (4 cells)*	*12 signals (3 miles) (12 cells)*	*20 signals (6 miles) (20 cells)*
Cell Modems	$2,000	$8,000	$24,000	$40,000
Annual Cost	$500	$2,000	$6,000	$10,000
Cost over 10 yeare	$5,000	$20,000	$60,000	$100,000
Assumed Life cycle 7 years- replace 1 time with signal staff	$2,000	$8,000	$24,000	$40,000
Cell, annual cost, replacment cost		**$38,000**	**$114,000**	**$190,000**

Although cell modems seem to be the least expensive option, operating cameras, adaptive or other data intensive tools, cell modems may not provide enough band width. It is more typical to provide a mixed system of cell plus fiber, or cell plus wireless.

Figure 3-3c
Example Communications Comparison of Costs- Cellular



Meeting Street (US 1) & Sunset Blvd.
West Columbia , SC



SCDOT HQ Building
Park St & Pendleton St.
Columbia , SC

Figure 3-4
Wireless Broad Band Communications Link btwn SCDOT building & signal @ Meeting Street/Sunset Blvd.,

Ethernet Switches

Ethernet switches are used to assign IP addresses to the various traffic signal devices. One Ethernet switch is needed per signal. Ethernet switches are available with a range of ports to accommodate the amount of equipment requiring an IP address.

Ethernet switches cost approximately $2500 per signal.

State equipment contracts for Ethernet switches and appurtenances are maintained by SCDOT Network Services. This equipment resides on the SCDOT network and is provided and installed by SCDOT.

Switches in Cabinet

Communications Between the Traffic Signal System and the Signal Network (Either SCDOT or Co-location)

Cell Modems

These devices are used to enable communications between the Traffic Signal Communications Network and the Signal System. Cell modems are used when the Signal System is not able to be connected directly to the SCDOT Communications Network. Initial costs to install the cell modem are typically in the $2k range and SCDOT pays a monthly fee (typically $38) to the service provider for this connection.

Point of Presence (POP)

The Point of Presence is the location where the Signal System is connected directly to the SCDOT Network, usually the ITS Network fiber along the interstate. The Point of Presence is the demarcation line that denotes maintenance responsibility. Any repairs required between the POP and the ITS fiber is the responsibility of ITS. Any repairs required between the POP and the Traffic Signal System communications is the responsibility of the District Signal Maintainers. The POP is typically within the traffic signal cabinet closest to the Interstate fiber. Initial costs to install the POP are typically in the $10k range, however there is no ongoing monthly cost for the POP.

Point to Multi-point

Wireless broadband communications can be used to provide communications between the network at the facility and the traffic signals.

Wireless radios can be installed on the top of buildings on water towers , or on communications towers. The elevated heights allow great line of site directly to traffic signals.

Point to Multi-point

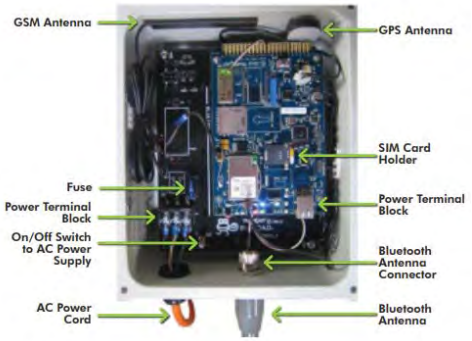
Traffic Signal System Operations Tools

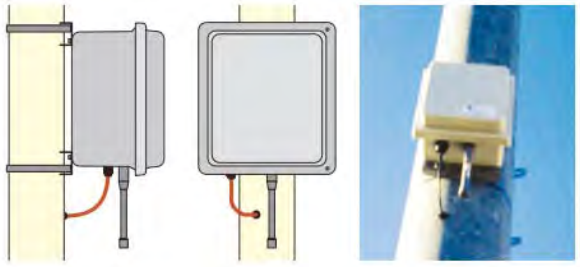
Traffic Monitoring Cameras

Traffic monitoring cameras that can pan, tilt and zoom can be used to monitor and operate the signal system. Ethernet communications enable real time monitoring of signal systems. IT Services has an equipment contract to provide and configure these cameras. Any TM camera residing on the SCDOT Communications Network must be an approved IT device. The cost to furnish the TM cameras is typically $5k and the cost to install the TM cameras is typically $850.

As of August 2018, approximately 120 traffic monitoring cameras were installed at traffic signals. Another 150 traffic monitoring cameras are planned to be installed within the next five years.

Traffic Monitoring Cameras





BlueTOAD™ Roadside Bluetooth™ Sensor Equipment
AC Power Configuration

Short Range Radio Device Detector System
(Origin/Destination Device)

Short Range Radio Device Detector System (Origin Destination Devices)

Short Range Radio Device Detectors can provide travel time, speed and destination information and are used to evaluate the operation of signal systems. These detectors should be used when major improvements are implemented, such as responsive or adaptive signal systems.

There are two types of detectors that measure different radio signals - Wi-Fi or Blue Tooth. These detectors do not pick up each vehicle as not all motorists have these type of devices. SCDOT's current specification for this device measures blue tooth radio signals.

The detectors can be installed temporarily to provide before and after data for signal system improvements or they can be installed permanently to provide ongoing information about the performance of the signal system. It is beneficial to provide permanent detection on corridors that are part of an overall Traffic Management Center operation. The cost to furnish and install the Short Range Radio Device Detector System is typically $6-8k per device.

CHAPTER 4

STOP & GO SIGNAL DESIGN

SCDOT

The following information should be used to design the signal plan. Other design standards include FHWA approved SCDOT Traffic Signal Supplemental Technical Specifications (SC-M-675) and the SCDOT Standard Drawings.

This manual is intended to detail SCDOT standard practice, as well as guidance concerning SCDOT's expectations for signal plan formatting. This manual provides design parameters for relatively normal conditions; engineering judgment should be used for all signals including non typical conditions.

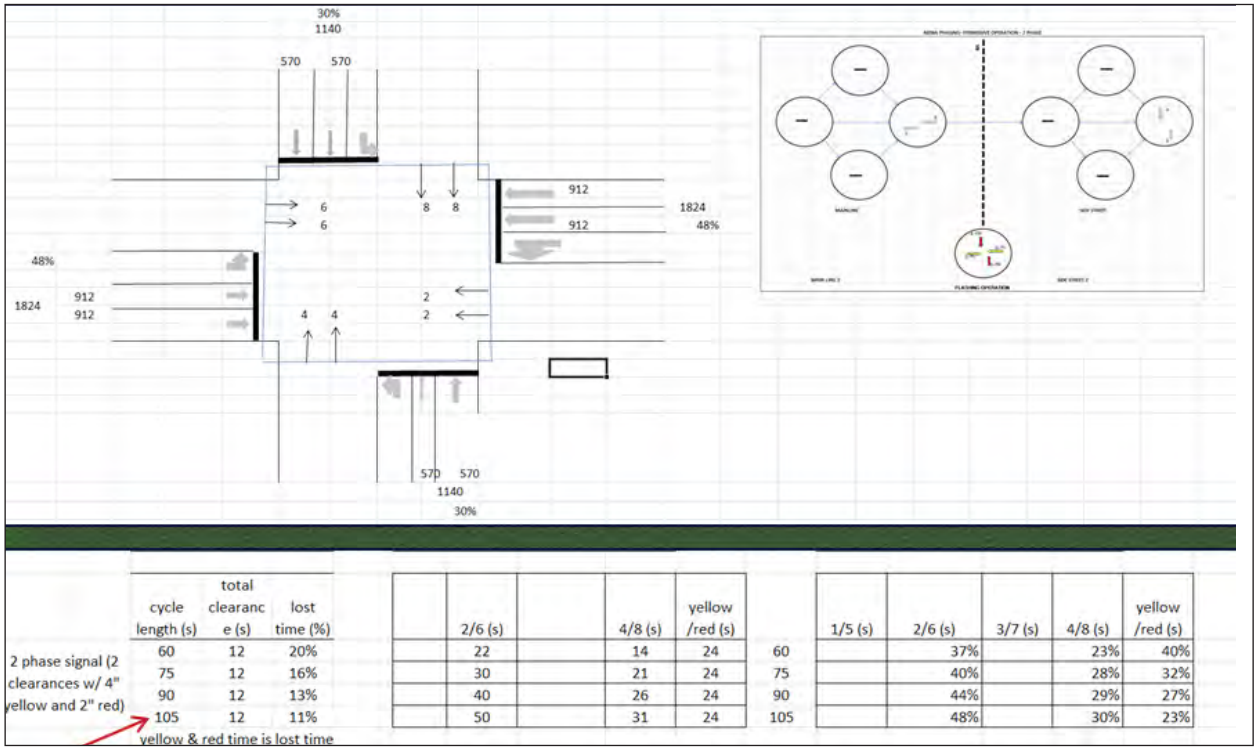
Signal Design Standards

Signal design shall be in accordance with:

- ***Manual of Uniform Traffic Control Devices (MUTCD)***
  The MUTCD details standards for signing, marking and signals.
- ***FHWA Traffic Signal Timing Manual***
  The Traffic Signal Timing Manual details methods to determine signal phasing and timings to serve traffc volumes.
- ***SCDOT Traffic Signal Manual***
  The SCDOT Traffic Signal Manual is intended to detail SCDOT standard practice, as well as guidance concerning SCDOT's expectations for signal plan formatting. This manual provides design parameters for relatively normal conditions; engineering judgment should be used for all signals including non typical conditions.
- ***SCDOT Traffic Signal Supplemental Technical Specifications (SC-M-675)*** , ***SCDOT Standard Drawings.***
  The SCDOT Supplemental Technical Specifications and SCDOT Standard Drawings detail installation methods for contractors, but are usefule to engineers in designing signals and choosing pay items.

Signal Capacity - Volume to Capacity

Roadway capacity is generally 1,900 passenger cars per lane per hour (pcplph). Capacity at signals is reduced to percent green time for each phase. Signals are designed to provide green time for side streets only when cars are present, thus maintaining as much capacity as possible on the main line . Poorly timed / or maintained signals reduce roadway capacity, thereby reducing the value of the roadway asset. Below is an example of how roadway capacity is impacted by installation of a traffic signal.



	cycle length (s)	total clearance (s)	lost time (%)
2 phase signal (2 clearances w/ 4" yellow and 2" red)	60	12	20%
	75	12	16%
	90	12	13%
	105	12	11%

yellow & red time is lost time

	2/6 (s)		4/8 (s)	yellow /red (s)
	22		14	24
	30		21	24
	40		26	24
	50		31	24

	1/5 (s)	2/6 (s)	3/7 (s)	4/8 (s)	yellow /red (s)
60		37%		23%	40%
75		40%		28%	32%
90		44%		29%	27%
105		48%		30%	23%

Figure 4-1
Impact to Capacity (2 Phase)

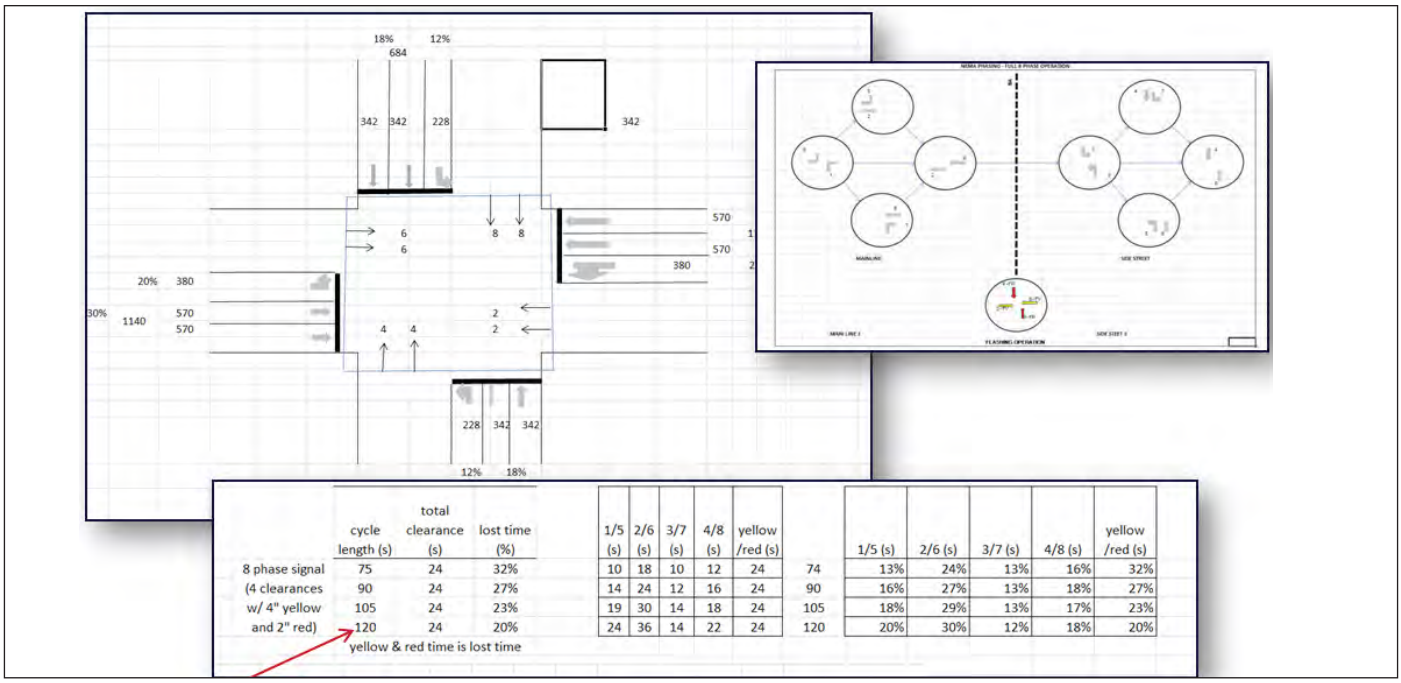


Figure 4-2
Impact to Capacity (8 Phase)

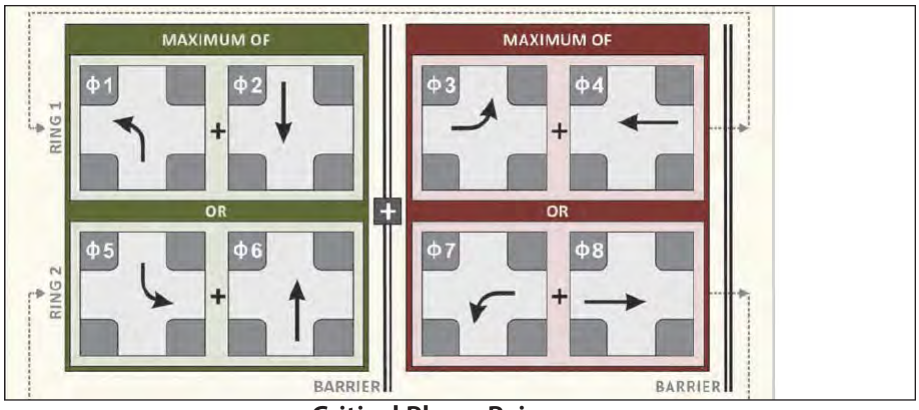
Figure 4-1 shows the impact of a 2 phase signal on mainline roadway capacity, between 11% to 20% depending on cycle length. **Figure 4-2** shows the impact of an 8-phase signal on mainline roadway signal capacity, between 20% to 32% depending on cycle length. The mimimum number of signal phases is two phase, consisting of the main line phase and the side street phase. Each additional phase added to a traffic signal affects the capacity due to the required clearance between signal phase and the reduced percent of time serving the mainline through traffic. Engineers should review the traffic volumes and roadway capacity, as well as field conditions to determine the need for seperate phases for left turns, concurrent phases, split phases for side streets, and overlaps. Left turn phase study information can be found in **Chapter 1.**

Signal Phasing

Traffic signal plans are developed to install new traffic signals, to revise existing traffic signals due to roadway construction , or to rebuild existing signals due to age of equipment.

- At new signals, engineers should determine what signal phases are needed to accomodate traffic movements and volumes. Based on a combination of roadway geometry, including number of lanes and lane usage, sight distance and traffic volumes, engineers should determine what signal phasing is needed.
- Once the signal phasing is determined, engineers should use a critical movement analysis to determine the length of green time to serve each phase. As detailed in Chapter 5 of the FHWA Signal Timing Manual, the following steps should be followed to determine Critical Movements see **Figure 4-3:**
    1. Record Demand Volumes, adjusting for 15 minute peak, heavy vehicles and lane balance
    2. Determine Critical Phase Pairs
    3. Calculate the Critical Volume
    4. Estimate the Cycle Length
- At existing signal revised due to roadway construction, engineers scan use existing signal phasing as well as proposed roadway geometry, including number of lanes and lane usage, sight distance, traffic volumes and accident history to determine what revisions to the signal phasing is needed. Once the signal phasing is determined, engineers should use a critical movement analysis to determine the length of green time to serve each phase.
- At existing signals where upgrades are needed due to age of equipment and where no roadway changes are planned, engineers should generally use existing phasing when developing a new signal plan. The District Traffic Engineer may request phasing or timing changes to address existing concerns with safety or signal operation.

In addition to determining the phasing and timings needed to accomodate vehicular traffic, engineers should also make a determination on how to accomodate pedestrians.



Critical Phase Pairs

Critical Intersection Volume

Cycle Length (Seconds)	Number of Cycles Per Hour	Lost Time Per Cycle (Seconds)[1]	Effective Green Time Per Cycle (Seconds)	Number of Vehicles Per Cycle[2]	Maximum Number of Vehicles Per Hour[2]
60	60	20	40	16	933
70	51	20	50	19	1000
80	45	20	60	23	1050
90	40	20	70	27	1089
100	36	20	80	31	1120
110	33	20	90	35	1145
120	30	20	100	39	1167

[1] This lost time assumes that the intersection is operating with eight phases (four in each ring) with 5 seconds of lost time per phase. The lost time will be less at an intersection with fewer phases.
[2] The number of vehicles that can be accommodated under the various cycle lengths was calculated assuming a headway of 2.5 seconds per vehicle, which is generally conservative for urban/suburban environments.

Estimated Cycle Lengths based on Critical Volume (8 phase)

Figure 4-3
Critical Movement Analysis (from Signal Timing Manual)

Signal Phasing

Left Turn Phasing

Left turn phase study information can be found in **Chapter 1**. Use the following information to prepare the signal plan for the various types of left turn phases.

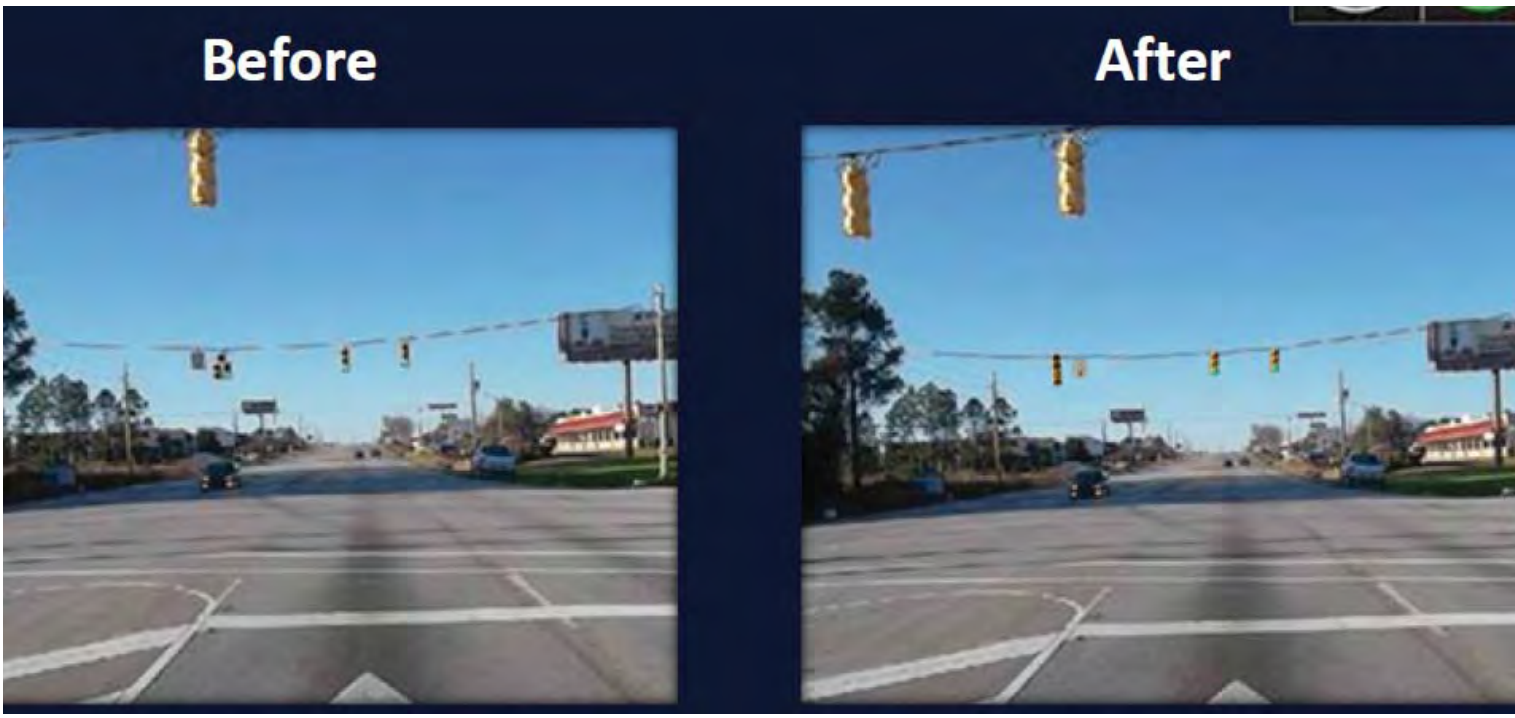
Protected Only Left Turn Phases shall have a separate signal head, consisting of a RA, RA, YA, GA signal head for a single lane or two RA, YA, GA signal heads for two left-turn lanes. These should be used for protected-only left-turn phases and placed within the 20-degree cone of vision for the exclusive left turn lane. This signal head configuration eliminates the need for the left turn signal sign.

Protected/Permissive Left Turn Phase shall generally consist of a ***four-section*** flashing yellow arrow (FYA) signal head, RA, YA. YA, GA directly over the left turn lane. In certain cases a ***five-section*** (doghouse) signal head may be used, for example where the left turn movement is made from a shared left/through lane. If a ***five-section*** signal head is installed, install a 'Left turn yield on Green ball sign (R10-12) adjacent to the ***five-section*** head..

Flashing Yellow Arrow (FYA) - In areas where left turn lanes are offset from the through lanes, installation of a FYA provides guidance to motorist directly over the left turn lane. For permissive-only operation one ***three-section*** signal head, (RA,YA,YA,) should be installed directly over the left turn lane with a sign adjacent (R10-12A) to the signal head. If protected-permissive operation is desired, a ***four-section*** flashing yellow arrow (RA,YA,YA,GA) left turn signal head should be installed where a separate left turn lane is present unless geometric issues or lateral signal spacing issues reduce the effectiveness of a separate FYA signal face over the left turn lane. Where an offset left turn lane is present and protected/permitted left turn operation is warranted, a ***four-section*** FYA left turn signal head shall be installed. A R10-12A sign should be installed adjacent to the FYA signal head, indicating that the left turn should yield to oncoming traffic with the flashing yellow arrow. Where protected/permitted left turns are provided with a ***four-section*** FYA and lagging operation of the protected left turn phase is anticipated, a FYA signal head (***three-section*** for permitted only lefts or ***four-section*** for protected/permitted lefts) must be installed for the opposite approach to eliminate the yellow trap.

In conditions where the minimum signal head height (17') cannot be provided due to utilities or other issues, a ***three-section*** flashing yellow arrow signal face that uses the bottom section to show both the steady green arrow (GA) and the flashing yellow arrow (FYA). This dual mode signal head is approved for use in Section 4D.20 of the MUTCD.

For additional guidance on Flashing Yellow Arrow, see Traffic Engineering Guideline 7. Also, see Figure 4-8 for FYA Overlap Chart for phase numbering conventions. Guidance on programming the controller and conflict monitor for FYA operation is detailed in Figures 4-51a, 4-51b, and 4-51c.



Changing from leading to lagging by time-of-day to improve progression is permissible as long if appropriate direction is provided to motorists for the opposing left turn movement; ie. the opposing left turn movement has protected only phasing, a FYA signal head is provided over the opposing left turn approach lane, the opposing left turn movement is prohibited or not available (T intersection).

If an intersection is a candidate for Lead/Lag phases, special attention must be given to ensure a left turn trap is not created.

FHWA's Signalized Intersection Guide in **Figure 4-4** explains how a left-turn trap works.

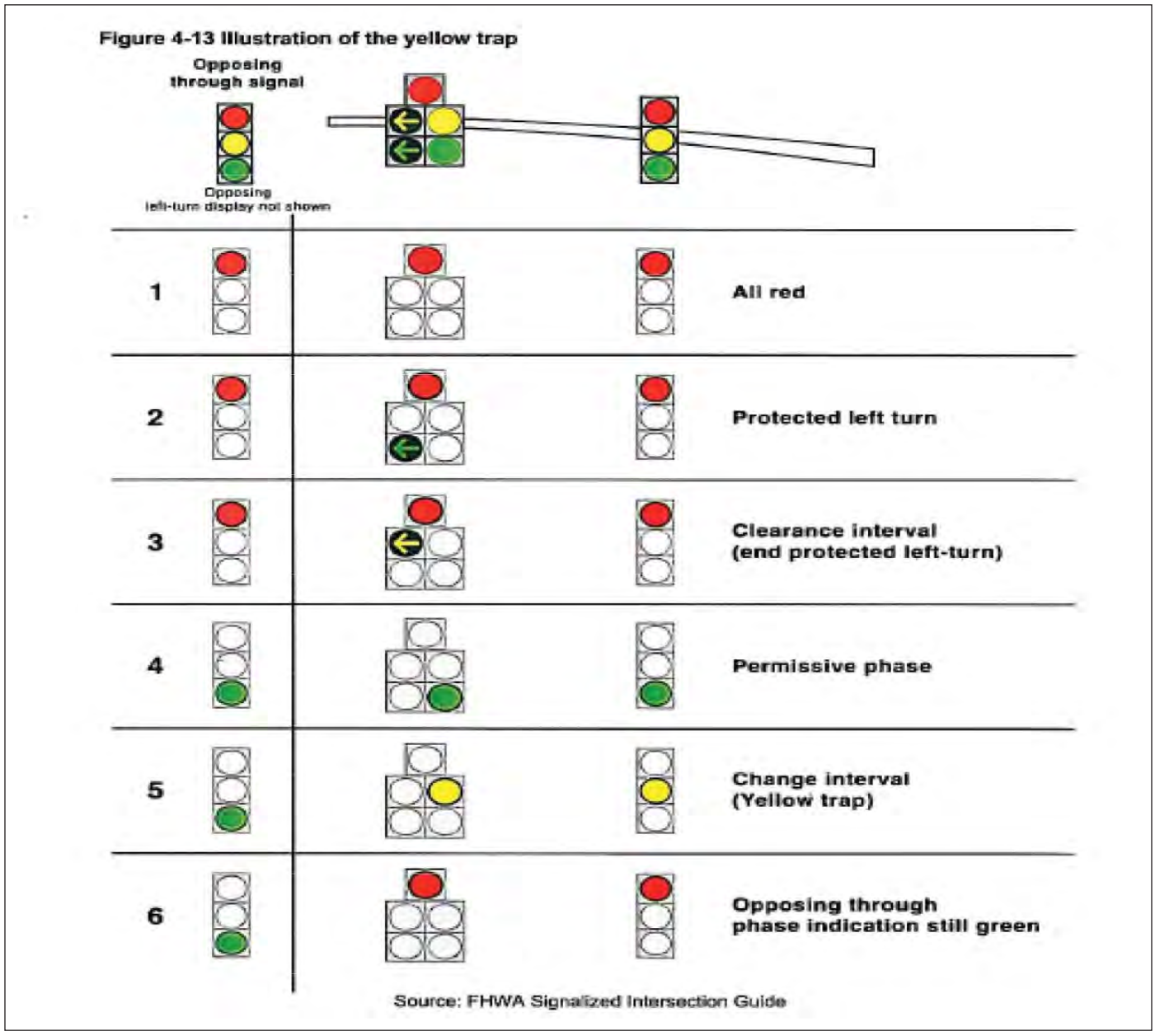


Figure 4-4
FHWA Explantion of Yellow Trap

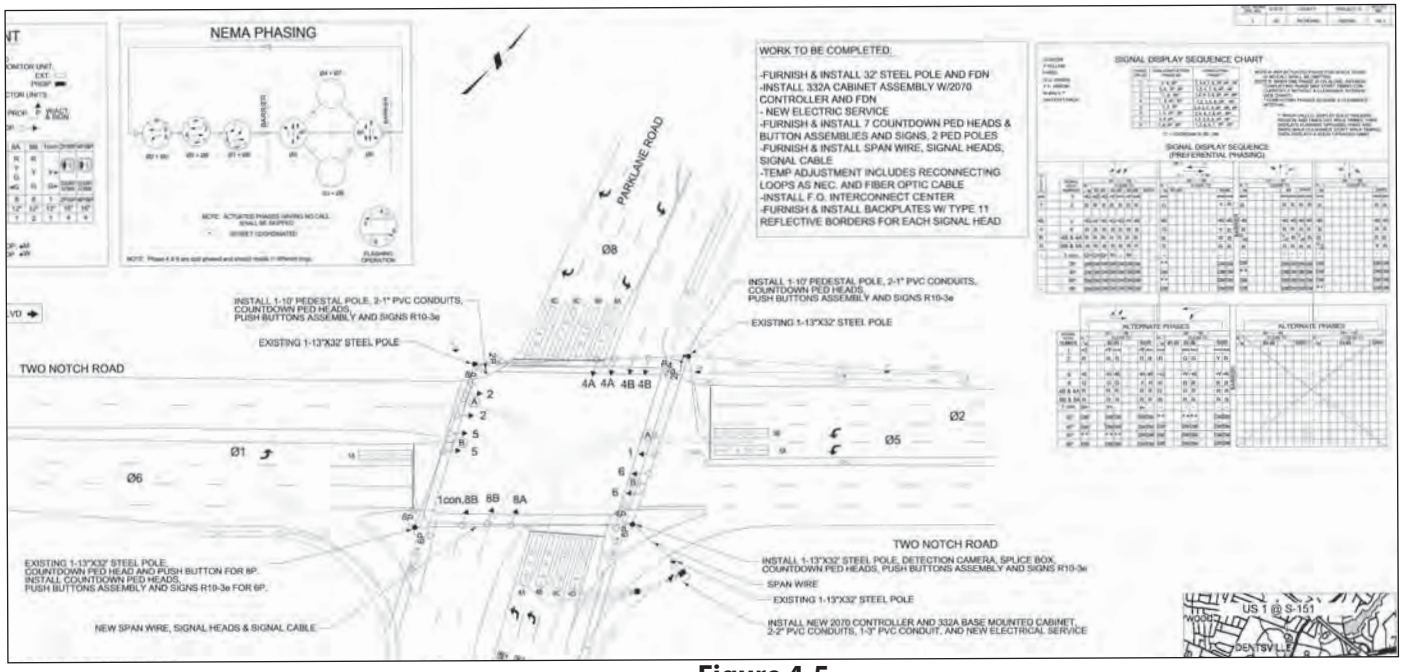


Figure 4-5
Example Signal Plan for Lead/Lag Operation

Geometric Conflicts for Opposing Left Turns - In areas where operating simultaneous left turn movements is not permissible due to geometric conflicts, the left turn phases can be programmed for one left turn phase to be leading and the opposing left turn phase to be lagging. In areas where the opposing left turn lanes interlock due to offset (doglegged) side streets, the engineer may operate one approach as protected only lagging and the other as protected permissive leading, to avoid the conflict.

Variable Left-Turn Mode MUTCD 4D.17, Variable Right-Turn Mode MUTCD 4D.21 - Variable Left-Turn Mode operation consists of changing from Protected Only, Protected/Permissive, Permissive by time of day or other selection criteria.

Use of variable left-turn mode and/or variable right-turn mode at traffic signals is not a standard practice in South Carolina. An engineering study to evaluate the impact of this operation should be submitted for review and must be approved by SCDOT prior to installation.

Concurrent Phasing - Concurrent phasing is typically utilized to serve a right-turn movement in an exclusive right turn lane during the appropriate left-turn phase. Concurrent phasing is typically combined in a ***five-section*** right-turn signal head, where the right-turn green arrow display operates concurrently with the appropriate left-turn phase. An example is shown in **Figure 4-6**.

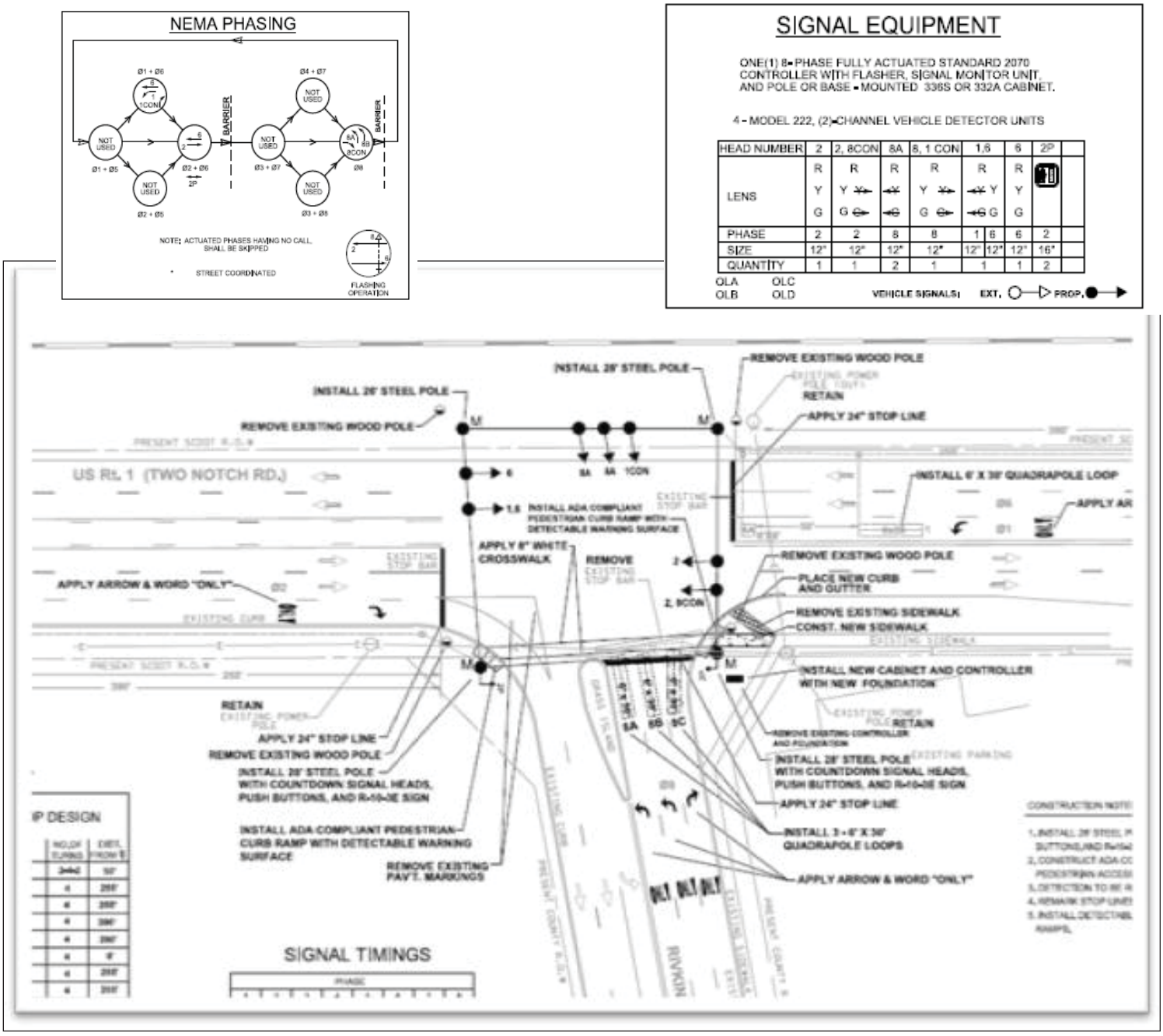


Figure 4-6
Concurrent Phasing

Split Phasing - Split Phase operation is when phases operate sequentially rather than simultaneously and is commonly used for offset side streets where simultaneous through movements are not possible due to geometric configuration. Split phase operation is also used where heavy left turn/ through movements oppose low volume movements or where roadway improvements to increase capacity are not possible and dual left turns are required to address capacity issues. An example is shown in **Figure 4-7**.

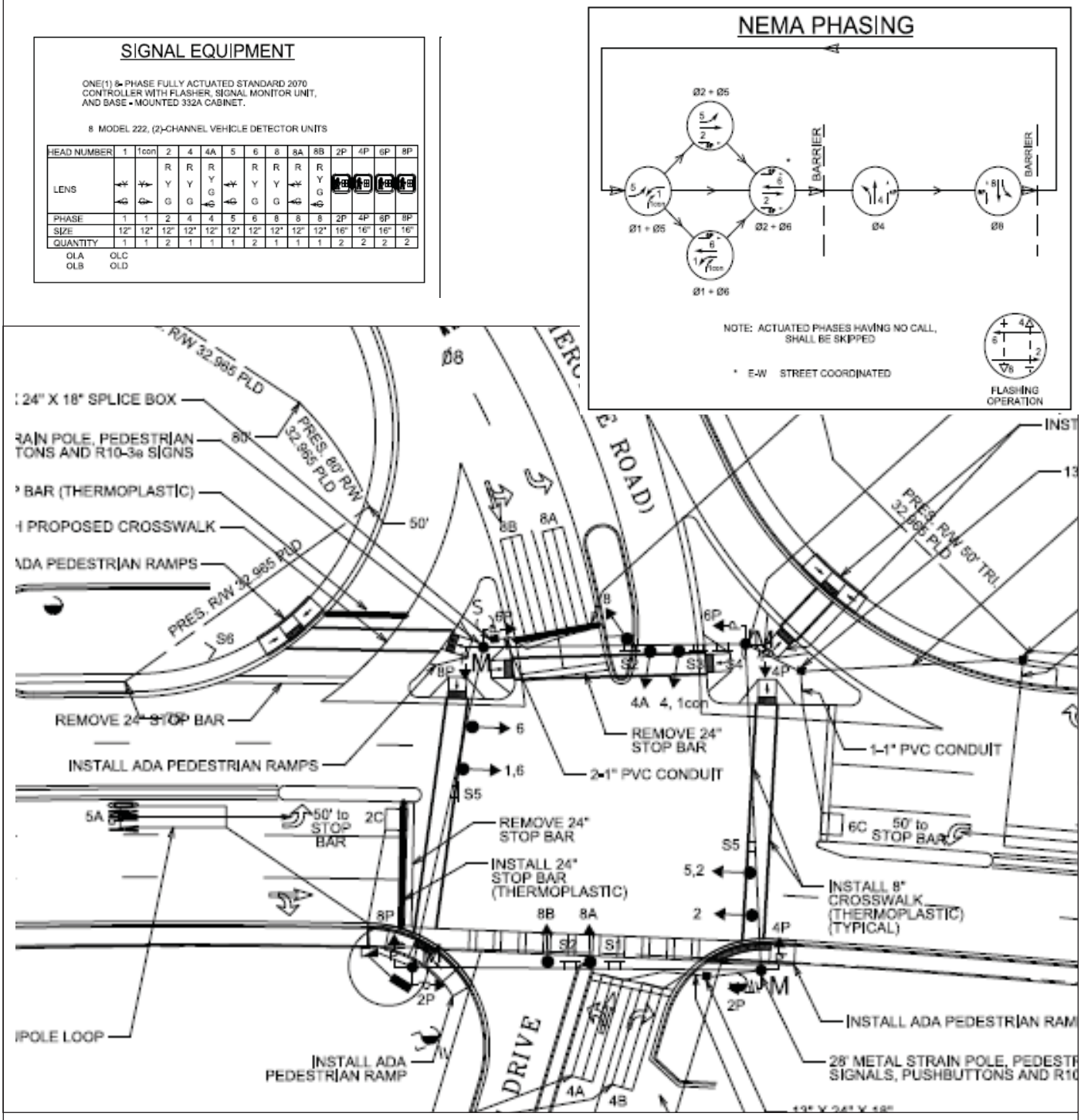


Figure 4-7
Split Phasing

Phase Overlaps -Overlaps are signal phases that can operate during multiple signal phases such as flashing yellow arrow during the opposing green phase, that extend a green display on particular signal heads to 'clear' a designated area, or that operate signal heads are closely spaced signals. Example overlaps are shown in **Figure 4-8 Flashing Yellow Arrow (FYA) Overlap, Figure 4-9 Timed Overlap and Figure 4-10 Complex Intersection Overlap.**

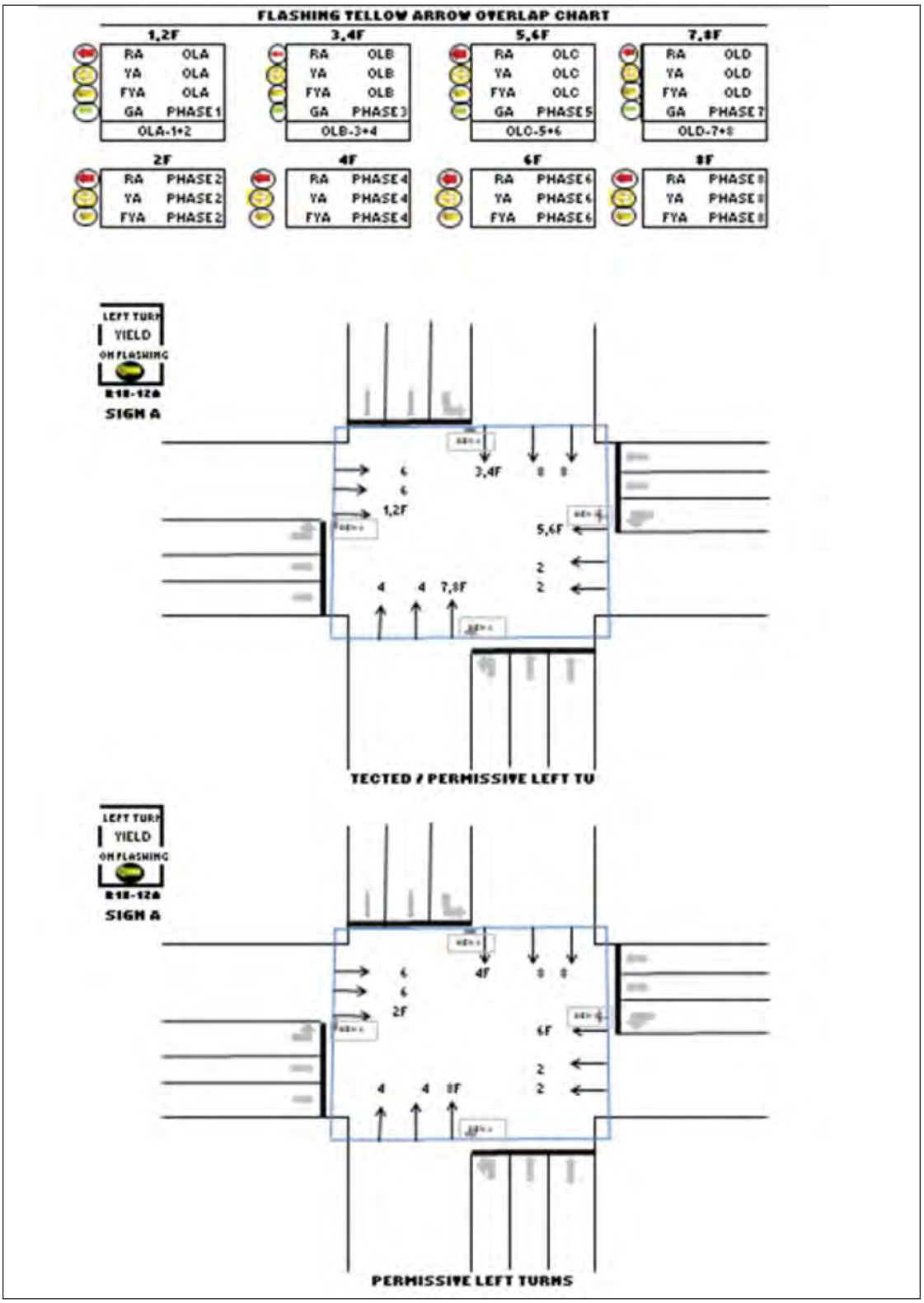


Figure 4-8
Example FYA Overlaps

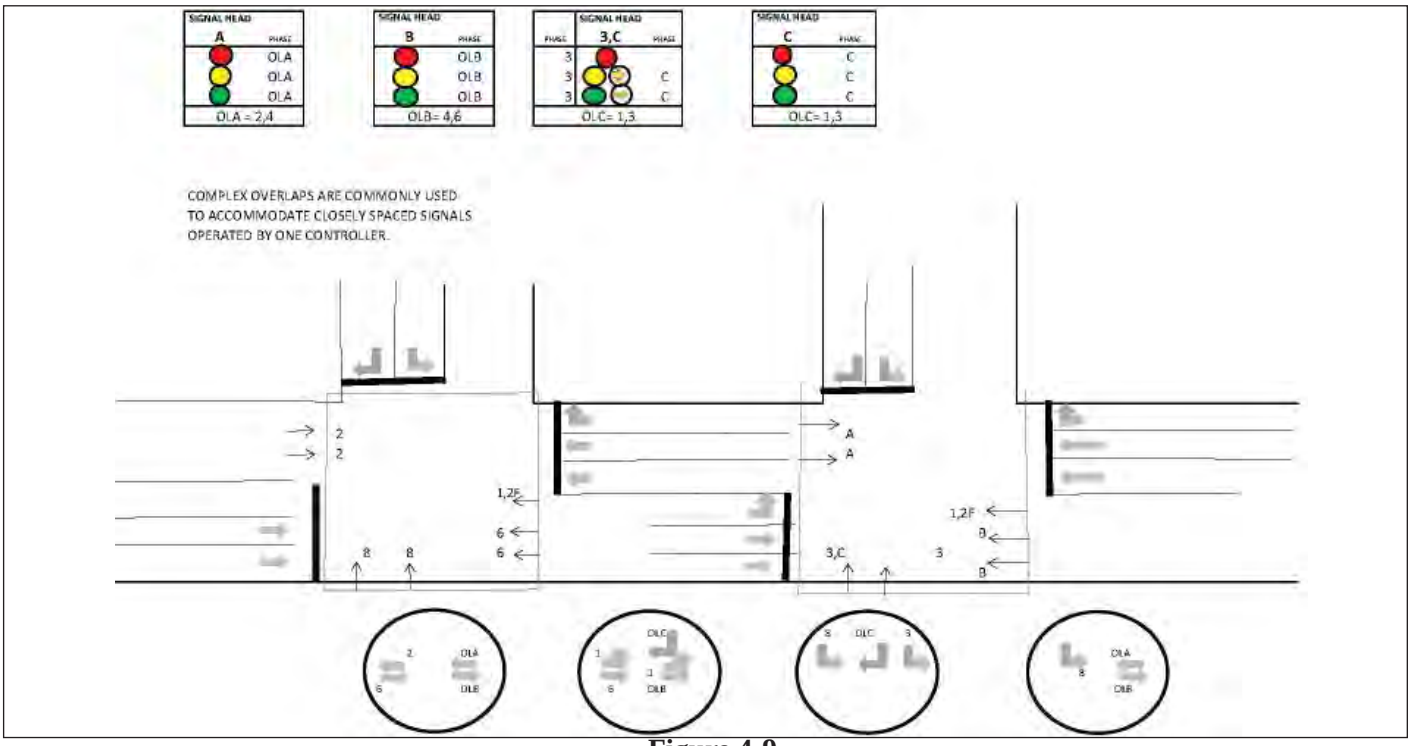


Figure 4-9
Example Complex Overlap

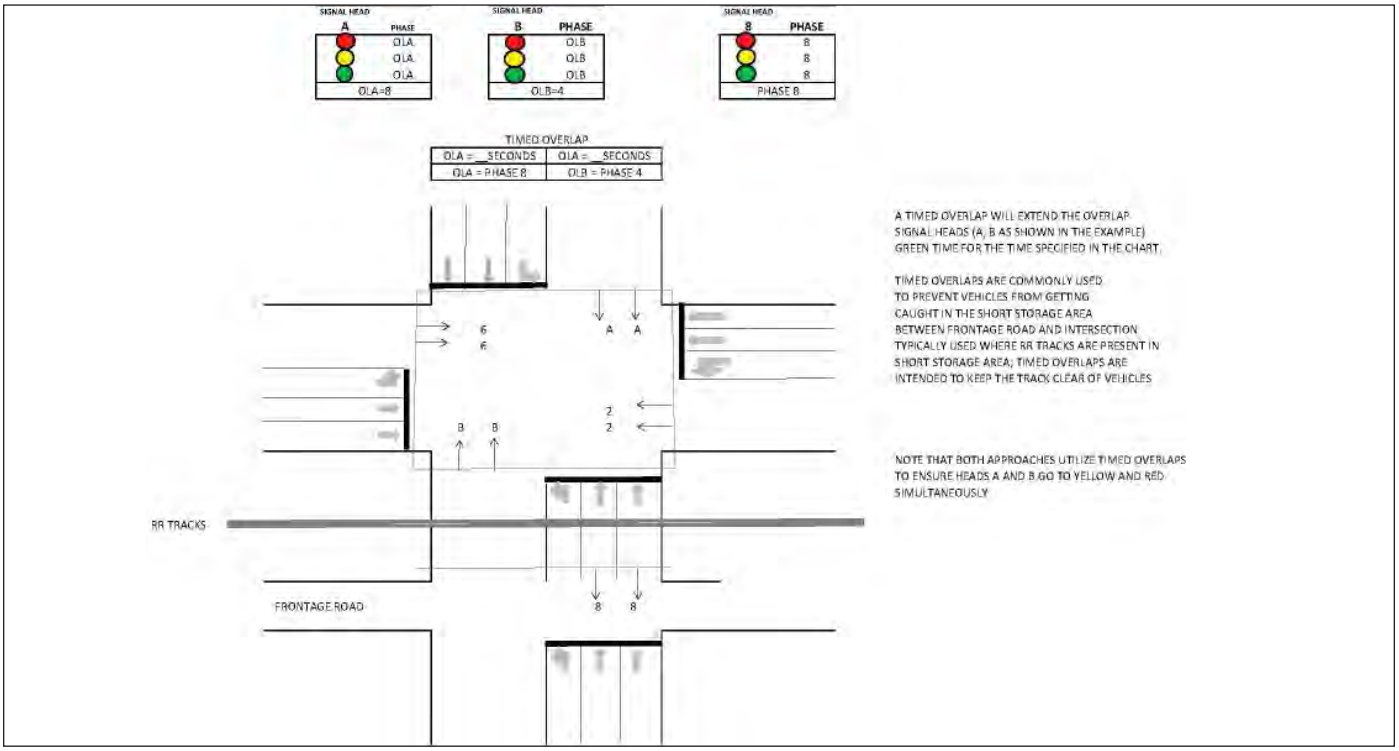


Figure 4-10
Example Timed Overlap

When Timed Overlaps or Complex Overlaps are used, engineers should consider the need for additional signing, markings and signal indications to ensure motorists are given appropriate direction. For example, when a timed overlap is used to clear an area, a Stop Here on Red sign may be installed at the near side signal heads that turn red, when the far side signal heads display a green. Options for minimizing the visibility of the far side signal heads using louvers, programmable signal heads or 8 inch green displays may be considered to improve compliance.

Pedestrian Phasing

Signal phasing must take into account the time required to address pedestrian crossing movements. In most cases, pedestrian phasing operates concurrently with the parallel vehicle through phase and does not impact signal phasing, other than possible increases to required green time to accomodate pedestrian walking speeds. Signal phasing is impacted if exclusive pedestrian phasing (where pedestrians have the right of way and all vehicle phases are stopped with red displays) is needed to address specialized circumstances. For example, intersections where heavy left or right turn movements that conflict with pedestrian movements may be a candidate for exclusive pedestrian phasing. Following is guidance for engineers to determine what pedestrian treatment may be needed.

Pedestrian Treatment Design

Minimum Pedestrian Signal Treatment

Pedestrian accommodations at signals should be designed in cooperation with road designers as well as Traffic Engineers. The elements at the intersection, traffic patterns , presence of pedestrians, type of development and complexity of the signal phasing all play a role in deciding what type of pedestrian treatment is needed. **Figure 4-11** depicts minimum pedestrian signal treatments for common roadway conditions. **Figure 4-11** also details SCDOT's standard concerning installation of curb ramps at signals where existing curbs are barriers and where a walkway is present.

As indicated in **Figure 4-11**, the pedestrian treatment is based on the presence of a path crosswalk, curb ramps. In addition, engineers should consider the following to ensure the appropriate pedestrian treatment is provided.

- Studies or official observations have documented pedestrian presence and crossing frequency.
- There exists physical evidence of pedestrian activity (i.e. a path) and logical beginning and end points for short trips (generally less than ½ mile; typically made on foot) on opposite sides of the intersection, even in isolated areas. Examples include, but are not limited to, the following:
    - Homes on one side, a grocery store or general store on the other
    - Homes on one side, a park or other attraction on the other
    - Motels on one side, a food establishment on the other
    - An established bus stop on one side, homes on the other
    - An established bus stop on one side, places of employment on the other

In addition, **Figure 4-12** will assist project managers in determining if existing curb ramps must be updated to current standards. If installed, curb ramps should have Detectable Warning Surfaces (DWS). Crosswalks should be provided based on engineering judgement. Engineering judgement may dictate additional pedestrian treatments if the development in the area would indicate a probable pedestrian presence.

Road designers make decisions concerning shoulder treatments, lane assignments , presence of medians or islands and curb ramps, which influence the signal designer's decisions concerning the appropriate pedestrian treatment. In addition, the pavement marking designer also influences these decisions. Signal designers should coordinate closely with those individuals designing the roadway, developing the marking plans and operating the signal to ensure pedestrians are accomodated without negative impact to signal operations.

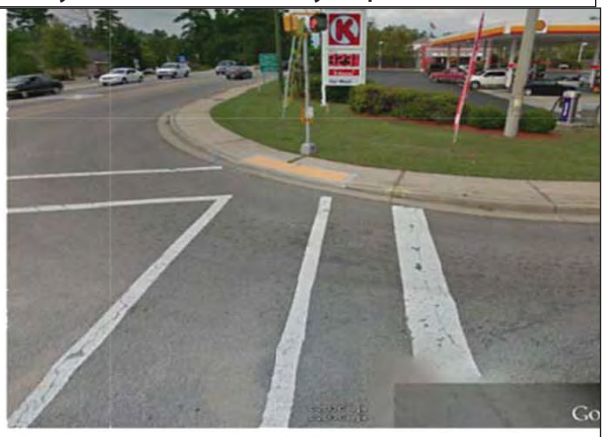
At signals with sidewalks on four sides and crosswalks marked on all four approaches the decision for pedestrian treatment type is typically very simple. In this situation, pedestrian heads and buttons are typically installed on each quadrant allowing pedestrian crossing on each approach. However many signalized intersections have a variety of pedestrian accommodations, such as sidewalk on one side only or on two approaches, and engineering judgement should be applied to decide on the pedestrian treatment.

MINIMUM PEDESTRIAN SIGNAL TREATMENTS WITH ENGINEERING

Barriers should be removed with curb ramps only where a walkway is present.

Sidewalk, Curb & Gutter, Existing Ramp

No requirement to modify ramp



Curb & Gutter Section

Existing sidewalk or worn path. Minimum treatments to install pedestrian heads, buttons, crosswalk, ; and to remove barriers by installing curb ramps

Shoulder Section
No sidewalk, no path
Minimum treatment is to install pedestrian button only, no crosswalk

Curb & Gutter Section
No sidewalk, no worn path
Minimum treatment is to install pedestrian button only, no crosswalk

Curb & Gutter Section (Central Business District/Urban Area

Existing sidewalk

Minimum treatment is to install pedestiran heads, curb ramps where none exist and crosswalk Pedestrian buttons installed based on signal actuation

Figure 4-11
Minimum Pedestrian Treatments

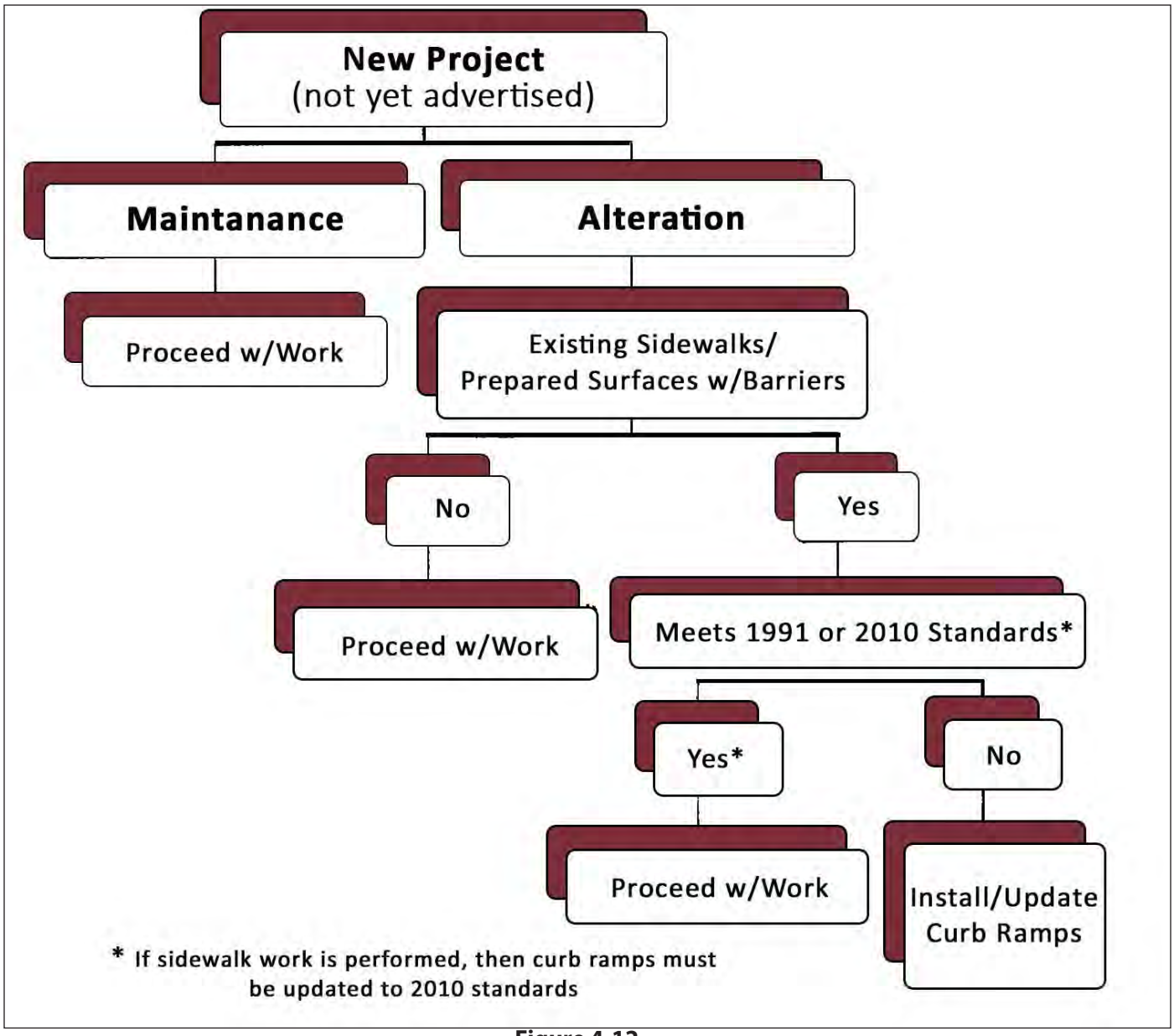


Figure 4-12
Flow Chart for Curb Ramp Revisions

Channelized Islands:

In situations where a pedestrian must cross an uncontrolled, channelized lane, such as a channelized right turn lane, the pedestrian treatment should be placed in the channelizing island. The island should be of sufficient size to accommodate ADA treatments for access to the pedestrian button. Appropriate crosswalk markings and signage should be provided on the uncontrolled channelized lane. Consideration should be given to the impact that trucks may have on the channelizing island (i.e. is sufficient turning radii provided to prevent trucks from running up on the island and hitting the pedestrian pole). If it appears that the island is not large enough or the turning radii is not sufficient, the island should not be used and the right turn movement should be included in the signal and stop controlled.

Crosswalks :

If a crosswalk is marked, it creates a 'path' and pedestrian heads should be installed. Therefore, crosswalks should be provided based on the conditions at the intersection, namely signal phasing, existing or expected pedestrian patterns, and safety. One or more crosswalks may be provided across the mainline roadway, based on engineering judgment. If only one crosswalk is provided across the mainline, adequate direction in the way of signs or marking should direct pedestrians to the crossing location. Pedestrian signals must be in place at each end of each marked crosswalk at the intersection, see MUTCD 4E.04 F.

Installation of Pedestrian Detectors only (usually push buttons)

Pedestrian detectors allow minimal interruption of the normal signal operation and should be considered prior to the installation of both pedestrian signal heads and detectors. Pedestrian detection should be provided at all actuated or semi-actuacted traffic signals, unless determined not to be an appropriate pedestrian crossing. When pedestrian crossings are not appropriate, they should be restricted by signing.

Installation of Pedestrian Heads only:

Installation of pedestrian heads without pedestrian buttons may be appropriate in downtown business districts and other areas where pedestrian traffic is crossing regularly during business hours. Pedestrian heads may be installed without detectors, if sufficient crossing time is provided and the pedestrian phase is recalled each cycle, for the phase that is always on recall or for pre-timed operation.

Installation of Pedestrian Signal Heads & Detectors

The installation of pedestrian signal heads typically requires a larger cycle length to accomodate the Walk and Pedestrian Clearance signal settings. Pedestrian signal heads should be installed if a pedestrian path exists. A pedestrian path can be the presence of a marked crosswalk, presence of a sidewalk, or simply a worn out pedestrian path adjacent to the roadway.

if the traffic signals meet any the following conditions consider installing pedestrian heads and buttons:

- The signal will currently meet the Pedestrian Signal Warrant, per Section 4E.03 MUTCD.
- The crossing at the signal is an obvious established school crossing.
- An exclusive, protected phase is available for pedestrians in one or more directions.
- Where the signal phasing may be confusing to the pedestrian as to when to cross.
- At signals where pedestrians cannot see the traffic signal heads to make a crossing decision

Two Stage Pedestrian Crossing

SCDOT typically prefers having pedestrians cross the entire street without a stop in the median, however the following may be used in making a decision on two stage crossing operation:

- A two-state crossing requires a median that is sufficiently wide enough to store pedestrians.
- Providing sufficient pedestrian timing for one stage crossing is extremely detrimental to signal operation, resulting in severe delays and queuing

If two stage crossing is implemented:

- Additional detection should be provided in the median area.
- Appropriate signing should be provided to clearly direct pedestrians in safely navigating crossing

Pedestrian Hybrid Beacon

In locations where a signal may not be warranted or at midblock crossings, a pedestrian hybrid beacon may be installed as a pedestrian treatment. TG-26 Pedestrian Hybrid Beacon Guideline gives guidance on when this treatment may be approved. See **Figures 4-50c,d** for example plans. Although this treatment is classified as a beacon, a signal cabinet, controller is required to operate the Pedestrian Hybrid Beacon.

HAWK Design

Timing: The ability to balance the needs of the pedestrian and the delay of the driver is a valuable component of the pedestrian hybrid beacon. Extensive red light time when pedestrians no longer need it to cross safely can encourage violations. The flashing yellow interval typically lasts for five seconds. The duration of the solid yellow light should be calculated based on existing field conditions and the SCDOT Traffic Signal Design Guidelines.

The solid red light displayed to drives is equal to the pedestrian walk indication. The flashing red indication is the same as the flashing hand indication for the pedestrian countdown head and is determined by the width of the crossing.

Signing and Marking: A pedestrian hybrid beacon shall be used in conjunction with signs and pavement markings to warn and control traffic at locations where pedestrians enter or cross a street or highway. A Crosswalk Stop on Red (symbolic circular red) (R10-23) sign shall be mounted adjacent to a pedestrian hybrid beacon face on each major street approach. If an overhead pedestrian hybrid beacon face is provided, the sign shall be mounted adjacent to the overhead signal face.

A Pedestrian (W11-2) warning sign with an AHEAD (W16-9P) supplemental plaque shall be placed in advance of a pedestrian hybrid beacon. A warning beacon may be installed to supplement the W11-2 sign, which, if installed, should be programmed to flash only when the pedestrian hybrid beacon is not in the dark mode.

A pedestrian hybrid beacon shall only be installed at a marked crosswalk. A stop line shall be installed for each approach of the major street. A pedestrian hybrid beacon may be installed at midblock or at intersections where the side street is controlled by a stop sign. Both applications are illustrated in the following example plans. Pedestrian hybrid beacons should not be placed in proximity to signalized intersections. There shall be a minimum of 300' distance between any proposed hybrid beacon and a signalized intersection.

An example signal sequence is shown in MUTCD **Figure 4F-3** and shown below:

Example Signal Sequence:

Figure 4F-3. Sequence for a Pedestrian Hybrid Beacon

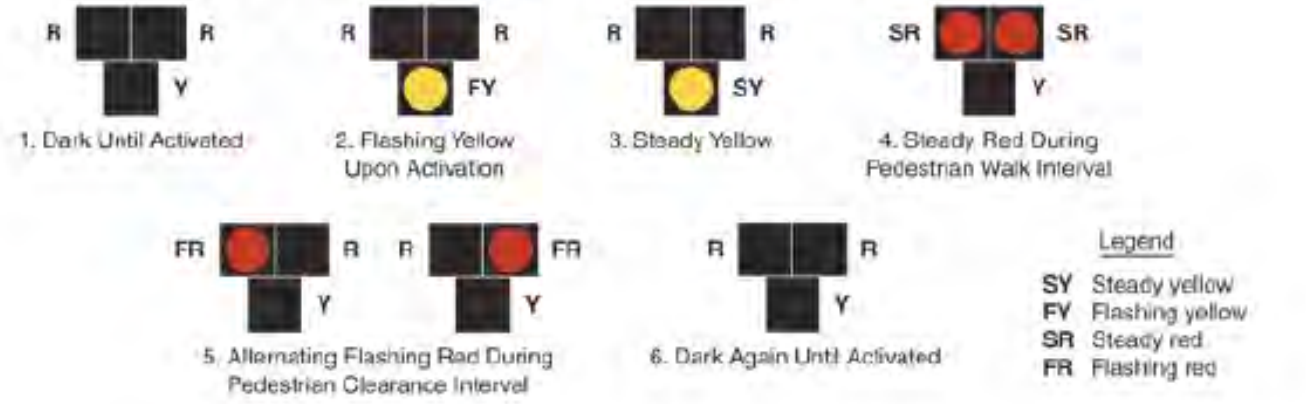


Figure 4F-3, Manual on Uniform Traffic Control Devices, 2009 Ed.

Placement of Pedestrian Signal Heads, Buttons, Signage

- Pedestrian heads should be placed where they are clearly visible within the entire crosswalk.
- When not activated, and if sufficient time does not exist during the minimum green time for the active phase, the pedestrian signal head displays should rest in the solid hand mode. If adequate time is available in the minimum green time, the pedestrian signal head display may operate without activation.
- Pedestrian buttons should be placed in accordance with MUTCD see **Figure 4-13.**
- Pedestrian detectors (buttons) or heads should be supplemented with the use of proper signs to indicate appropriate signal use for pedestrians and/or to provide explanation and guidance to the use of the detector (R10-3e, R10-4).
- Engineers should consider installing the following signs based on engineering judgement :
  - No Turn on Red (R10-11)
  - Turning Traffic must Yield to Pedestrian (R10-15)
  - Other tools for more complex pedestrian crossings include blankout signs restricting right turn movements or right turn Flashing Yellow Arrow (FYA) signal heads

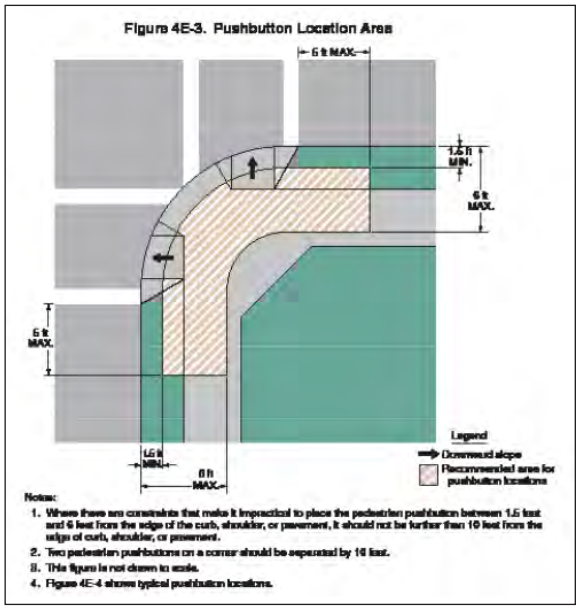


Figure 4-13

Push Button Location Area MUTCD 4E-3

Countdown Signal Heads

New and replacement pedestrian signal heads will use raised hand and walking man with countdown pedestrian heads and should comply with SCDOT Material Specifications Section and QPL.

Accessible Pedestrian Signals (APS)

Accessible Pedestrian Signals consists of pedestrian equipment that is audible or vibro-taactile or both to provide additional guidance to visually impared pedestrians. Installation is site specific and based upon request. All requests for APS shall be reviewed by the District Traffic Engineer. For additional information see sections 4E.09 through 4E.13.

Restricting Pedestrian Traffic

Engineers may determine that allowing pedestrian movements would present a serious consistent safety concern. In these cases, pedestrian crossings should be prohibited by using R9-3-12 (NO PEDESTRIAN CROSSING) signing. Restricting pedestrians at a particular intersection can be accomplished through appropriate signing and guidance, to preferable crossing locations.

Signal Cycle

After the signal phases are determined, engineers use turning movement counts to determine critical green times for each signal phase (see **Figure 4-3**).

Although not shown on the Signal Settings Chart, determining the signal cycle is vital to providing a basis for signal system operationss. Signals in a system must have the same cycle length (or a multiple such as double or half cycles) to provide progression with the offset settings. See **Chapter 6** Signal Systems for more information. The signal cycle is the sum of the maximum green settings, the yellow change and the red clear settings for each non-compatible phase. The signal may not operate a full cycle each time, since some phases may 'gap out' or even be skipped, based on lack of demand. This is true, especially in non-peak traffic times. Signal cycles should be as short as possible, to reduce delay and to serve each phase as many times as possible during a peak hour.

Cycle Length Calculation Example :

Sum the larger values of:

Phases 1 and 5 (maximum green plus yellow plus red) +

Phases 2 and 6 (maximum green plus yellow plus red) +

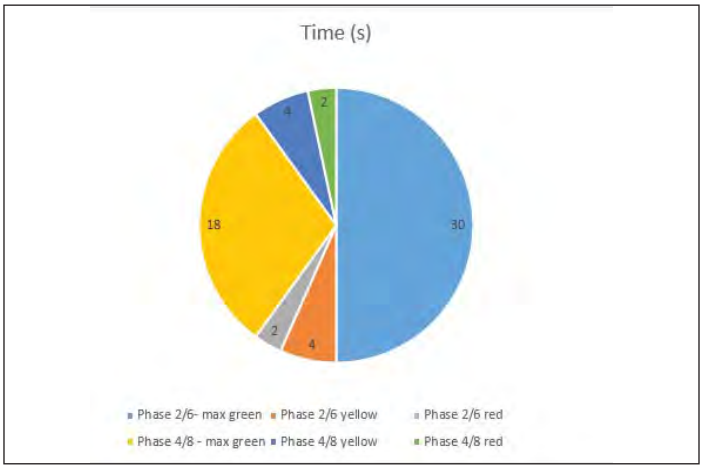
Phases 3 and 7 (maximum green plus yellow plus red) +

Phases 4 and 8 (maximum green plus yellow plus red) = ***Maximum Cycle Length***

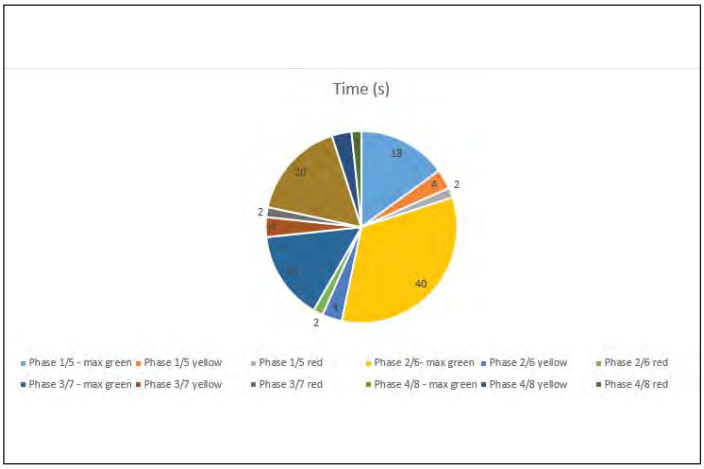
Table 3-4 Planning-level cycle length assumptions

Signal Complexity	Commonly Assumed Cycle Length(s)
Permissive left turns on both streets	60
Protected left-turns, protected-permissive left turns, or split phasing on one street	90
Protected left-turns, protected-permissive left turn phasing, and / or split phasing on both streets	120

Figure 4-14
Planning Level Cycle Length Assumptions (FHWA Traffic Signal Timing Manual, 1st edition)



60 second cycle length (2 phase)



120 second cycle length (8 phase)

Figure 4-15
Example Cycle Lengths

Signal Plans

(1) Signal plans shall be signed and sealed by a South Carolina Professional Engineer (PE) seal.
(2) Signal plans are the property of the District office and/or the local government.
(3) Every effort should be made to load CADD files and electronic images of signal plans on the SCDOT Signal Inventory program for easy access.
(4) Plans for flashing beacons are more schematic in nature and do not require a PE seal.
(5) A record of the location and type of signal flashing beacon should be maintained within the SCDOT Signal Inventory program.
(6) Signal plans should include accurate depictions of rights-of-way (referenced back to file # or deed, per Instructional Bulletin No. 2012-2, pavement markings, signal head placement, span wires, driveways, sidewalks, control of access, and also should indicate signal timings, speed limits, grades, route names and numbers, adjacent development, coordination details etc. Example signal plans are shown in **Figures 4-50a amd 4-50b**.

Roadway Geometry

Signal plans should be drawn to scale, depicting roadway elements including lanes, markings, sidewalk, poles and other elements to depict proposed conditions. For roadway projects, engineers should use the roadway design plans and the signing and marking plans to develop signal plans. For signal upgrade projects where no roadway improvements are planned, engineers may use roadway plans from plan library or aerial images to develop more schematic signal plans that are generally drawn to scale.

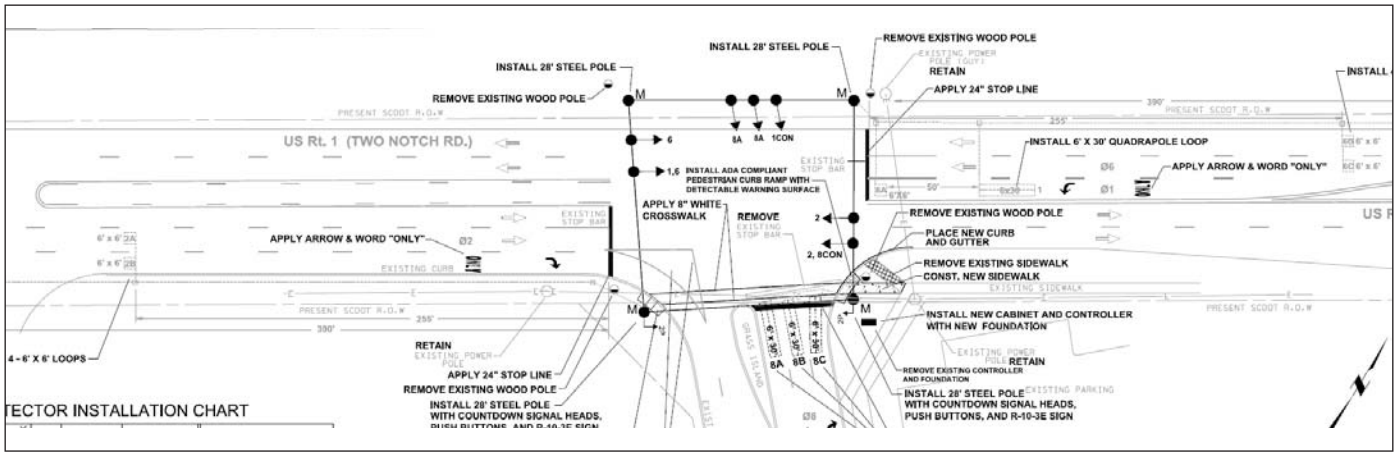


Figure 4-16
Example Roadway Geometry

Signal plans should depict graphical information showing conduit, splice boxes, signal support poles, detection, signal heads, span wire, messeger wire, signal cabinet and pedestrian features. All signal equipment is shown on the signal plan but not 'to scale' as signal construction is heavily reliant on location of overhead and underground utilities. Utility survey information is generraly not available, therefore actual placement of signal equipment is field determined by the contractor in accordance with the standard drawings and utility coordination. In addition to signal equipment, markings should be shown, including stop bar, arrows, crosswalks and painted islands. Any signage related to the signal should be details, as well as shoulder mounted signals that are pertinant. Sidewalks, curb ramps and islans should also be shown. Intersecting roadways or driveways within 400 feet along the mainline and within 200 feet along the side street should also be shown.

Right-of-Way information

Existing and proposed right-of-way should be shown on the signal plan in accordance with SCDOT Instructional Bulletin No 2012-2 Verification of Present Right of Way (R/W) on plans prepared by or for SCDOT. The right of way is to be verified and noted on the plans indicating the right of way width measured from the centerline and the source of verification (initials of the designer).

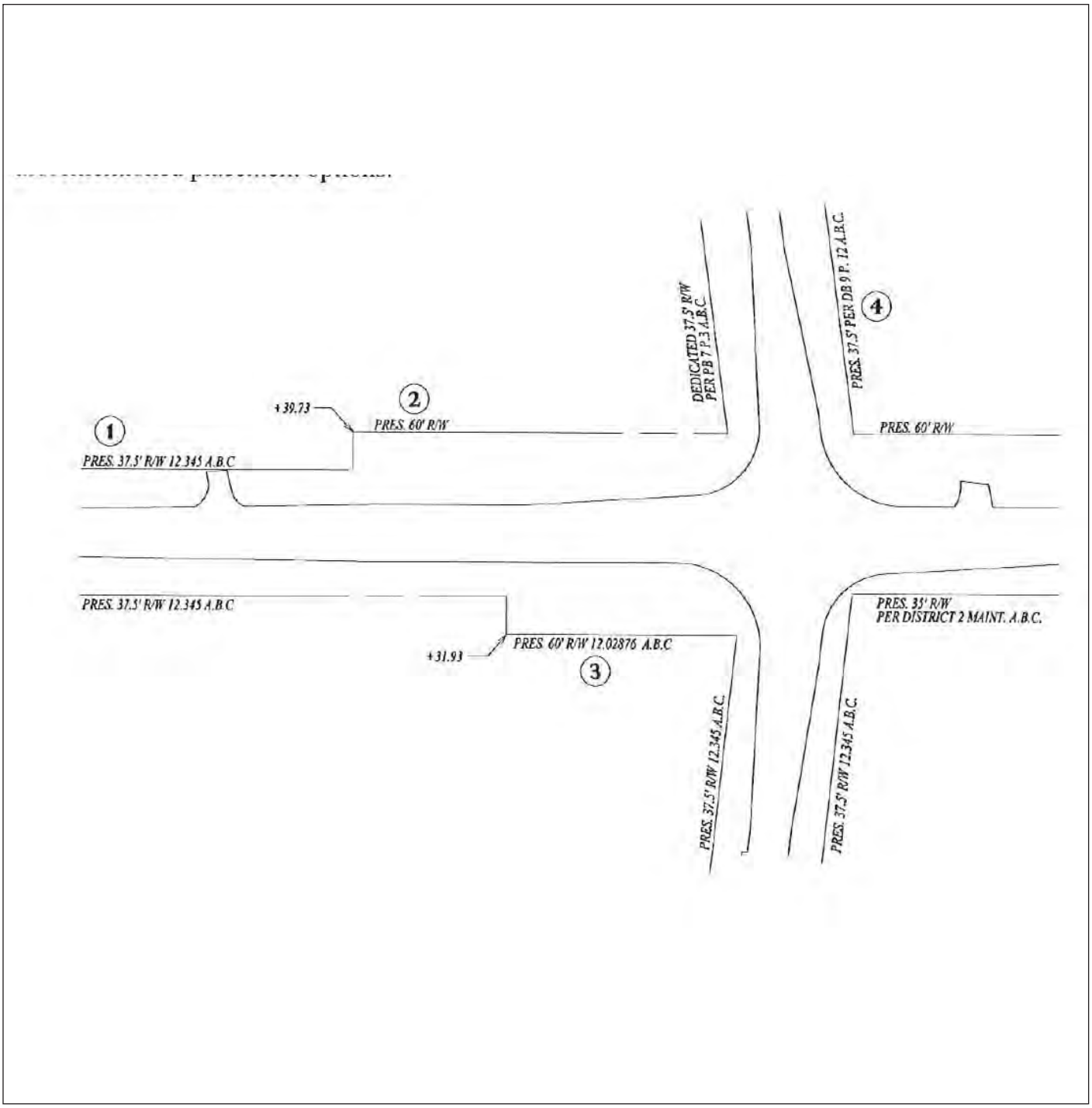


Figure 4-17
Example R/W Labeling

Placement of Signal Equipment

Signal Heads

Placement - Signal heads should be located between 40' and 180' from the stop bar for each approach. There should be a minimum of two signal heads per approach, and they should be within a 20-degree cone of vision. Signal heads should have a minimum spacing of 8' apart and a maximum spacing of 16' apart. There should be one (1) signal head per lane for each through lane. The vertical clearance from the pavement to the bottom of the signal head shall be 17-19'. See SCDOT Standard Drawings.

Size - The SCDOT uses 12" section signal heads as a standard installation size. In special situations, 8" signal heads maybe used, such as the bottom yellow on emergency flashers or the far-side green at a timed overlap for clearance.

Visibility - The signal heads should be visible for the minimum distances shown in the Manual on Uniform Traffic Control Devices Chapter 4 for various approach speeds. If this visibility cannot be achieved, a near-side signal head should be installed to provide appropriate visibility.

Back plates w/ 2" Yellow Retroreflective Border (Type XI-eleven) - The back plate with retroreflective border should be used for all approaches on signals with 45 mph or greater approach speed. See Standard Drawings for installation details.

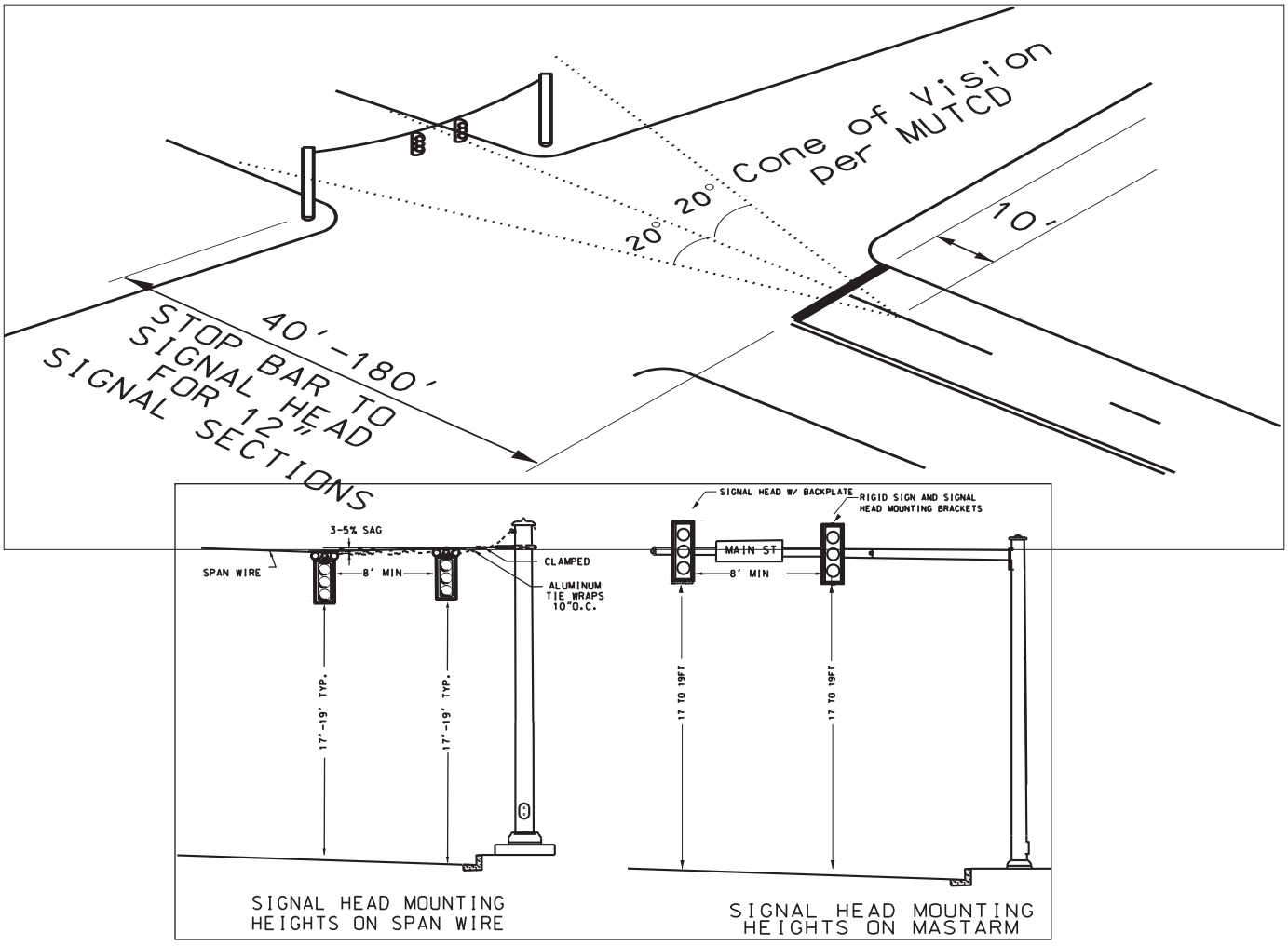


Figure 4-18
Signal Head Placement

Signal Cabinet

Visibility **-**The signal cabinet should be located to prevent sight distance blocking for motorists making a right turn on red. In addition, the cabinet should be placed to allow a signal technician visibilty of the intersection when working on the cabinet.

Placement - The signal cabinet should be located as far as possible from the edge of roadway and adjacent to the signal support structure in that quadrant. The cabinet is generally in the quadrant closest to the electrical transformer. The electric service is also located close to the signal cabinet, generally on a signal pole or seperate pole or pedestal.

If a rebuild project requires replacement of the existing signal cabinet, in general all new span wire, signal heads, cable for signal heads should be installed for ease of transition.

Size **-** The standard cabinet to be installed is a 332A Cabinet, which is base mounted. A smaller 336S cabinet can be installed either on a signal pole or base mounted, if right of way and space is severly limited (such as a downtown location where buildings are very close to the roadway). A 336 cabinet does not have a lot of spare room for communications equipment, therefore provisions should be made if communications equipment is needed.

Aesthetic Treatment **-** Traffic Signal Cabinets are constructed of aluminum and have a natural silver metallic finish. Aesthetic elements such as powder coating of one solid color (black, green or brown) or vinyl wraps are not standard equipment for SCDOT but are acceptable under approved encroachment permit or other agreement, such as a Financial Participation Agreement (FPA) within a construction project. Although powder coating or vinyl wraps are the only acceptable methods of aesthetic treatment. SCDOT prefers the vinyl wrap treatment over powder coating since the vinyl wrap can easily be removed with little cost outlay if issues arise. Artistic renderings painted directly on the cabinet are not acceptable.

Installation

- These aesthetic treatments can be installed upon approval of an encroachment permit submitted by the appropriate local government.
- All costs associated with these aesthetic treatments are the responsibility of the local government.
- If this treatment is desired by the local government during an SCDOT construction project involving signal reconstruction or installation, this treatment must be included in the agreement between SCDOT and the local government. The local entity will be required to pay the ENTIRE difference in cost associated with the aesthetic treatment.
- The installation has to be performed under the supervision of the appropriate signal maintenance staff and SCDOT will inspect the installation
- The aesthetic treatment must not interfere with the ventilation of the cabinet
- The aesthetic treatment must not cause the temperature to go up in the cabinet. An additional fan may be required (at the local government's expense) installed to mediate this issue.
- Advertisement is not allowed on the traffic signal cabinet.
- SCDOT reserve the right to review aesthetic treatment for content and to deny any treatment that may be a distraction to the motoring public

Maintenance

- The local government is responsible for maintenance of aesthetic treatment. The Department will not maintain the quality of the aesthetic treatment
- If any operational issues arise, SCDOT reserves the right to remove the treatment or require the local government to replace the cabinet.
- Although the Department will coordinate with local governments concerning needed equipment replacement, if cabinets are changed out, SCOOT is not responsible or liable for the aesthetic treatment. SCDOT is not obligated to replace in kind whenitems require replacement due to malfunction or age
- SCDOT reserves the right to remove any aesthetic treatments that are in disrepair.

Pedestrian Treatments
Placement of pedestrian treatments are described earlier in this chapter.

Detection
Placement and types of detection are described later in this chapter.

Conduit / Splice Boxes
Splice Boxes - Each signal support pole shall have a splice box installed adjacent to accommodate conduit connections for electrical cable and signal equipment. Signal splice boxes shall be installed along conduit runs approximately on 150' spacing. Typical size for splice box is 13' x 24" x 18". Larger splice boxes shall be installed at the signal cabinet and for underground fiber communications runs, 17" x 30" x 24". More information concerning splice boxes is provided in Chapter 5, SCDOT Traffic Signal Supplemental Technical Specifications and SCDOT Standard Drawings.

Conduit - All electrical cable should be placed in conduit runs. Placement of conduit and splice boxes shall be shown behind the sidewalk or adjacent to the edge of the roadway. Conduit can be installed in a variety of ways with various types of conduit. Schedule 80 PVC is the most common electrical conduit used. HDPE (High Density Polyethylene) Rolled Conduit is also used. Conduit is generally trenched, however, under driveways and roadways conduit is installed by directional boring. Common sizes for PVC conduit is 1", 2" and 3".

Trenching/Riser
The typical installation method for Schedule 80 PVC is trenching. Trenching is accomplished either by hand digging or mechanically using a ditch witch. Schedule 80 PVC conduit is also installed on poles as risers. Risers are attached with steel bands.

Directional Boring
Where conduit runs intersect driveways or roadways, directional boring is most commonly used. Directional boring uses HDPE rolled conduit.

Conduit for Inductive detection
At the edge of the roadway, a 1" conduit should be provided from the sawcut(edge of roadway) to the splice box. If sidewalk is present, the conduit is installed under the sidewalk to the splice box by directional boring, drilling or other acceptable method.

More information concerning conduit is provided in Chapter 5, SCDOT Traffic Signal Supplemental Technical Specifications and SCDOT Standard Drawings.

Typical Signal Signs
Typical signal signs can be used to improve the safety or operation at a stop and go traffic signal. Guidelines for their use can be found in the Manual on Uniform Traffic Control Devices.

Street Name Signs
Street name signs can be placed on signal span wires or mast arms by local governments. SCDOT does not particpate in maintenance of street name signs. Street name signs should typically be placed between signal heads if the sign does not intefere with the proper placement/spacing of the signal heads. Mounting hardware for signs on span wire are incidental to furnish and install pay item for overhead signs, however additional pay item must be provided for furnish and install pay item for overhead signs mounted on mast arms.

Overhead Lane Control signs should be used for signalized intersections that include lane drops, multiple-lane turns, shared thru-turn lanes, and other unexpected lane use.

Overhead Regulatory signs common at signals are shown below:

R10-12A

R10-12

R10-11

R10-15

R10-6

Signal Support Poles

Placement -

SCDOT's typical signal design consists of four signal supports, one in each quadrant. Signal support poles should be 5' to 10' from the edge of the roadway when curbing is present. The standard drawings allow signal poles to be a minimum of 2' from face of curb, however this distance does not accommodate future sidewalk or pedestrian treatments. Where no curb is present, signal poles should be place 10-15' from edge of the roadway. The heights of the poles should be determined by the length of the span between poles and the height of existing utility lines. Pole placement should consider both overhead and underground utilities.

In general In accordance with Preconstruction Design Memorandum 13 (PCDM-13 dated 1/10/2018) - Depicting Proposed Signal Poles and Signal Cabinets on Roadway Design Plans, roadway design plans shall depict the approximate location of all proposed signal poles and signal cabinets in order to adequately address right of way needs and potential utiltiy conflicts. These locations shall be identified during the Design Field Review (DFR) and when signal plans are developed, the proposed locations should match the locations shown on the roadway plan set. All other signal elements are located schematically and not generally to scale.

Signal Span Wire

The SCDOT standard placement for signal support poles is one pole in each quadrant, resulting in a box span wire configuration, using 3/8" galvanized steel cable. Span wire allows signal support placement to be quite flexible and field conditions may require signal pole placement to be more trapezoidal than square in nature. If appropriate distances between signal heads and stop bar cannot be achieved with pole to pole spans, modifications to the span can be made. A modified box span can also be used for optimum signal head placement at wide intersections or to accomodote skewed intersections.

Messenger Cable

Messenger cable (1/4" galvanized) should be used to provide overhead cable connections such as communications cable (fiber) or detection home run cable.

Selection of Signal Support Type:

Steel Poles

Steel poles are SCDOT's standard signal support pole. Every effort should be made to provide four steel poles, one per quadrant. The typical steel pole height is 28' for two to three lane section roadways. Five lane section or wider roadway sections may require 32' steel poles. In areas where roadways are narrow and overhead utilities are low, 26' steel poles may be required. Foundations for steel poles are detailed in the SCDOT Standard Drawings and Traffic Signal Supplemental Technical Specifications. Steel poles provide internal conduit for electric cable and communications.

Steel poles are easier to install than concrete poles. Steel Poles can be powder-coated to provide a more aesthetic look to the traffic signal. Pedestrian poles, signal heads, pedestrian heads may also be powdercoated. These treatments typically add very little cost to the overall signal installation costs, however if project budgets are limited, local governments may be asked to participate in the cost to obtain this aesthetic treatment.

Wood Poles

Wood poles are not typically used unless the signal is placed in an area that is scheduled for construction. If wood poles are installed, back guys must be installed, requiring sufficient right of way for 1 to 2 back guys. Wood poles are the least expensive signal support pole, however all electric cable must be run in riser attached to the outside of the pole. In addition, pedestrian treatments are also installed on the wood pole, which can crowd the wood pole. Wood poles also tend to lean and should be replaced more often than steel or concrete poles.

Typical wood poles used at signals are 35' or 45' wood poles. Wood poles are placed in drilled holes and backfilled with clean earth or sand.

Concrete Poles

Concrete poles are typically used at very wide intersections because they can support span wire spans without the sag that may occur with steel poles. Concrete poles require boom trucks to install due to the weight , therefore they are more difficult to install . Concrete poles also have conduit interior for electric cable.

Typical concrete poles used at signals are 35' or 45' in length. Concrete poles are placed in drilled holes and backfilled with Class 3000 concrete. Concrete poles provide internal conduit for electrical cable and communications.

Utility (Shared Use) Pole

If there is not sufficient room or right of way to install steel poles, signals span wire can be installed on existing utility poles. Utility coordination is required to obtain permission to attach span wire, back guys and conduit to shared use poles. As indicated with the wood pole description above, any electric cable must be installed in riser (conduit) and attached to the pole, as well as pedestrian treatments, if pedestrian poles are not installed.

Mast Arm Poles

Mast arms are not the SCDOT Standard for signal support poles. Mast arms are typically more expensive than steel or concrete poles and require extensive underground utility coordination and conduit placement. In addition, mast arms require greater lead time in ordering and delivery. Lastly, mast arms must be sufficiently long to accomodate signal head placement over left turn lanes. Therefore in most cases, mast arms are not the most feasible option for signal supports.

Mast Arm Feasibility

During signal design the following issues may arise that could indicate that mast arms may be more feasible to facilitate signal installation than SCDOT's standard steel pole installation, one per quadrant.

- Insufficient right of way to allow signal poles in each quadrant, when right of way procurement will unduly delay the project or cost to buy the right of way is more than installation of a mast arm in another quadrant
- Overhead utility issues that restrict installation of steel poles in each quadrant
- Underground utilities that restrict installation of steel poles in each quadrants
- Unique lane arrangements that require rigidly mounted signal heads for safety, such as

If Mast Arms are the most Feasible Option - If SCDOT determines that mast arms are the most feasible option, then SCDOT will approve the mast arm installation as part of the project, with no additional cost to the local government and no requirement for mast arm maintenance for the local government.

If the local government is requesting mast arms as part of the signal design, then the local government should conduct an engineering study to determine if mast arms are the most feasible design option. The engineering study should be reviewed by the appropriate District Traffic Engineer (DTE). The DTE shall make a decision on feasibility of mast arms versus SCDOT standard signal supports SCDOT to determine feasibility as this affects the cost of the signal installation.

When funding has been identified and obtained for roadway work and traffic signals are included in said funding, and circumstances indicate that mast arms are the most feasible, no agreement is needed and SCDOT will include mast arms in the design of said improvements and maintain the mast arms.

If Mast Arms are not the most Feasible Option

SCDOT recognizes that local governments often desire mast arm installations for aesthetic purposes. Since, mast arm installation costs typically exceed the costs of standard signal installations using span wire and steel poles, funding for said mast arms should be provided as discussed in Engineering Directive 33, SCDOT Mast Arm Standards. A Financial Participation Agreement (FPA) should be prepared to detail cost responsibilities using following chart.

Information needed to include Mast Arms in Projects
The following information should be obtained to appropriately design mast arm signals and prepare agreements for financial participation and maintenance.

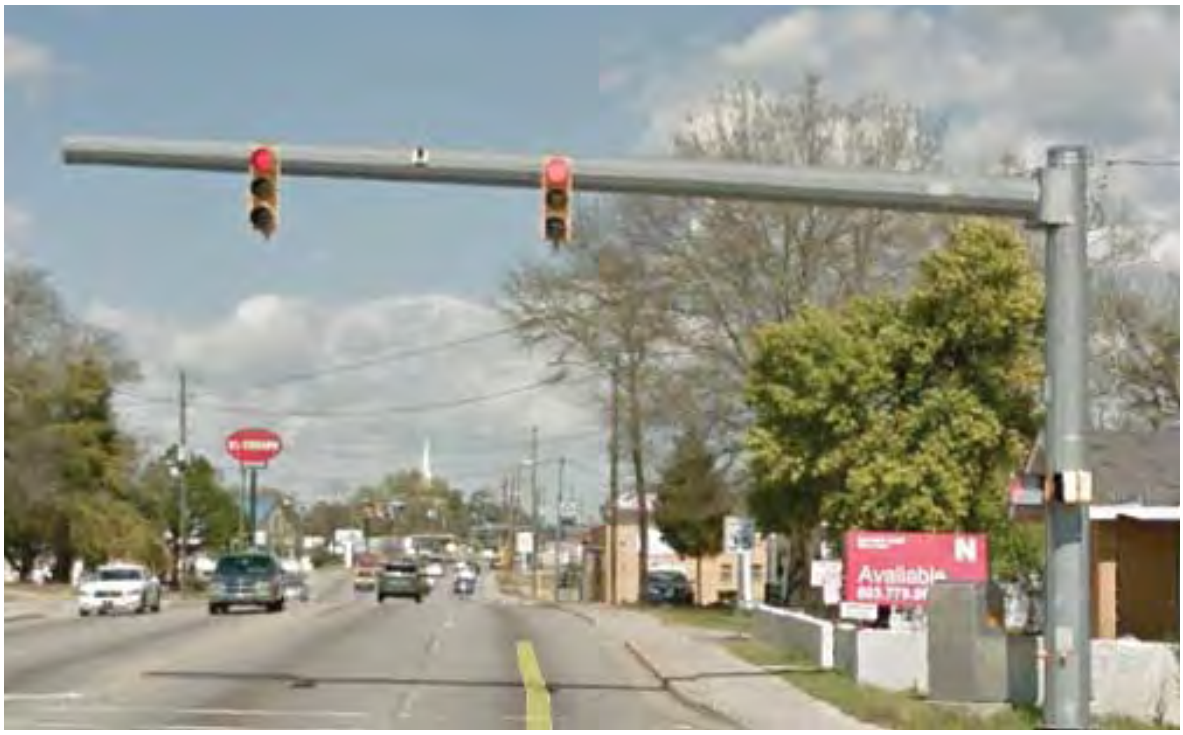
	Information needed to include Mast Arms in Projects	
1	**Who is responsible for signal design?** ***(local government, consultant or SCDOT staff)***	
2	**Who is responsible for mast arm foundation / mast arm signal support design?** ***(local government, consultant or contractor)*** *This is not always the same entity as who performs the signal design*	
	• If local government provides the design: ***include said design in plans for better pricing during letting.***	
	• If the design is to be included as a pay item and is the responsibility of the contractor: ***consider using pay item 6888174 for mast arm foundation installation including concrete and rebar that uses CY as unit cost.*** *Since the size of the foundation can only be estimated prior to the letting, using the CY measured pay item requires less risk to the contractor when pricing the design/furnish/install mast arm cost.*	
	• When will the geotechnical study be completed to determine the soil type at the location? ***(prior to letting or after letting within 'design, furnish & install' pay item)*** *The soil type and length of arm determines the size of the foundation.*	
	• Ensure the designer designs for the worst case scenario loading, either as indicated in the SCDOT specifications or what is provided on the signal plan	
	• How many mast arms are required, and are they dual arms or single arms? *Many designs try to minimize the number of mast arms by using 2 dual mast arms.*	
3	**Who will furnish the mast arm?** ***(Local government or contractor)*** *This information is needed to determine what pay items are needed.* If the local government is providing the mast arm, they should also provide the mast arm foundation / mast arm signal support design, as this is typically done by the mast arm vendor. The pay items to be included in the project should be install mast arm, install mast arm foundation. Also, if project is federally funded, and the local government provides the mast arm, a public interest finding must be submitted and approved by SCDOT. Federally funded projects typically require contractors to provide all materials not listed in a public interest finding.	
4	**Who will install the mast arm?** (***Contractor or local government)***	
5	**What type of mast arm is desired ?** (***standard or decorative with fluted arms),*** ***decorative items such as skirt or other decorative features.*** ***powdercoated color, over base or over galvanized?*** **Should the mast arm match other mast arms in the area?** ***If so, local government should provide details/specifications of decorative elements.***	
6	**Is luminaire desired, what type?** ***(above the mast arm or below the mast arm)*** If so require local government to provide luminaire type/ design/ specifications and placement. The luminaires mounted above the mast arm requires a taller pole than the standard mast arm (See standard drawing 675 115-02 (Traffic Signal Pole with Mast-arm). Ensure a pay item is included in the project to furnish and install the luminaires and the mounting hardware.	
7	Who will be responsible for future maintenance of the mast arm?	
8	***Is Agreement needed?*** ***F*inancial Participation Agreement detailing financial responsibilities** ***(local governments pay for the decorative elements)*** **Maintenance Agreement** ***(not needed is local government is already participating in Signal Maintenance Agreement)***	
9	**Ensure signal design package addresses the additional engineering and coordination during construction.** *There is typically a 6 month waiting time between ordering and delivery of mast arms, once the mast arm lengths and field locations have been mutually determined by contractor and SCDOT.*	

Methods to install mast arms

1. Mast arms can be installed as part of a typical construction letting managed by SCDOT
2. Local governments may use the Fixed Price On Call Signal Contract to install mast arms with their own funding. There are over 10 signal contractors that have agreed to the fixed prices in the contract that can be contacted by the local governments to determine if the contractors will honor these prices for local government work.
3. Local governments will be required to apply for an encroachment permit to perform any work on SCDOT right of way.

Encroachment Permit Requirements For Mast Arm Installation

- A mast arm agreement must be in place between SCDOT and the appropriate local government prior to installation of mast arms. SCDOT shall not enter into a mast arm agreement with a private entity.
- All work must be performed under an approved encroachment permit or within the scope of signal work planned during an SCDOT construction project. The local government must be the applicant on the encroachment permit.
- Mast arm installation, necessary conduit placements, and signal head or sign installation (directional boring, wiring, signal head placement, etc.) shall be the responsibility of the local government and performed by an SCDOT approved contractor.
- All signal work shall meet SCDOT Standard Specification for Highway Construction, Signal Standard Drawings and SCDOT Signal Specifications and conform to the Manual on Uniform Traffic Control Devices (MUTCD). The local government or the SCDOT-approved contractor shall contact the appropriate SCDOT signal shop at least two weeks prior to beginning the installation.
- The local government shall be responsible for maintenance of the traffic signal during installation and responsible for any work required for up to sixty days after construction (typical burn-in period).
- The local government shall include a signal plan with the permit. This plan shall be developed within the guidelines and format of SCDOT's standards and specifications and stamped by a professional engineer.
- The local government shall be responsible for mast arm and foundation design and provide approved drawings stamped by a professional engineer. The local government shall also be responsible for maintenance, repairs, and replacement of mast arms, all associated hardware in or on the mast arm, all conduit maintenance and replacements, and signal head attachments throughout the use of mast arms at the signal location.
- The local government or the SCDOT-approved contractor shall contact the appropriate SCDOT signal shop at least two weeks prior to beginning the installation.
- Documentation for each mast arm, as indicated on the Mast Arm Information form, must be provided with the encroachment permit application. This documentation should include manufacturer cut sheets and specifications. A copy of this information should also be retained by the local government.
- SCDOT shall approve the desired color of the mast arm. The manufacturer information and color code shall be included on the mast arm information form. Mast arms are to be powder-coated, not painted.
- Electrical service meter enclosure must be in accordance with SCDOT specifications.
- The design engineer shall ensure that conduit runs are sufficient and of proper size to meet the electrical codes for the required number of conductors. The controller conduit must be placed in the controller pole.
- Luminaries on top of the mast must be separately metered, since SCDOT will not pay electricity costs for these devices.
- The local government must perform an annual inspection of all mast arms and certify that the mast arms are in good repair. A copy of these inspection forms must be sent to the appropriate SCDOT signal shop, along with photos of the mast arms. Any visual damage to mast arms must be detailed on the inspection form. SCDOT reserves the right to require the local government to replace damaged mast arms. If the local government does not have sufficient funding to replace a mast arm, SCDOT will install a wood, concrete, or steel pole and span wire mount the associated signals until the local government can fund the mast arm replacement, as stipulated in the Emergency Repairs section.



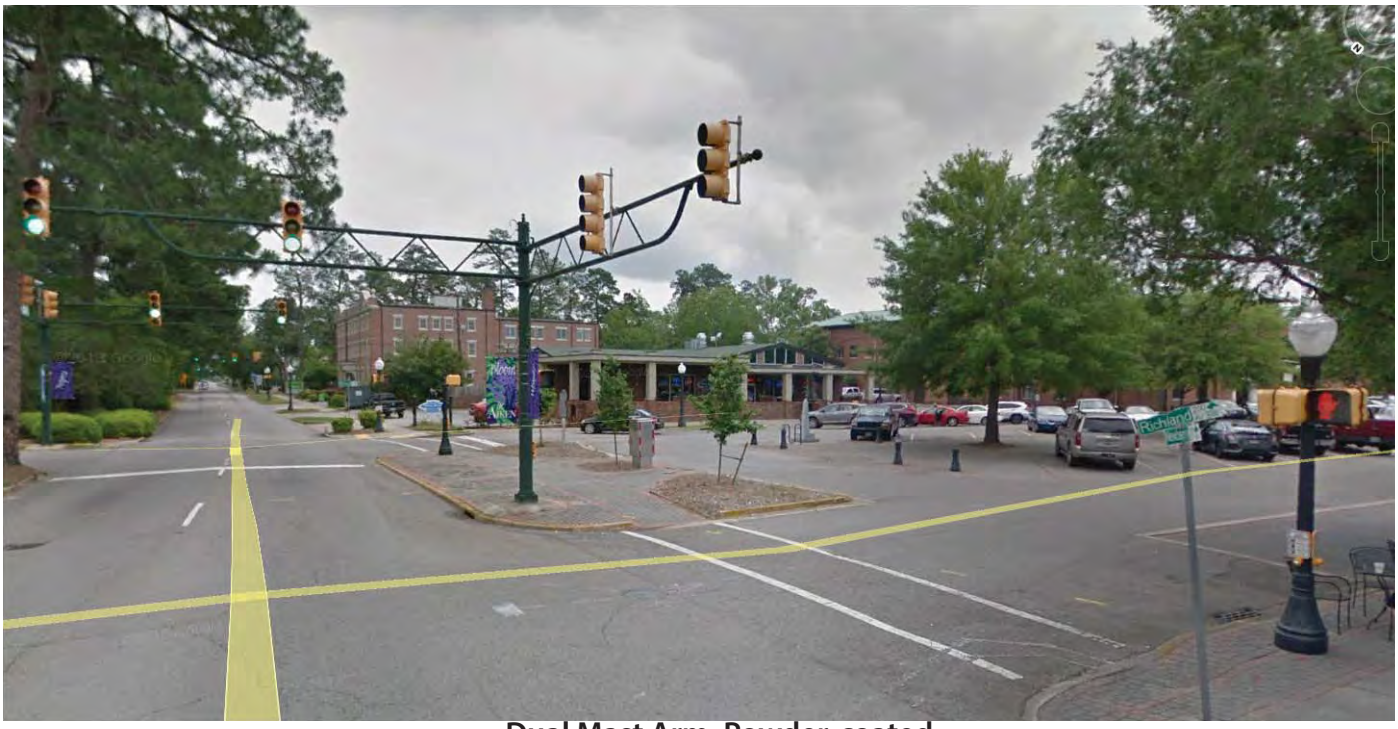
Single Mast Arm, Galvanized, Non decorative, no luminaire
Standard yellow pedestrian heads and signal heads

Dual Mast Arm, Galvanized, Non- decorative, with luminaire
Standard yellow pedestrian heads and signal heads

Single Mast Arm, Powder-coated, Non- decorative, no luminaire, Powder-coated pedestrian heads and signal heads

**Single Mast Arm, Powder-coated, Decorative (skirt), Luminaire (below mast arm)
Standard Yellow pedestrian heads and signal heads
Decorative/Powder-coated pedestrian poles**

**Dual Mast Arm, Powder coated, Non- decorative, with luminaire mast arm
Powder-coated pedestrian pole, standard yellow pedestrian heads and signal heads**



Dual Mast Arm, Powder-coated,
Decorative (skirt, truss style arm), no luminaire
Standard Yellow pedestrian heads and signal heads
Decorative/Powder-coated pedestrian poles with luminaires (for street lighting)

Dual & Single Mast Arms, Powder-coated,
Decorative (skirt, fluted), no luminaire
Standard Yellow pedestrian heads and signal heads
Decorative/Powder-coated treet light pole used as pedestrian poles

Mast Arms with arched arms

Skirt for Mast Arm

Decorative mast arm cap

Adapter Plate for Mast Arm

Mast Arm Inspection form

Inspector: _____ Inspection date: _____

County: _____
Mast Arm Maintaining Agency: _____
Custom ID Signal: _____
Signal Location: _____

Route 1: _____
Name: _____

Other Route: _____
Name: _____

Route 2: _____
Name: _____

Other Route: _____
Name: _____

Mast Arm 1

Quadrant / location: _____
Single- or Dual-arm: _____
Signal heads (#, type, cond): _____
Signs (#, type, size, cond): _____

Document condition of the following (rust, dents, cracks, exposed wires, etc.):

Arm / boom: _____
Pole / mast: _____
Hand hole cover: _____
Skirt / base / foundation: _____
Junction box: _____
Other comments: _____

Mast Arm 2

Quadrant / location: _____
Single- or Dual-arm: _____
Signal heads (#, type, cond): _____
Signs (#, type, size, cond): _____

Document condition of the following (rust, dents, cracks, exposed wires, etc.):

Arm / boom: _____
Pole / mast: _____
Hand hole cover: _____
Skirt / base / foundation: _____
Junction box: _____
Other comments: _____

Mast Arm 3

Quadrant / location: _____
Single- or Dual-arm: _____
Signal heads (#, type, cond): _____
Signs (#, type, size, cond): _____

Document condition of the following (rust, dents, cracks, exposed wires, etc.):

Arm / boom: _____
Pole / mast: _____
Hand hole cover: _____
Skirt / base / foundation: _____
Junction box: _____
Other comments: _____

Mast Arm 4

Quadrant / location: _____
Single- or Dual-arm: _____
Signal heads (#, type, cond): _____
Signs (#, type, size, cond): _____

Document condition of the following (rust, dents, cracks, exposed wires, etc.):

Arm / boom: _____
Pole / mast: _____
Hand hole cover: _____
Skirt / base / foundation: _____
Junction box: _____
Other comments: _____

*** Submit form, with pictures depicting any indicated damage, to the corresponding SCDOT District Signal Shop. ***

NOTE: Submittal of form indicates Local government is compliant w/ ED 33. Repairs are the responsiblity of the Local government. SCDOT is not responsible for maintenance and repair of mast arms.

Signal Plan Drawing

(1) Signal plans shall be signed and sealed by a South Carolina Professional Engineer (PE) seal.

(2) Signal plans are the property of the District office and/or the local government.

(3) Every effort should be made to load CADD files and electronic images of signal plans on the SCDOT Signal Inventory program for easy access.

(4) Plans for flashing beacons are more schematic in nature and do not require a PE seal.

(5) A record of the location and type of signal flashing beacon should be maintained within the SCDOT Signal Inventory program.

(6) Signal plans should include accurate depictions of rights-of-way (referenced back to file # or deed, per Instructional Bulletin No. 2012-2, http://www.scdot.org/doing/technicalPDFs/instructionalBulletins/ib12-2.pdf), pavement markings, signal head placement, span wires, driveways, sidewalks, control of access, and also should indicate signal timings, speed limits, grades, route names and numbers, adjacent development, coordination details etc. An example Signal Plan drawing can be found at the end of this chapter, along with a signal plan checklist. When reviewing a signal plan, there is a helpful guide to follow that is also in the back of this chapter.

Descriptions of items shown on the signal plan:

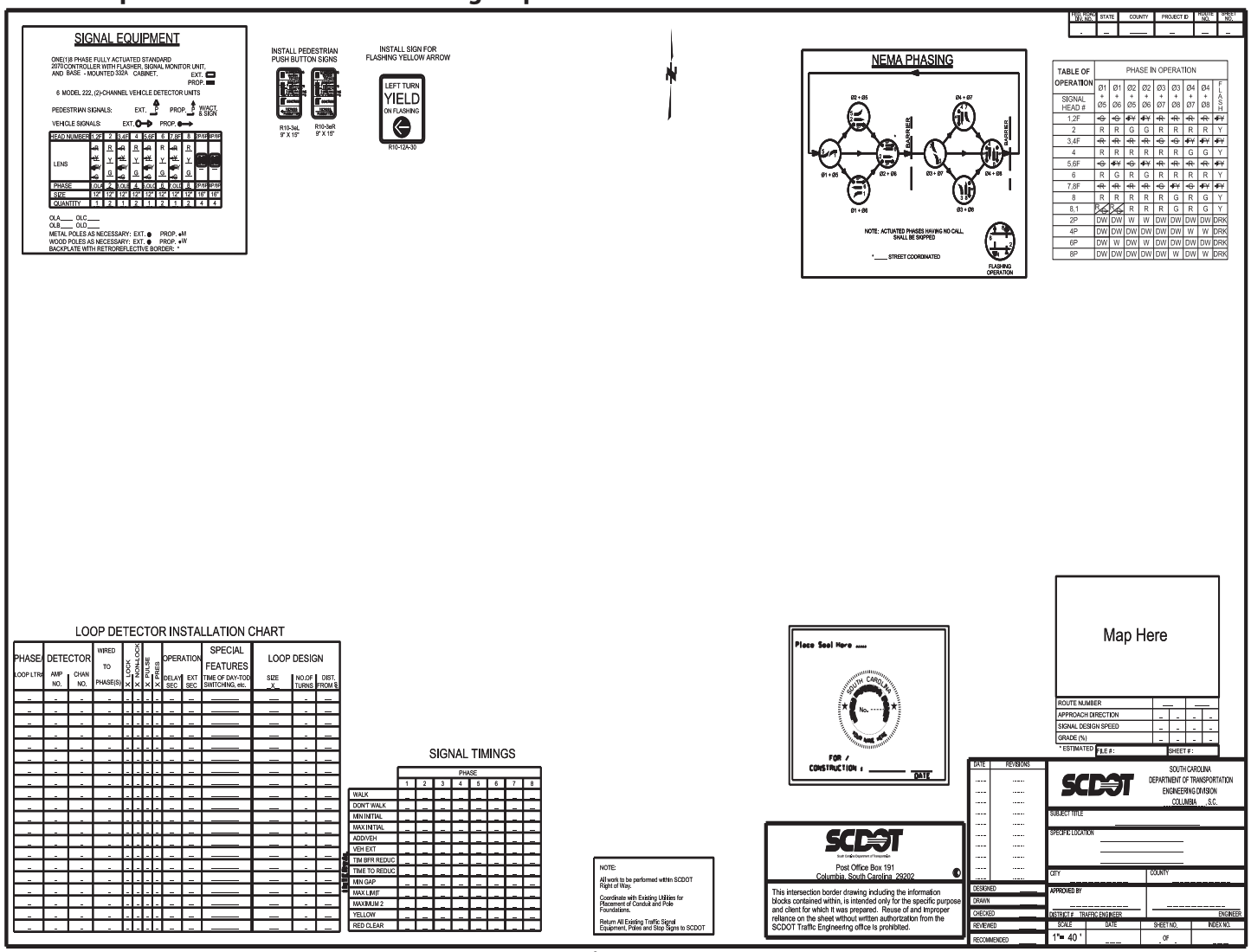


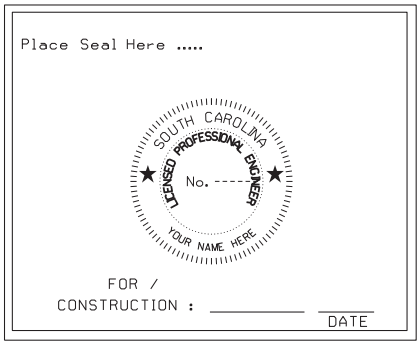
Figure 4-19

Signal Plan Border and Charts

PE Seal - Signal plans should be prepared under the supervision of a South Carolina registered engineer. The signal plan should be signed and sealed by the same engineer.

North Arrow - Signal plans should have a north arrow to indicate direction

North Arrow



PE Seal

Plan Information Chart - This chart details project information in the upper right corner of the plan.

FED. ROAD DIV. NO.	STATE	COUNTY	PROJECT ID	ROUTE NO.	SHEET NO.
_	__	_____	__	___	__

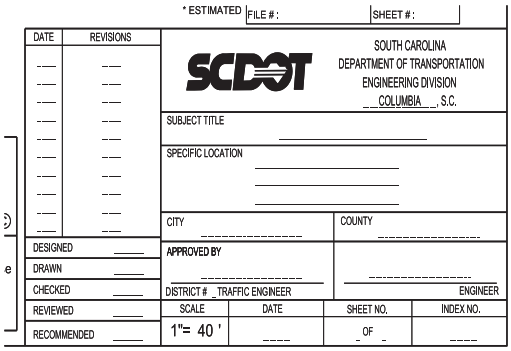
Plan Information Chart

Map/Grade/Speed Chart - This chart details the general location as well as approach grades and speeds. This information is used in calculating Yellow and Red Clearance Times

Map Here				
ROUTE NUMBER		___		____
APPROACH DIRECTION	_	_	_	_
SIGNAL DESIGN SPEED	_	_	_	_
GRADE (%)	_	_	_	_
* ESTIMATED	FILE # :		SHEET # :	

Map/Grade/Speed Chart

Title Block - The Title Block is placed on the lower right of the signal plan and details location information and revision information.



Title Block

Figure 4-20
Various Signal Plan Elements

Signal Plan Charts

The following information will detail how to fill out the following charts on the signal plan:

- Signal Equipment Chart
- NEMA Phasing Chart
- Table of Operations or Phase Sequence Chart
- Signal Timing chart
- Vehicle Detection Chart

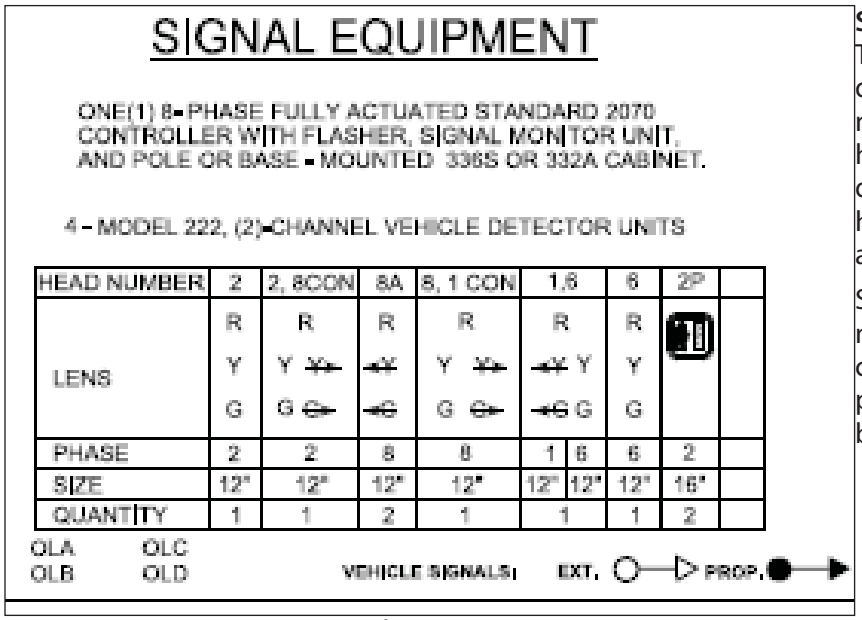


Figure 4-21
Signal Equipment Chart

Signal Equipment

The signal equipment chart (**Figure 4-21**) details the controller type, cabinet type, number of detector units, pedestrian heads/detectors, traffic signal heads lens description per phase and pedestrian heads by phase. Overlap information is also depicted in this chart.

SCDOT Preferred Equipment is 332A (170 model) Cabinet, 2070 Controller, 2010 IP conflict monitor, signal heads with back plates with retro-reflective 2" yellow border (TYPE 11 (eleven) sheeting).

Signal Phase Numbering Convention

Figures 4-22, **4-23,** and **4-24** detail the phase and movement numbering convention. Signal heads shall be numbered to correspond with the phase number for that approach.

Even numbers are for through movements and odd numbers are for left turn movements.

Phase(s) 2 and 6 are for main line through movements while *Phase(s) 4 and 8* are for side street through movements.

Phase(s) 1 and 5 are for mainline left turn phases while Phase 3 and 7 are for side street left turn phases.

Phase 2 shall generally be eastbound or southbound and the movements shall be numbered in a clockwise manner.

Phase(s) 2 and 6 are generally the coordinated phases in a signal system.

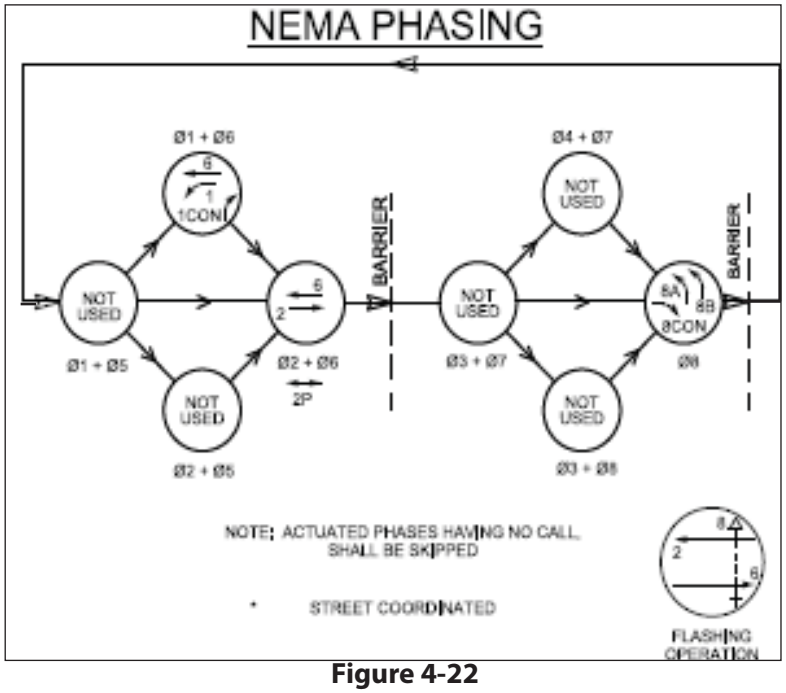


Figure 4-22
NEMA Phasing Chart

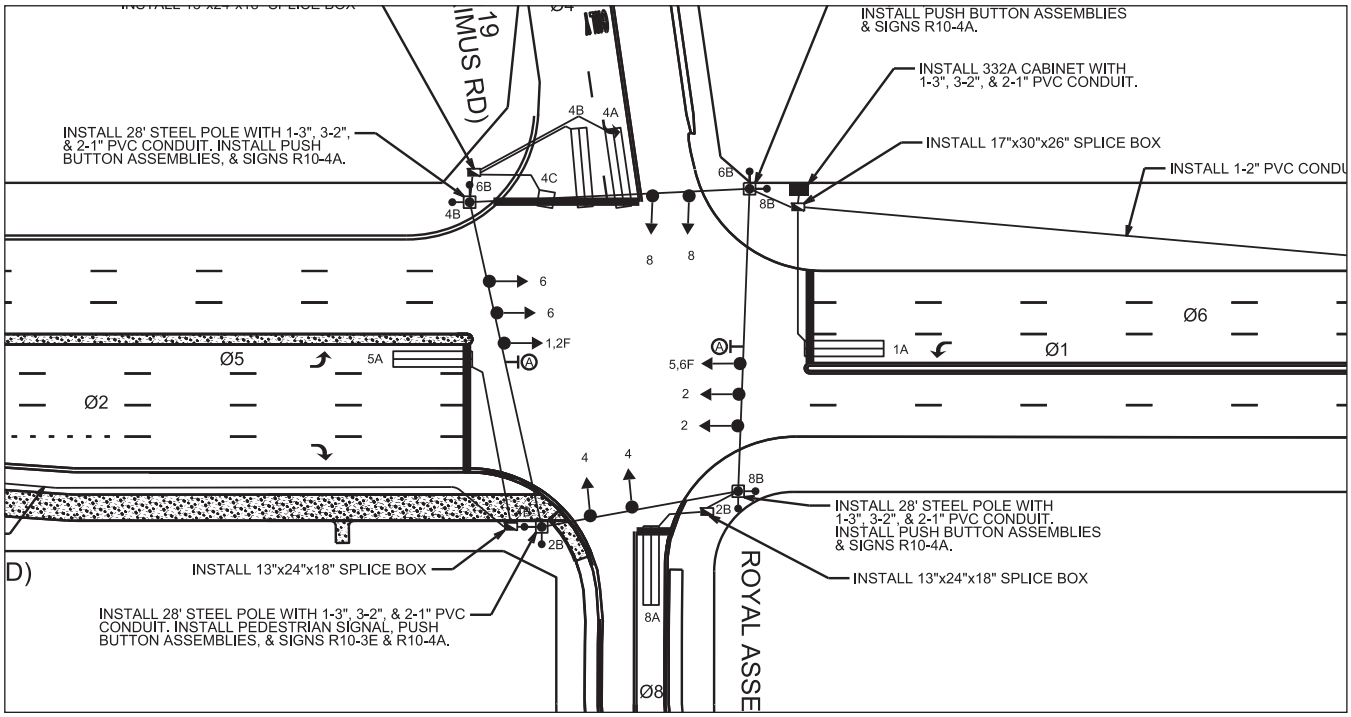


Figure 4-23
Example of Signal Head and Signal Phase Numbering

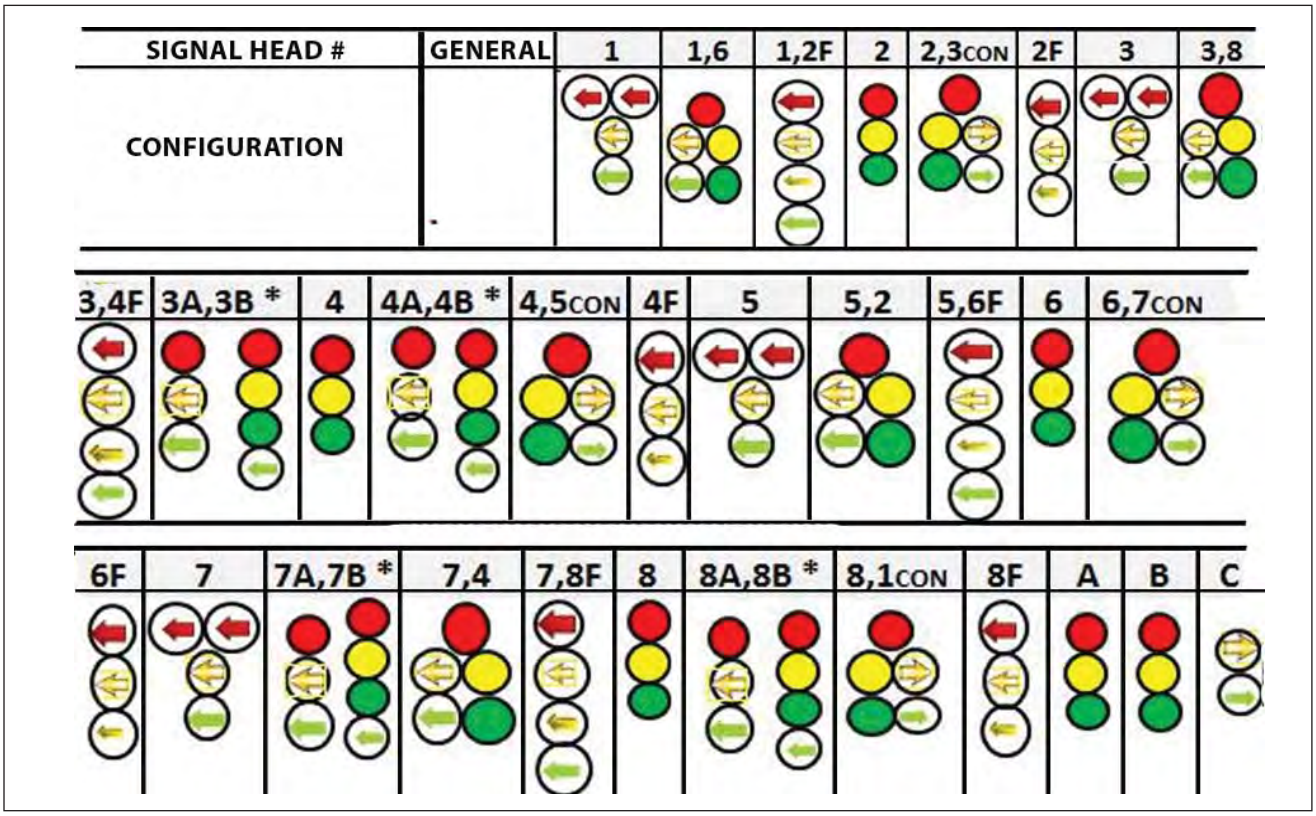


Figure 4-24
Typical Signal Head Displays

Phase Sequence Chart / Table of Operation Charting (Figure 4-25 and 4-26)

The Nema Phasing Chart is required on the signal plan. The SCDOT standard is to include the Table of Operation Chart on the signal plan; however, the Phase Sequence Chart may be used on the signal plan in lieu of the TOO Chart. The information shown within the TOO Chart and the Phase Sequence Chart is interchangeable. **Figures 4-52** through **4-61** depict example Phase Sequence Charts and Table of Operation Charts (TOO) corresponding to the appropriate NEMA Phasing Chart.

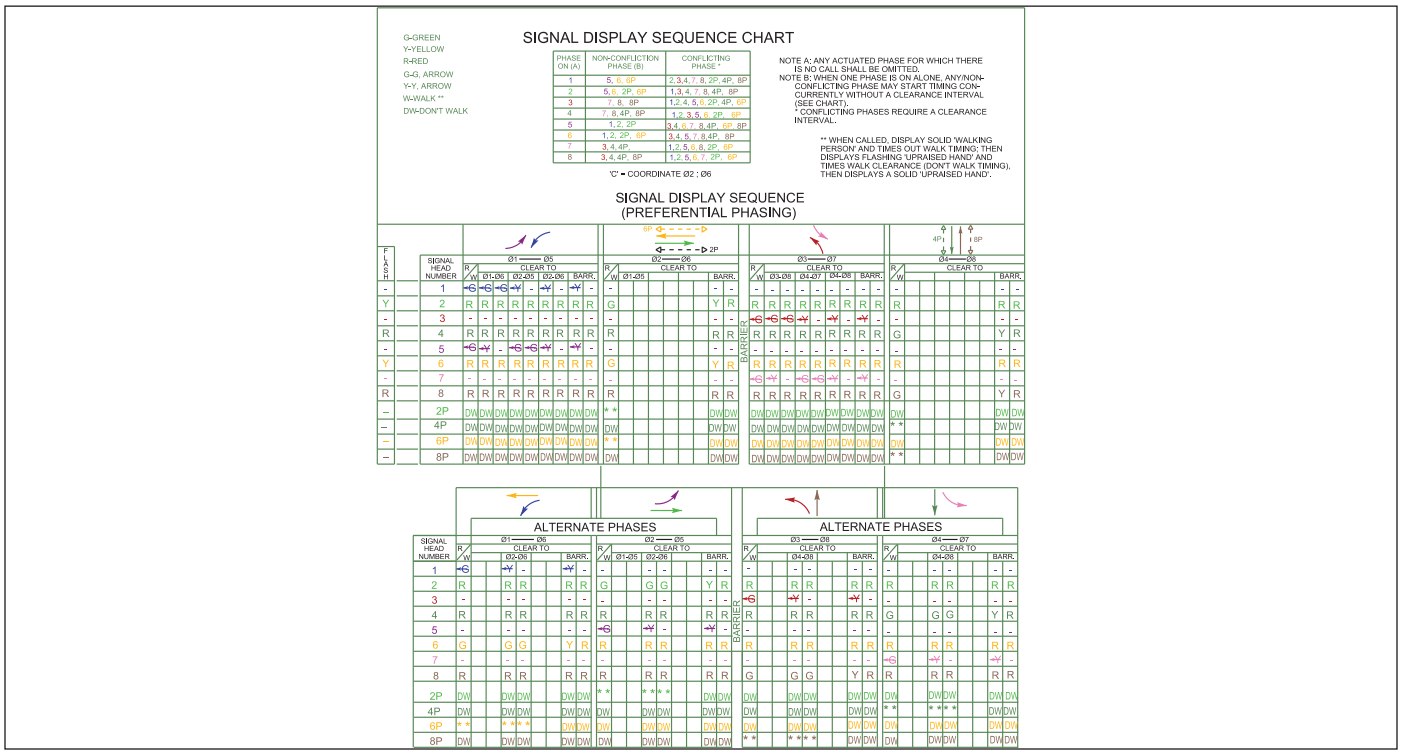


Figure 4-25
Phase Sequence Chart

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	Ø1 + Ø5	Ø1 + Ø6	Ø2 + Ø5	Ø2 + Ø6	Ø3 + Ø7	Ø3 + Ø8	Ø4 + Ø7	Ø4 + Ø8	FLASH
1	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---
5	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	---	---
7	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---
2P	---	---	---	---	---	---	---	---	---
4P	---	---	---	---	---	---	---	---	---
6P	---	---	---	---	---	---	---	---	---
8P	---	---	---	---	---	---	---	---	---

Figure 4-26
Table of Operation Chart
(SCDOT Standard Chart)

	SIGNAL TIMINGS	PHASE							
		1	2	3	4	5	6	7	8
INTERVAL (SEC)	WALK*	---	---	---	---	---	---	---	---
	DON'T WALK	---	---	---	---	---	---	---	---
	MIN INITIAL	---	---	---	---	---	---	---	---
	MAX INITIAL	---	---	---	---	---	---	---	---
	ADD/VEH	---	---	---	---	---	---	---	---
	TIM BFR REDUC	---	---	---	---	---	---	---	---
	TIME TO REDUC	---	---	---	---	---	---	---	---
	MIN GAP	---	---	---	---	---	---	---	---
	MAX LIMIT	---	---	---	---	---	---	---	---
	MAXIMUM 2	---	---	---	---	---	---	---	---
	YELLOW	---	---	---	---	---	---	---	---
	RED CLEAR	---	---	---	---	---	---	---	---

* VALUES MAY BE FIELD ADJUSTED. DO NOT ADJUST MIN GREEN TIMES FOR PHASES 2 & 6 LOWER THAN WHAT IS SHOWN. MIN GREEN FOR ALL OTHER PHASES SHOULD NOT BE LOWER THAN 4 SECONDS.

Figure 4-27
Signal Timing Chart

Signal Timing Chart

The Signal Timing Chart is required on the signal plan. The SCDOT standard is to include timing setting for each phase including:

- Minimum Initial
- Vehicle Extention,
- Maximum Limit, Maximum Limit 2
- Yellow
- Red Clearance.

In addition, through Phases 2,4,6, and 8 may have:

- Walk and Don't Walk timings for pedestrian movements

Volume Densitiy Settings will generally be required for Phase 2 and 6 and may be required on certain high volume side streets for Phases 4 and 8. Volume Density setings include:

- Max initial
- added/ vehicle
- Time Befor Reducing
- Time to reduce
- Minimum Gap

Signal settings are determined baseed on vehicle and pedestrian speeds, lane widths and markings, detection zone placement, roadway conditions such as grades and traffic volumes. Following is guidance on each setting .

Below are definitions from the FHWA Traffic Signal Timing Manual, 1st edition, Chapter 5.

1. ***Actuated Signal Control*** - A type of signal control where time for each phase is at least partially controlled by detector actuations.
2. ***Call*** - An indication within a controller that a vehicle or pedestrian is awaiting service from a particular phase or that a recall has been placed on the phase.
3. ***Extend*** - A detector parameter that increases the duration of a detector actuation by a defined fixed amount.
4. ***Gap Out*** - A type of actuated operation for a given phase where the phase terminates due to a lack of vehicle calls within a specific period of time (passage time).
5. ***Interval*** - The duration of time during which the indications do not change their state (active or off). Typically, one or more timing parameters control the duration of an interval. The pedestrian clearance interval is determined by the pedestrian clearance time. The green interval duration is controlled by a number of parameters including minimum time, maximum time, gap time, etc.
6. ***Isolated intersection*** - An intersection located outside the influence of and not coordinated with other signalized intersections, commonly one mile or more from other signalized intersections.
7. ***Minimum Gap*** - A volume density parameter that specifies the minimum green extension when gap reduction is used.
8. ***Minimum Green*** - A parameter that defines the shortest allowable duration of the green interval.
9. ***Minimum Recall*** - A parameter which results in a phase being called and timed for at least its minimum green time whether or not a vehicle is present.
10. ***Movement*** - Movements reflect the user perspective. Movements can also be broken down into classes (car, pedestrians, buses, LRT, etc.). Typical movements are left, through and right. Movement is an activity in response to a "go" (green ball, green arrow, walk, white vertical transit bar) indication.
11. ***Max Out*** - A type of actuated operation for a given phase where the phase terminates due to reaching the designated maximum green time for the phase.
12. ***Passage Time*** (Vehicle Interval, Gap, Passage Gap, Unit Extension) - A parameter that specifies the maximum allowable duration of time between vehicle calls on a phase before the phase is terminated.
13. ***Pedestrian Clearance Interval*** - Also generally known as "Flashing Don't Walk" (FDW). An indication warning pedestrians that the walk indication has ended and the don't walk indication will begin at the end of the pedestrian clearance interval. Some agencies consider the pedestrian clearance interval to consist of both the FDW time and the yellow change interval.
14. ***Phase*** - A timing unit associated with the control of one or more indications. A phase may be timed considering complex criteria for determination of sequence and the duration of intervals.
15. ***Pre-timed control*** - A signal control in which the cycle length, phase plan, and phase times are predetermined and fixed.
16. ***Queue*** - A line of vehicles, bicycles, or persons waiting to be served by a phase in which the flow rate from the front of the queue determines the average speed within the queue. Slowly moving vehicles or people joining the rear of the queue are usually considered part of the queue. The internal queue dynamics can involve starts and stops. A faster-moving line of vehicles is often referred to as a moving queue or a platoon.
17. ***Recall*** - A call is placed for a specified phase each time the controller is servicing a conflicting phase. This will ensure that the specified phase will be serviced again. Types of recall include soft, minimum, maximum, and pedestrian.
18. ***Semi-Actuated Control*** - A type of signal control where detection is provided for the minor movements only.
19. ***Volume-Density*** - A phase timing technique that uses a series of parameters (variable initial, minimum gap, time before reduction, time to reduce) to provide alternative, variable settings for the otherwise fixed parameters of minimum green and passage time.

Signal Timing Chart

Walk Setting

Walk Time - generally 4 to 7 seconds:

The minimum Walk time shown in MUTCD is 7 seconds, with a provision to reduce as low as 4 seconds if pedestrian volumes and characteristic do not require a 7 second walk interval. Walk times of 7 seconds or higher are typically considered when large groups of pedestrians are observed crossing at one interval. The larger walk time allows pedestrian to get into the intersection and still have sufficient time to cross the roadway. At locations where pedestrians are intermittent, walk times between 4 and 7 seconds are acceptable.

Pedestrian Clearance Setting

Don't Walk Time - calculated based on crossing distance and wallking speed

Pedestrian Clearance time is calculated based on a 3.5 feet per second walking time to cross from the edge of travel lane to the far side of the travel way or to a median of sufficient width to accommodate pedestrians. (See **Figure 4-34**)

When only pedestrian buttons are present, the walk time and pedestrian clearance time should equal the calculated crossing time, if the clearance time is served sequentially to the clearance interval. If the pedestrian clearance time encroaches into the clearance time, additional walk time should be provided.

For determining appropriate pedestrian treatments, see **Pedestrian Treatment Design section** within this chapter. Also, see MUTCD 4E-2 for additional guidance.

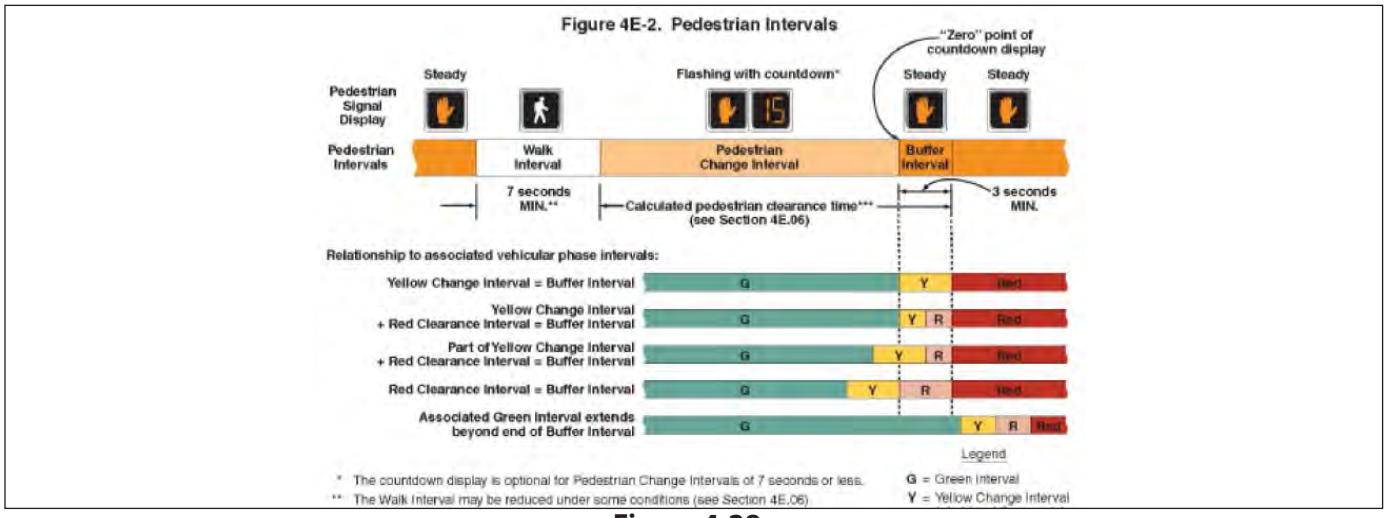


Figure 4-28
MUTCD Pedestrian Clearance

Minimum Initial, Maximum Initial, Vehicle Extension (also known as, Passage or Gap) Settings

Figures 4-29 and 4-30 should be used to determine these settings.

These settings are determined based on the placement of detection and vehicle approach speeds. Detection is placed based on approach speeds, traffic volumes and queues.

Typically detection on the main line is setback from the stop bar and detection on the side street is placed at the stop bar. The placement of this detection is intended to promote movement on the main line stopping only to serve side streets when vehicles are present. Since side street traffic is generally used to stopping at the main line, stop bar detection is sufficient.

When volumes on the side street are about equal to mainline volumes or when side street volumes may equal or exceed mainline volumes during particular times of the day. In these cases, detection on the side street can be placed set back from the stop bar or both at the stop bar and set back.

Other considerations for determining **Minimum Green** settings include providing sufficient time to accommodate pedestrian clearances in the absence of pedestrian button activation. The longer **Minimum Green** setting will be served each time the phase is activated either by vehicle detection or by placing the phase on recall. The benefit of increasing the **Minimum Green** setting is that pedestrians have sufficient time to cross without pushing the pedestrian button. The detriment is that the phase is served longer than necessary when pedestrians are not present, making the signal less efficient. Careful consideration to the effect on signal efficiency should be evaluated to determine the most appropriate setting. Setting **Minimum Green (Initial)** times based on the values in **Figure 4-29 and 4-30** and accommodating pedestrians by placing pedestrian buttons that will supply sufficient green time when activated is an accepted engineering practice.

	RECOMMENDED		TIMING PARAMETERS				
Speed (mph)	Setback (feet)	Equiv. Second	Min Initial	Max Initial	Passage	Min Gap	Notes
30	80*	1.8	12	12	2.5	2.5	**Low speeds - urban** Detection is primarily to gap out signal. Loops are placed at 80' from the stop bar with a 2.5 second gap to extend
35	**200**	**3.9**	**15**	**24**	**3.0**	**2.5**	**Urban and Suburban Arterials –** Detection is primarily used to determine minimum green times and gap out signal. Detection will be placed to provide limited decision zone protection. . Loops are placed at 4 - 5.5 seconds from the stop bar with a 2.5 second gap to extend vehicles through
40	300	5.1	15	34	6.0	2.5	
45	330	5.0	15	37	6.0	2.5	
50	370	5.0	15	41	6.0	2.5	
55	445	5.5	15	49	6.0	3.0	**High Speed Rural or Access Controlled Arterials –** Detection is primarily used to determine minimum green times and gap out signal. Loops are placed at approximately 5.5 seconds from the stop bar with a 3 second gap to extend vehicles through the decision zone.
60	485	5.5	15	53	6.0	3.0	
>45	**255', 385' ****	**Varies (4-6)**	**15**	**Varies (30-42)**	**3.0 (since 2)**	**2.5**	

Setback distances are approximate and may be adjusted based on presence of driveways or pavement types.
** Considered low speed - decision zone not an issue - volume density not used*
*** Settings for existing setback detection, consisting of 2 6'X6' loops per lane at 255' and 385'*

Figure 4-29
Main line Detection Placement Chart w/ Signal Settings

	RECOMMENDED		TIMING PARAMETERS			
Speed (mph)	Setback (feet)	Equiv. Second	Min Initial	Max Initial	Passage	Min Gap
n/a	@Stop Bar	n/a	Typically 4-8 seconds*	n/a	2-3	n/a

** Min Initial can be increased to accommodate pedestrian crossing time; however additional minimum green time can be obtained with pedestrian button activation.*

Figure 4-30
SCDOT Stop Bar Detector Placement Chart
(Typically side streets and left turn lanes)

Maximum Green, Maximum Green 2 Settings

Maximum Green Times - calculated based on traffic volumes.

These values are the maximum green times per signal phase which determine signal cycle lengths. These settings should be calculated based on existing or projected traffic volumes, lane capacity, and phasing relationships as determined by widely accepted methods or engineering analysis. SCDOT often uses Synchro software to assist in determining **Maximum Green** settings. The **Maximum Green** setting is typically for normal traffic volumes, while **Maximum Green 2** settings are for special times of day when increase traffic volumes are present.

See Chapter 5, in the FHWA Traffic Signal Timing Manual for Capacity and Critical Movement Analysis to determine critical movements and **Maximum Green** settings to serve each phase. Peak hour turning movement traffic counts performed in 15 minute intervals are required to determine the level of service and capacity, based on the signal settings. The counts should also include the number of heavy vehicles.

Since the maximum green times for each phase is only served when traffic volumes require it, engineers often use typical percent settings of the cycle length for main line and side streets, such as 60% mainline/40% side streets.

Volume - Density Settings

Volume - Density Timings should be utilized at all but the very simplest intersections (intersections with major route speed limits of **35 MPH** or less do not typically benefit from this type of control.) Consider the use of Volume Density Timings for major approaches where the speed limit equals or exceeds 40 mph. Volume Density Timing will only operate if the loops are operational; therefore maintenance of the signal detection is an important consideration. Short gap (passage) times and long maximum green times provide best results.

Added Initial, Maximum Initial Settings

These settings allow a dynamic minimum (initial) green time to be calculated to ensure vehicles queuing at the stop bar are able to dissipate without additional loop activations. This is accomplished using the **Added Initial**, **Maximum Initial** inputs on the controller software.

Use the following **Added Initial** settings as guidance:
During side street phasing, vehicles arriving on the mainline roadway are 'counted" . The number of vehicles counted is multiplied by the Added Initial setting resulting in a dynamic 'inital green' value, up to the Maximum Green setting. The **Minimum Green** time actually served is the greater of the **Minimum Green** setting or the dynamic 'inital green' value, not to exceed the Maximum Green Initial.

These values are approximate and engineering judgement should be used.
When traffic is evenly distributed over multiple lanes, use lower number. Increase for high truck traffic.

	1 loop per lane	2 loops per lane
Approach Lanes	Seconds	Seconds
Single through lane	2-3	1-1.5
Two through lanes	1.5-2.0	0.5-1.0
Three (or more) through lanes	1.0-1.5	0.5-0.7

Figure 4-31
Added Initial Settings

Calculation Example :

Added per Vehicle setting *= 2 seconds*
with 10 counted on mainline while side street is green calculated dynamic 'inital green = 20 seconds
Minimum Initial setting *= 15 seconds*
Maximum Initial Setting *= 25 seconds*
Minimum Green time actually served *= 20 seconds*

Minimum Gap Setting

Minimum Gap setting - generally 2.5 seconds.

Time Before Reduction Setting

Time Before Reduction - generally 10 to 15 seconds > Minimum Initial setting and 15 to 20 seconds < Maximum Green setting.

Time To Reduce Setting

Time to Reduce - generally 10 to 15 seconds

These settings allow the reduction of the gap (passage) to improve the efficiency of the intersection. Gap times need to be longer at the beginning of the green to allow vehicles to start up from a queued position and begin to pick up speed and increase the headway between them. At that point, the gap time can be reduced to obtain the most efficiency at the intersection. **Minimum Gap** is the gap time to be used to allow the most efficient operation of the signal, and is typically 2.5 seconds. Three inputs control this action, **Minimum Gap**, **Time before Reduction**, and **Time to Reduce**. Other settings to consider are Vehicle Extension, Minimum Green Timing and Maximum Green Timing.

Calculation Example :

Vehicle Extention setting ***= 3.5 seconds***
(if the Veh Ext time is 2.5 seconds, then there is no need to reduce it.)

Minimum Green ***= 15 seconds***
(In this example, 25 seconds into the mainline phase, the vehicle extention settin is reduced from 3.5 seconds to 2.5 seconds over a 10 second time frame

Maximum Green ***= 55 seconds***

Minimum Gap setting ***= 2 seconds***

Time before reduction ***=25 seconds***
(This value should be higher than the minimum green but less than the maximum green.)

Time to reduce ***= 10 seconds***
(This value is the amount of time the Veh Extension is reduce over; i.e., it would take 10 seconds to reduce 3.5 seconds to 2.5 seconds in this example)

Clearance Timings

Yellow, Red Settings

Clearance Timings shall be based on appropriate formulas that adhere to current professional standards. The clearance time consists of the yellow time and the all red time that separates phases. Clearance settings are calculated based on approach speed, approach grades, and intersection widths. As turning movement speeds are generally less than through movement speeds, accomodations or adjustments should be made to accomodate these speed variances. **Figures 4-32** and **4-33** are charts that depict yellow and red settings based on the ITE formulas. Items shown in grey are typical intersection values. Engineering judgment should be applied in calculating clearance time. In addition, **Figures 4-34, 4-35**, and **4-36** are tools that should be used when designing signals. These figures are a great resource to assist in reviewing clearance calculations. **Figure 4-36** shows a depiction of an Excel Worksheet that is available to assist engineers in calculating clearance timings.

	Posted Speed	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph
Measured approach grade (%)	v = velocity =>	29.33	36.67	44.00	51.33	58.67	66.00	73.33	80.67	88.00
g		Y= Yellow Change								
5%		2.3	2.6	2.9	3.2	3.5	3.8	4.2	4.5	4.8
4%		2.3	2.6	2.9	3.3	3.6	3.9	4.2	4.6	4.9
3%		2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0
2%	*Formula*	2.4	2.7	3.1	3.4	3.8	4.1	4.4	4.8	5.1
1%	*Y = t + v/2(a+32.174g)*	2.4	2.8	3.1	3.5	3.8	4.2	4.6	4.9	5.3
0%	*where t= 1 sec;*	2.5	2.8	3.2	3.6	3.9	4.3	4.7	5.0	5.4
-1%	*a=10 ft/sec/sec*	2.5	2.9	3.3	3.7	4.0	4.4	4.8	5.2	5.5
-2%		2.6	3.0	3.4	3.7	4.1	4.5	4.9	5.3	5.7
-3%		2.6	3.0	3.4	3.8	4.2	4.7	5.1	5.5	5.9
-4%		2.7	3.1	3.5	3.9	4.4	4.8	5.2	5.6	6.0
-5%		2.7	3.2	3.6	4.1	4.5	4.9	5.4	5.8	6.2
		use a minimum yellow clear of 3.0 seconds								
		mitigate yellows exceeding 6.0 seconds								
		calculated yellow times shown in grey from typical grades and speeds								

Figure 4-32
Yellow Calculation Chart

	Posted Speed	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph
Measured intersection clearance length	v = velocity =>	29.33	36.67	44.00	51.33	58.67	66.00	73.33	80.67	88.00
W		R = Red Clear								
20		1.4	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.5
30		1.7	1.4	1.1	1.0	0.9	0.8	0.7	0.6	0.6
40		2.0	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.7
50		2.4	1.9	1.6	1.4	1.2	1.1	1.0	0.9	0.8
60	Formula	2.7	2.2	1.8	1.6	1.4	1.2	1.1	1.0	0.9
70	R=(W+L)/v	3.1	2.5	2.0	1.8	1.5	1.4	1.2	1.1	1.0
80	where L-20 feet	3.4	2.7	2.3	1.9	1.7	1.5	1.4	1.2	1.1
90		3.8	3.0	2.5	2.1	1.9	1.7	1.5	1.4	1.3
100		4.1	3.3	2.7	2.3	2.0	1.8	1.6	1.5	1.4
110		4.4	3.5	3.0	2.5	2.2	2.0	1.8	1.6	1.5
120		4.8	3.8	3.2	2.7	2.4	2.1	1.9	1.7	1.6
130		5.1	4.1	3.4	2.9	2.6	2.3	2.0	1.9	1.7
140		5.5	4.4	3.6	3.1	2.7	2.4	2.2	2.0	1.8
150		5.8	4.6	3.9	3.3	2.9	2.6	2.3	2.1	1.9
160		6.1	4.9	4.1	3.5	3.1	2.7	2.5	2.2	2.0
170		6.5	5.2	4.3	3.7	3.2	2.9	2.6	2.4	2.2
180		6.8	5.5	4.5	3.9	3.4	3.0	2.7	2.5	2.3
190		7.2	5.7	4.8	4.1	3.6	3.2	2.9	2.6	2.4
200		7.5	6.0	5.0	4.3	3.8	3.3	3.0	2.7	2.5
		use a minimum red clearance of 1.5 seconds								
		mitigate reds exceeding 3.0 seconds								
		calculated red times shown in grey from typical intersection widths and speeds								

Figure 4-33
Red Calculation Chart

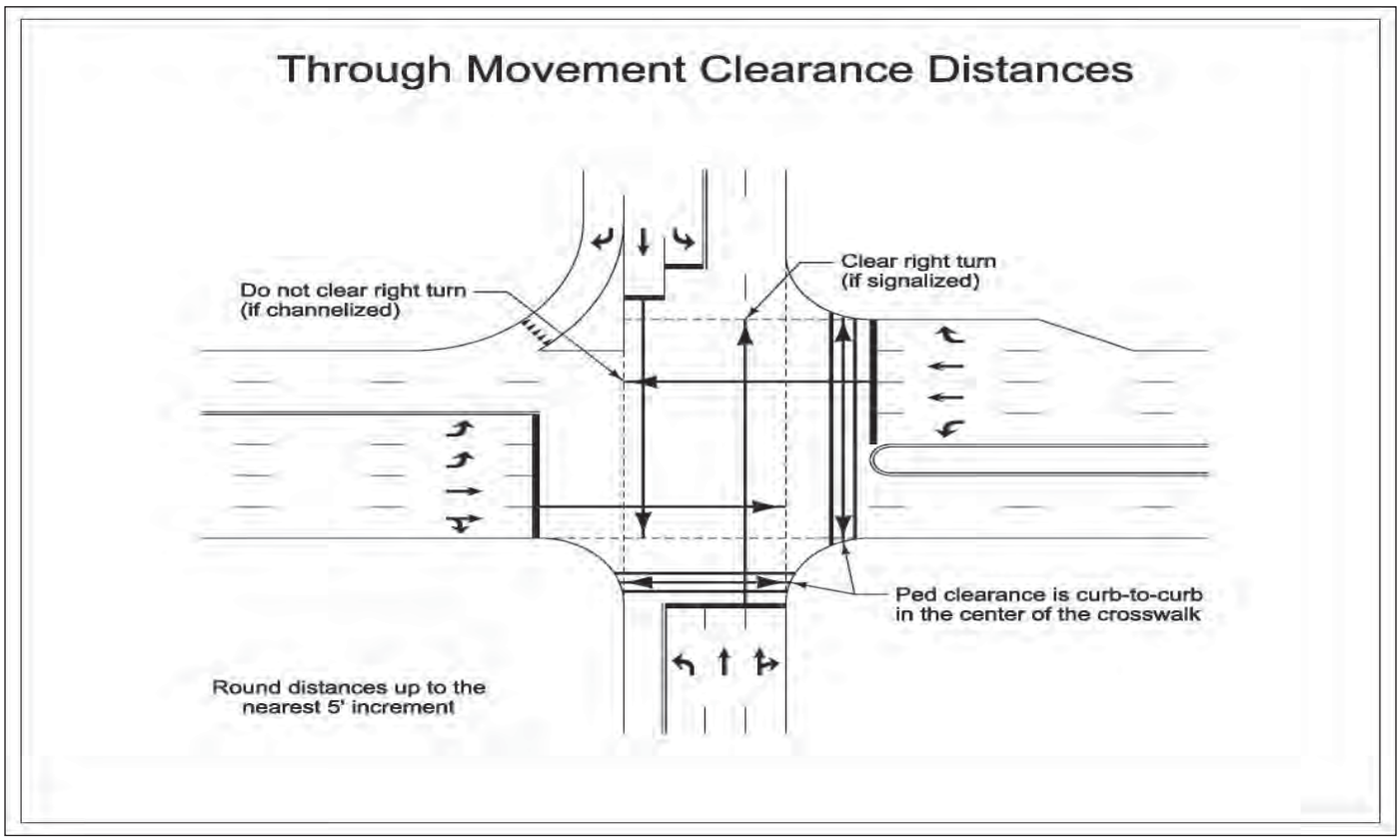


Figure 4-34
Through Movement Clearance Distances

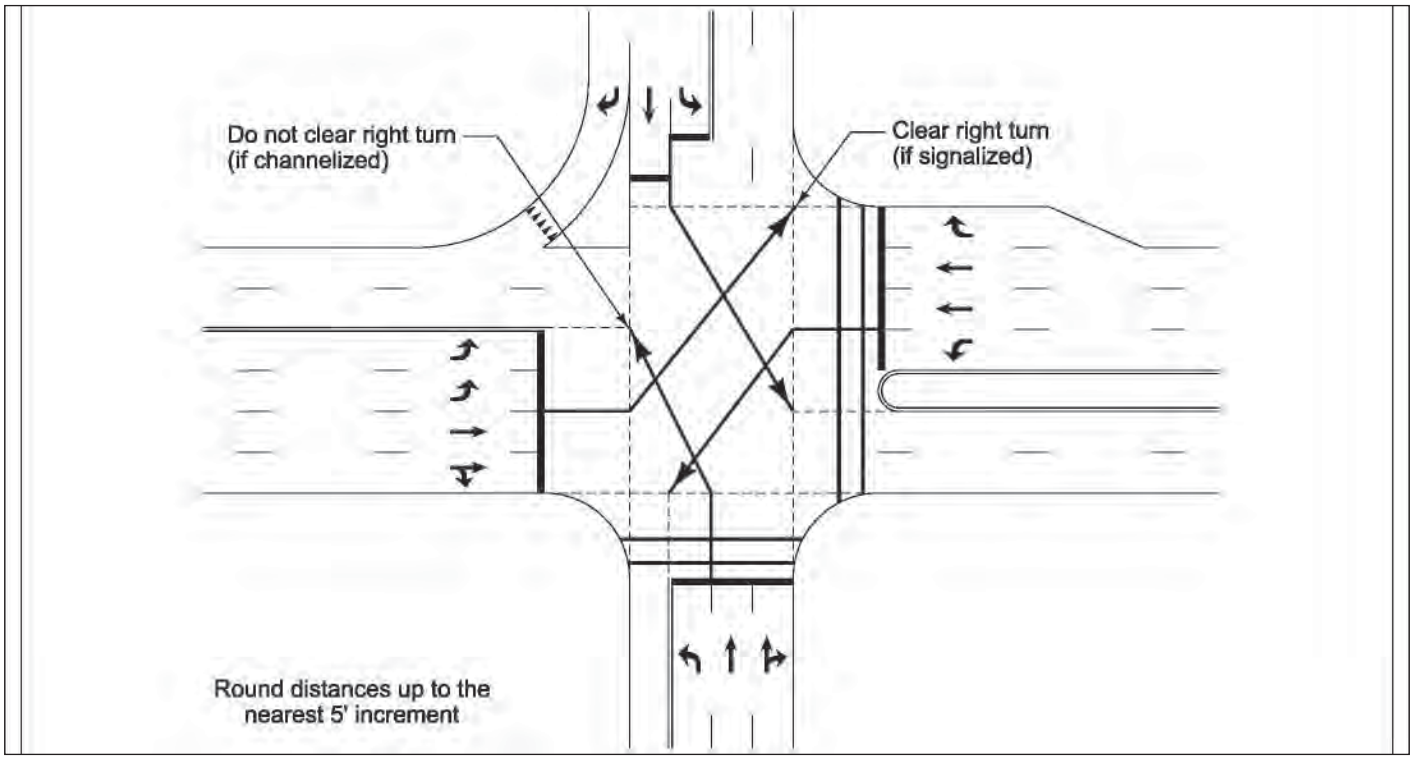


Figure 4-35
Left Turn Movement Clearance Distances

Clearance Time Calculations

Rev 2015-01-12

City:		District:	
County:		Sig. ID #	
NB Street:		Project #:	
SB Street:		Computed by:	
EB Street:		Checked by:	
WB Street:		Approved by:	

Movement	Street Name								
	Orientation	Northbound		Southbound		Eastbound		Westbound	
	Turn movement	Left	Thru	Left	Thru	Left	Thru	Left	Thru
NEMA Phase #	Protected	3	8	7	4	5	2	1	6
	Permissive	8		4		2		6	
FYA		Y		Y		Y		Y	
Speed	mph	20	35	20	35	20	45	20	45
	ft/sec	29.33	51.33	29.33	51.33	29.33	66.00	29.33	66.00
Grade	%	0		0		0		0	
	Elevation at Stopbar, ft								
	Elevation at Setback, ft								
	Dist to Setback, ft								
	-OR- Enter Grade, %								
Clear Distance	feet	70	100	70	100	70	100	70	100
Ped Cross Dist	feet		75		75		50		50
Parameters	Percept-React Time, sec	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Decel Rate, ft/sec^2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Walk Speed, fps	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Recommended:	**Phase #**	**3**	**8**	**7**	**4**	**5**	**2**	**1**	**6**
Yellow	**sec**	**3.0**	**3.6**	**3.0**	**3.6**	**3.0**	**4.4**	**3.0**	**4.4**
All Red	**sec**	**2.6**	**2.4**	**2.6**	**2.4**	**2.6**	**1.9**	**2.6**	**1.9**
Flashing Don't Walk	**sec**		**22.0**		**22.0**		**15.0**		**15.0**

NOTES:

Compute times only as needed for plan.
Yellow change interval should be between 3 and 6 seconds.
Red clearance intervals less than 1.5 and more than 4.0 seconds require special circumstances.
Grades are rounded to the conservative whole percent.
Yellow and All Red times are rounded up to the next tenth of a second.
Ped clearance time is rounded up to the next whole second.

Figure 4-36

Clearance Time Calculation Sheet

The excel file has formulas embedded that provide mitigated values for yellow and red settings.
Engineering judgement should be used when selecting the final yellow and red settings. to acomodate speed variances.

Vehicle Detection

The Department uses mainly inductive loop detection; however other detection types include video detection, microwave Flush Mounted Wireless Detection, and radar type detection. Although Inductive loops are used at the majority of the signalized intersections around the state; however, these other technologies are widely acceptable.

Vehicle Detection Placement

- Side streets may also function as the major routes by time of day, however the side street typically has stop bar detection.
- If both the main line and side street have high speed and have similar volumes, setback vehicle detection may be used on both roadways.
- System detections are typically placed on the departure side of the signal, while vehicle detection is placed on the signal approach.
- Detection zones for inductive loops have a typical range of 3' on either side of the loop; place loops to avoid detection from adjacent lane, or an opposing traffic flow area. The typical height of the inductive loop is 3' for a square loop and 18-24" for a quadrupole loop. Adjusting the sensitivity of the loop can help if motorcycles or bikes are not being detected.
- Place vehicle detection driveways intersect, before or after intersecting driveways. Set back detection may be needed after high volume driveways to detect the vehicles exiting.

See SCDOT Standard Drawings and the SCDOT Supplemental Technical Specifications for more details.

Quadrupole loops - Quadrupoles are SCDOT's standard for stop bar loop detection. Stop bar detection is typically used on side street approaches and on mainline left turn lanes. It is acceptable to place detection for the protected/permissive left turn phase up to 50' back from the stop bar based on engineering judgement. For protected left-turn phasing, loops should be present at the stop bar.

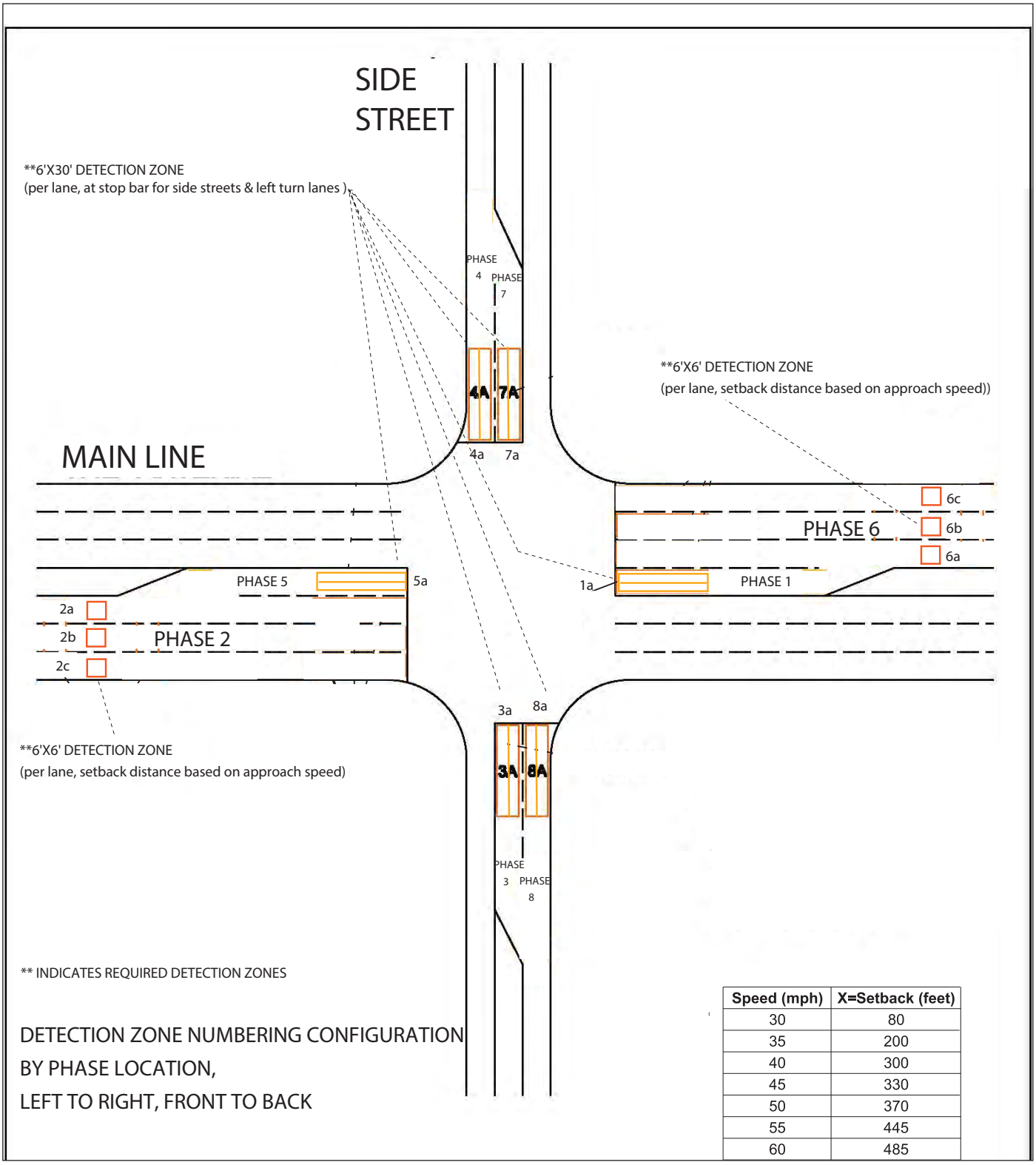
Quadrupole Loop

Semi-Actuated Designs should only be utilized or considered when a signal is being included in a coordinated system. This type of design is not efficient during non-coordinated operation, as the main street never gaps out.

Numbering - Loop detectors should be numbered according to the phase with which they are associated. If there are multiple loops on one phase then add letter designations, according to their location, left to right and from front to back as shown in **Figure 4-37.**

Setback Detection should be used on major routes to operate volume density timings. The chart below shows appropriate setback distances based on the posted speed limit. The setback detection should be individual lane loops. Wireless detection may be considered as an alternate to standard inductive loops for setback loops.

Other Types of Vehicle Detection consist of video detection, wireless detection and radar detection. More information on these are shown later in this chapter.



Speed (mph)	X=Setback (feet)
30	80
35	200
40	300
45	330
50	370
55	445
60	485

Figure 4-37
Vehicle Detection Numbering Configuration

VEHICLE DETECTION INSTALLATION CHART

PHASE/ LOOP LTR#	DETECTOR AMP NO.	DETECTOR CHAN NO.	WIRED TO PHASE(S)	X LOCK	X NON-LOCK	X PULSE	X PRES	OPERATION DELAY SEC	OPERATION EXT SEC	SPECIAL FEATURES TIME OF DAY-TOD, SWITCHING, etc.	LOOP DESIGN SIZE _X_	LOOP DESIGN NO.OF TURNS	LOOP DESIGN DIST. FROM $\mathbb{C}$

Figure 4-38
Vehicle Detection Chart

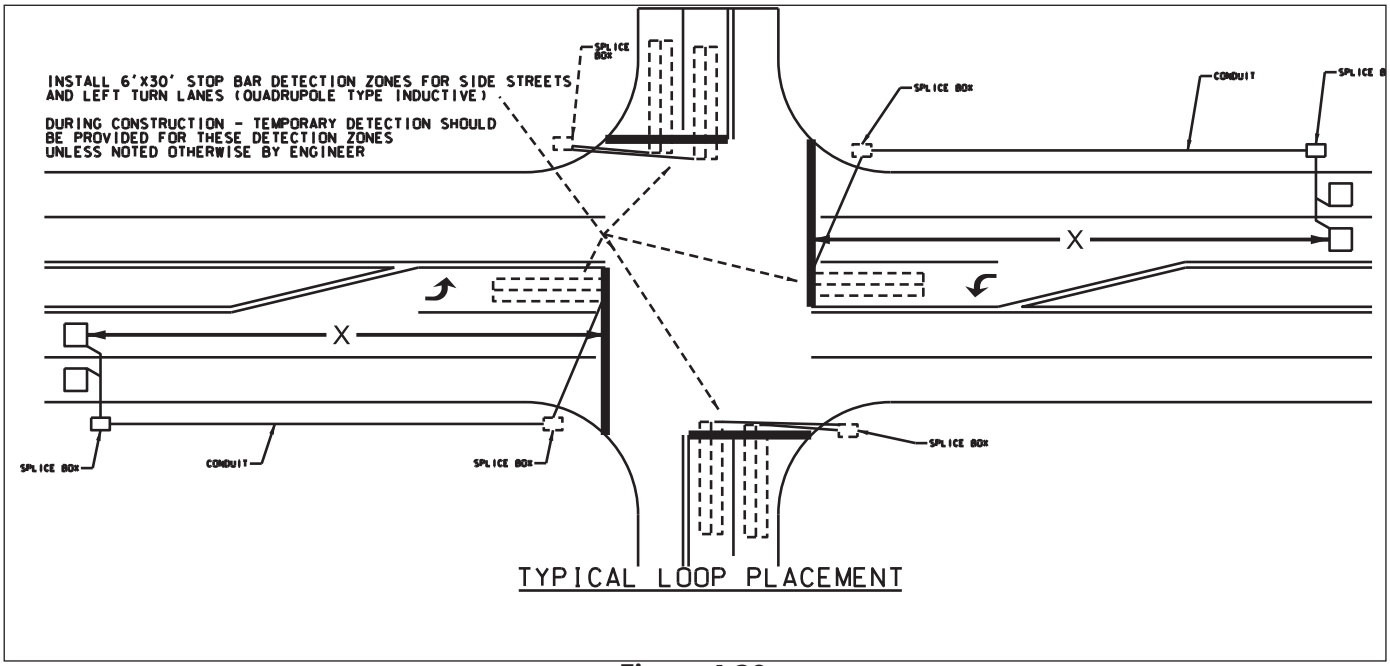


Figure 4-39
Typical Loop Placement

Vehicle Detection Chart Settings

Phase / Loop #
This column identifies the individual detection zone and is typically related to the phase the detection activates.

Detector - Amphlifier Number, Channel Number
This column identifies the individual detection zone and is typically related to the phase the detection activates.

Wired to Phase(s)
This column what phase the detector activates

Lock, Non-Lock, Pulse, Presence
Lock, Non-lock are Detector Memory settings and indicate whether or not the detector should 'remember' the call placed by a vehicle, once the vehicle moves off the loop. Lock mode extends the time as the car rolls over the loop and non-lock does not. In non- lock, a vehicle must rest on the loop to be detected and as long as the car is on the loop a call is placed. If the car leaves the detection zone, the call is lost. Typically a loop on or near the stop bar would be in non-lock mode and the set back loops would be lock.
Pulse, Presence are Detector Mode settings. A detector can be set to 'Presence' or to 'Pulse' mode. SCDOT typically sets all detectors in Presence mode since Pulse mode would not recognize the 'presence' of a vehicle on the loop, as may occur during substantial queuing.

Operation - Delay, Extension (seconds)
Delay is a setting to be used if you wanted to place a delay on the loop for vehicle actuation. The typical use is for the right most stop bar loop on a side street. A delay would be placed on the loop to allow a motorist, making a right turn, to do so without placing a call on the controller, if the turn was made within the set delay. The typical delay is 8-10 seconds.

Special Features - Time of Day, Switching
These settings can be used to adjust settings by time of day.

Loop Design - Size, Number of Turns, Distance from Stop Bar

Size, Distance from Stop Bar: SCDOT standard size for stop bar detection is 6' x 30, placed approximately 5' in advance of the stop bar. This is shown at -5' on chart. SCDOT standard size for set back detection is 6'x6' per approach lane. Distances from stop bar are based on speeds as shown in Figure 4-10.

Number of Turns relates to the installation of inductive loops based on the size and desired sensitivity desired. *SCDOT Traffic Signal Technical Supplemental Specifications, SC-M-678-1 Detector Loops* give standard number of turns for various loop sizes, however the engineer may change the number of turns to adjust sensitivity. In general, for 6'x30' quadrupole loops, the number of turns is typically 2-4-2; for 6'x6' loops, the number of turns is 4.

Vehicle Detection for Advanced Signal Systems

Advanced Signal Systems - For advanced signal systems (Traffic Responsive or Traffic Adaptive), additional detection is required to provide vehicle data for operation purposes. Adaptive signal systems typically require stop bar detection between 6'-10' for each lane. Setback loops may also be required for volume data collection. Responsive signal systems typically require setback loops for volume data collection at points where volumes fluctuate. When determining loop placement for signal design, consider future signal system operations and install additional detection as necessary.

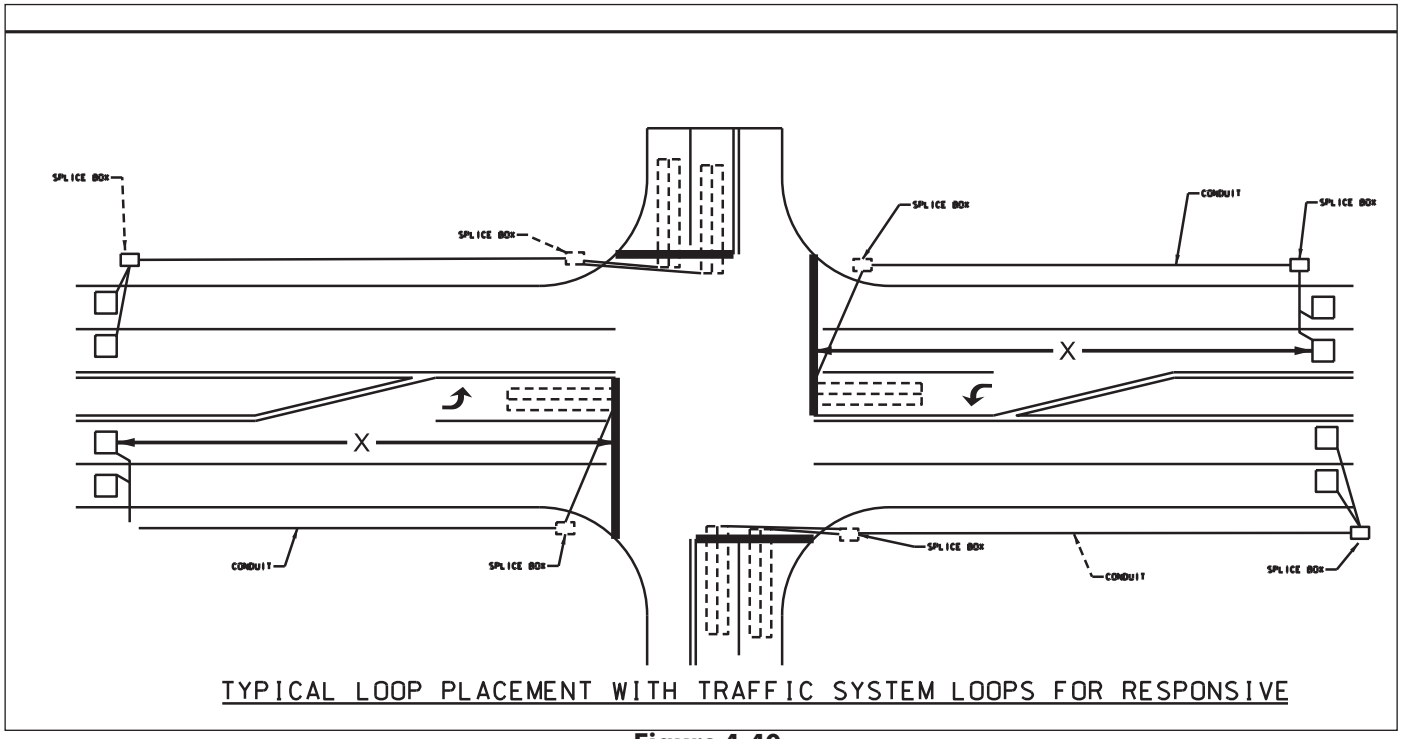


Figure 4-40
Typical Loop Placement for Responsive Signal System

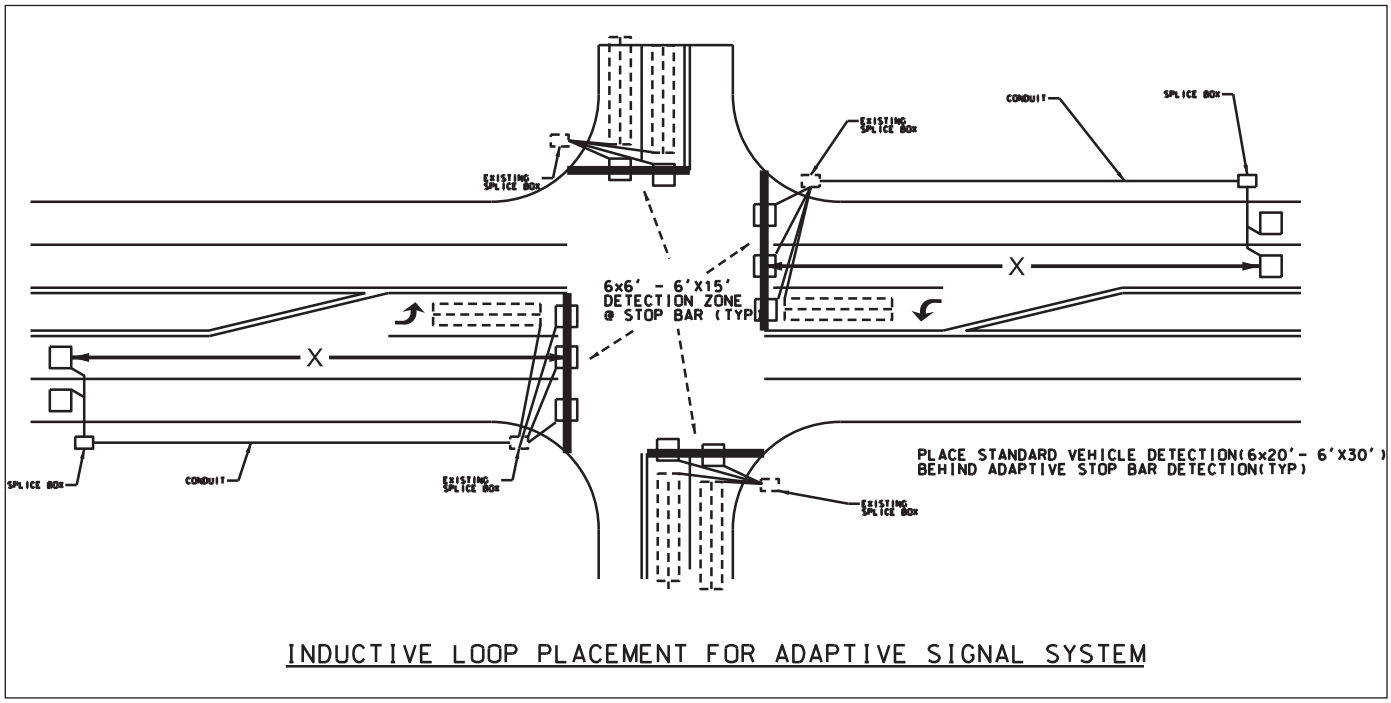


Figure 4-41
Typical Loop Placement for Adaptive Signal System

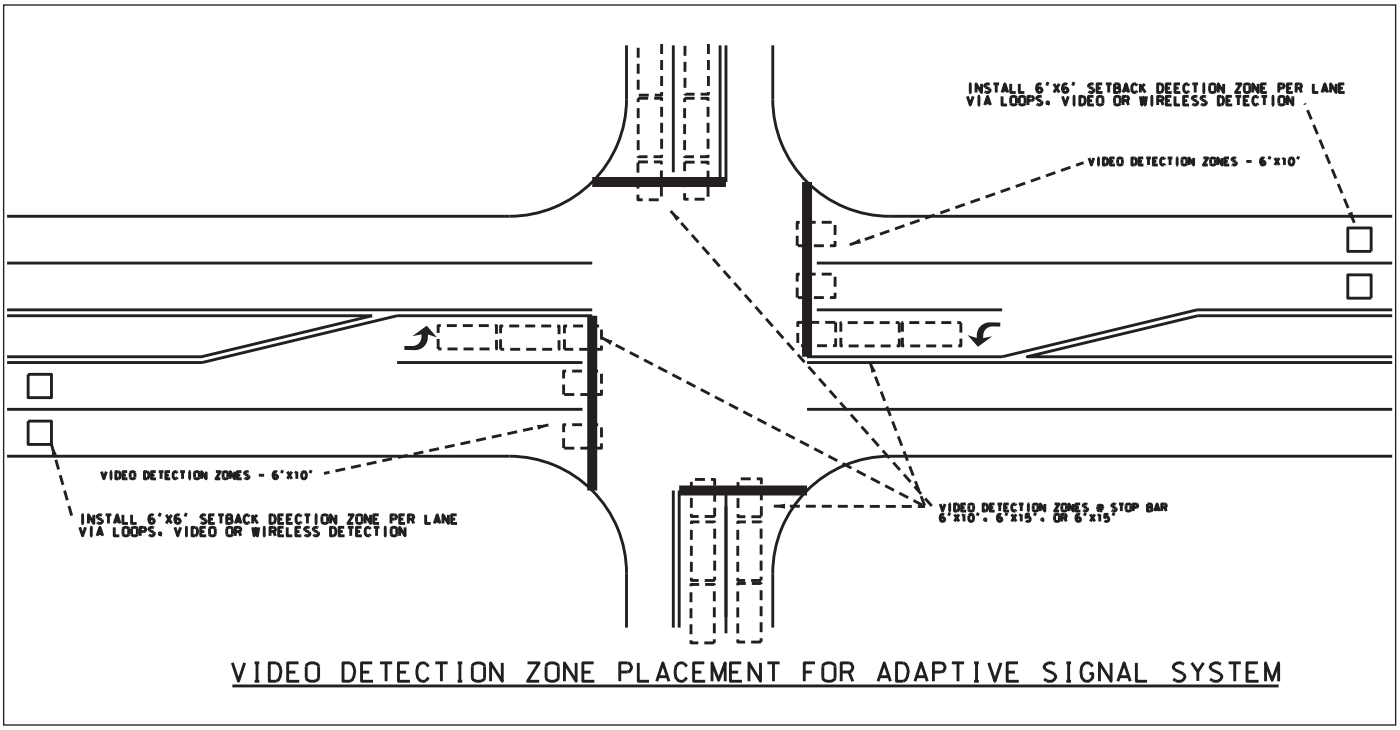


Figure 4-42
Typical Video Detection Placement for Adaptive Signal System

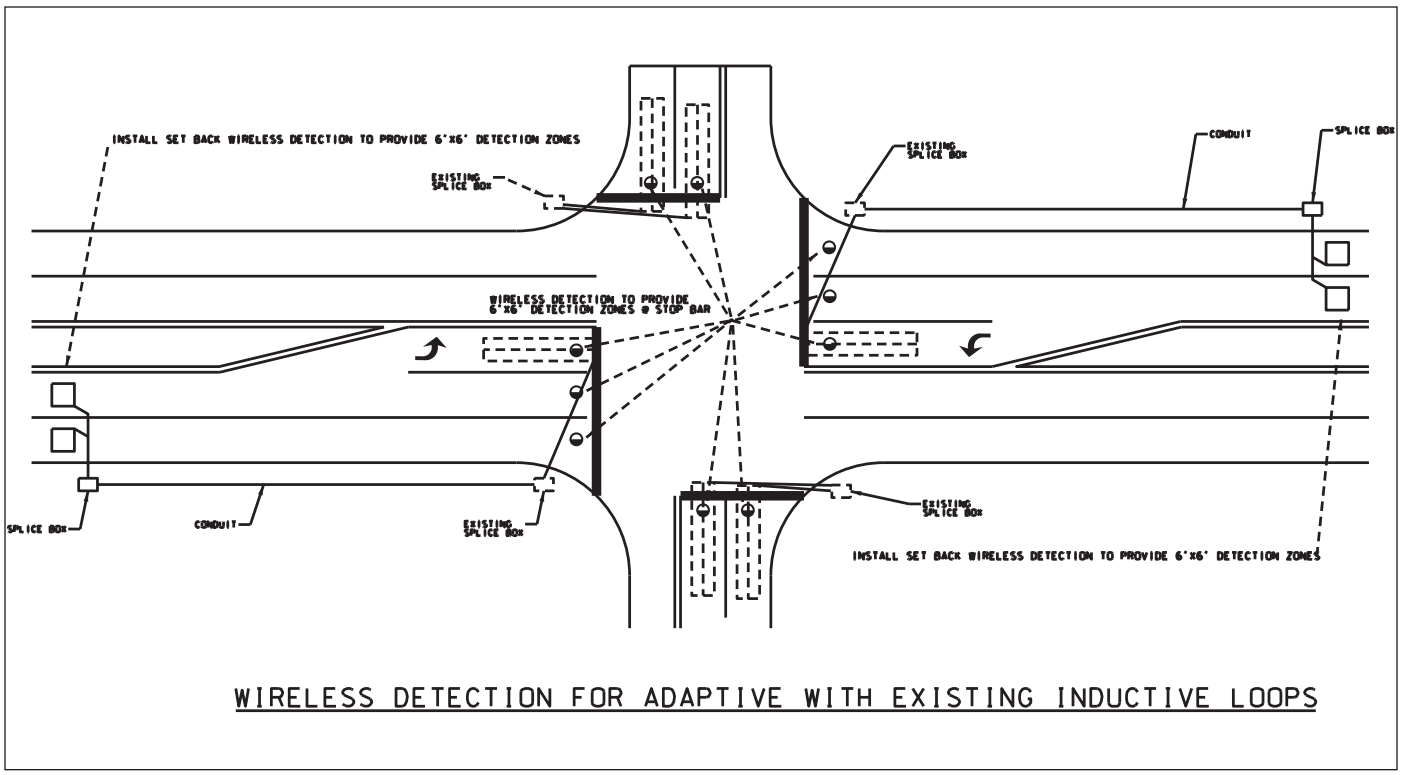


Figure 4-43
Typical Wireless Detection Placement for Adaptive Signal System with Existing Inductive Loops

Video Detection

Video Detection may be installed at intersections where there are unusual pavement conditions (rutting), where there may be future lane reassignments, and during construction when lane shifts are present.

Environmental changes such as fog, rain, or snow can cause pixel changes in video detection causing the equipment to temporarily malfunction.

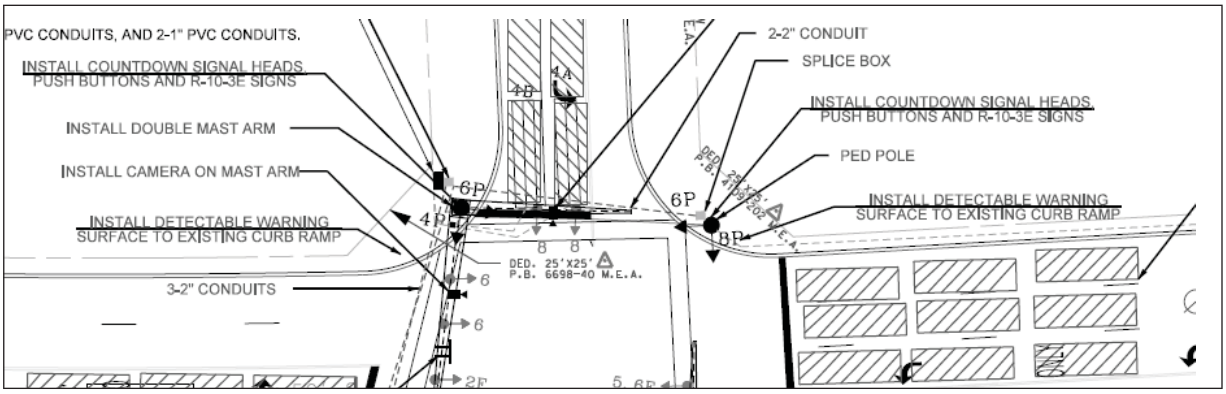
Video detection works best at locations with some lighting and lower approach speeds. The detection works best at the stop bar and is more effective if installed higher up to avoid occlusion (blocking from adjacent lanes). See **Figure 4-47, Chapter 5 and *SC-M-6788-3*** for more information.

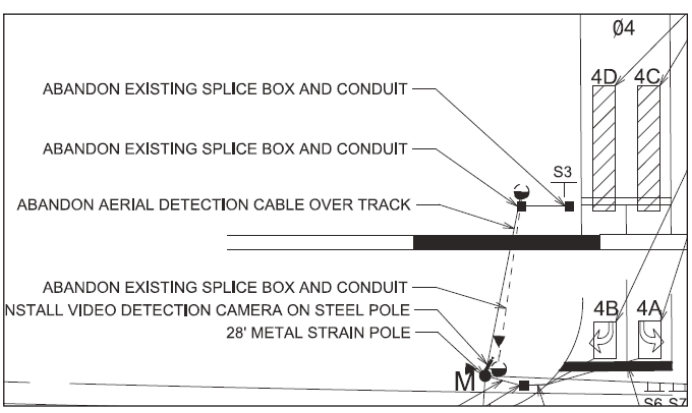
Comparison	***Video Detection***	***Inductive loop***
Installation	easy & quick	difficult & slow
Maintenance cost	low-medium	high
# of detection zones	up to 8	1
# of lanes detected	4	1
verification of detection	visual-cabinet software	field tested

Figure 4-44
Video Detection vs. Loop Detection

Installation

Video Detection cameras are installed overhead at the intersection. Cable connecting the cameras to the cabinet must be installed. Single channel or dual channel processing units are installed in the cabinet. Each camera requires a channel. If installed on corner poles, cares should be taken to provide the best visibility to the desired detection zone. Video detection cameras installed on mast arms provide optimum visibility for the detection zone. Examples of video detection cameras represented on plans are below:





Flush Mounted Wireless Detection

Flush-mounted wireless detection can also be use for locations where gathering volume, speed and occupancy is desired, like at signal systems.

These detectors are used just like inductive loops, however, they provide a more precise vehicle detection zone, without the variables of size and type that is normally attributed to typical loops.

See **Figure 4-47, Chapter 5** and ***SC-M-678-2*** for more information.

Advantages

The in-ground wireless detectors/sensors install in minutes. They are operational in a matter of hours, at which point they begin transmitting accurate, real-time detection data to Traffic Management Centers, signal controllers, and traveler information systems.

Installation is fast and simple, minimizing road closures and worker exposure, and greatly reducing operating and maintenance spending.

- In-pavement installation with no wires or lead-in cabling
- 10-year battery life
- Impervious to weatherRapid installation and deployment reduces road closures and worker exposure
- Re-usable and remotely upgradeable
- Easily deployed in complex configurations
- Capable of over 300 million detections
- RR detection - without requirement of conduit under track to connect to signal cabinet.

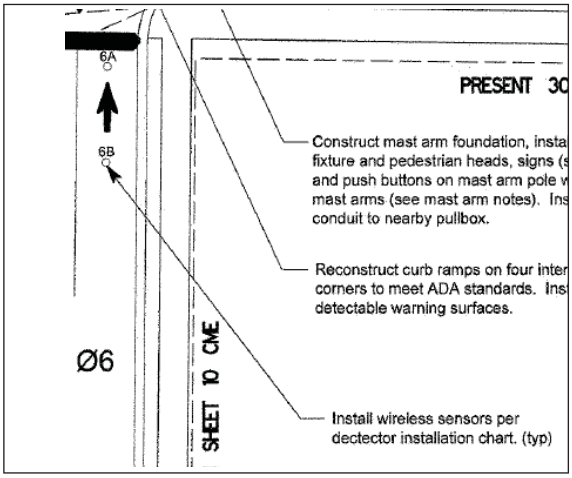
Flush-Mount Wireless Sensor

Disadvantages

- Expensive for using less than 10 detectors per signal due to l equipment in cabinet and overhead recievers/antennas/ repeaters.
- During resurfacing projects, sensors can be milled up and lost; If removed prior to milling, the detectors must be marked properly for re-use in the proper lane.

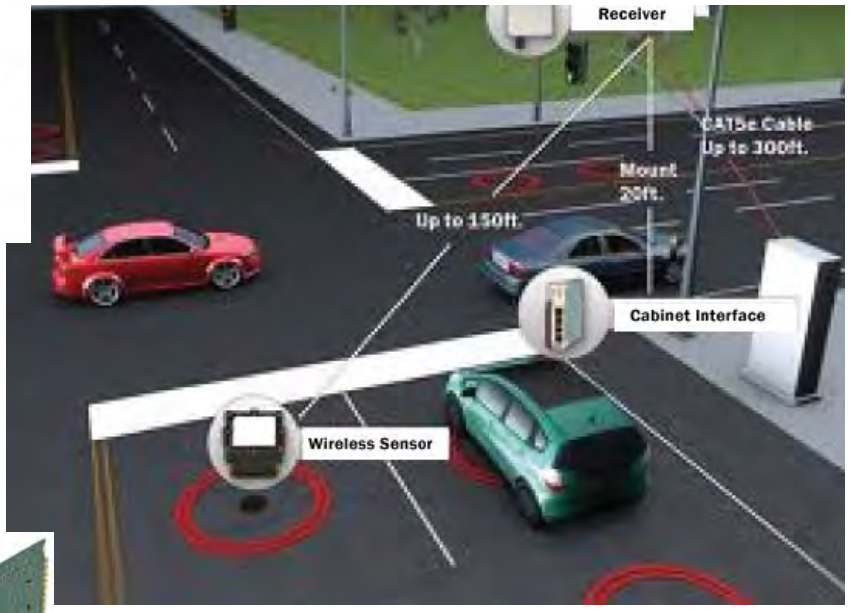
Installation

Antennas, receivers are installed on poles at the intersection, generally on the cabinet pole. If the wireless detection system utilized repeaters, these are installed at setback detection distances on poles. Some local governments use 15' pedestrian poles to mount the repeaters. An examples of wireless detection sensor represented on plans is on the right.

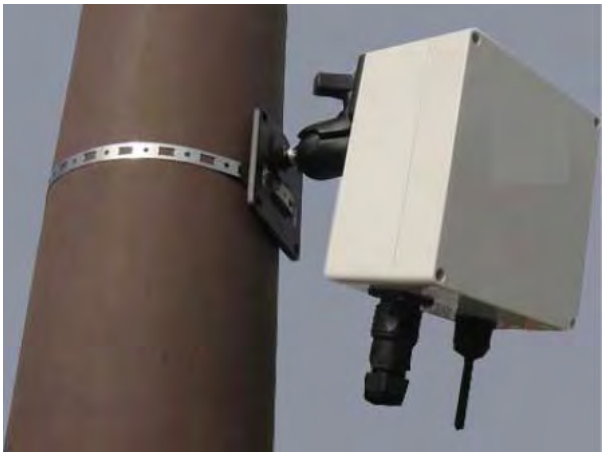


FLUSH MOUNTED WIRELESS DETECTION

Wireless Sensors



Cabinet Controller Interface

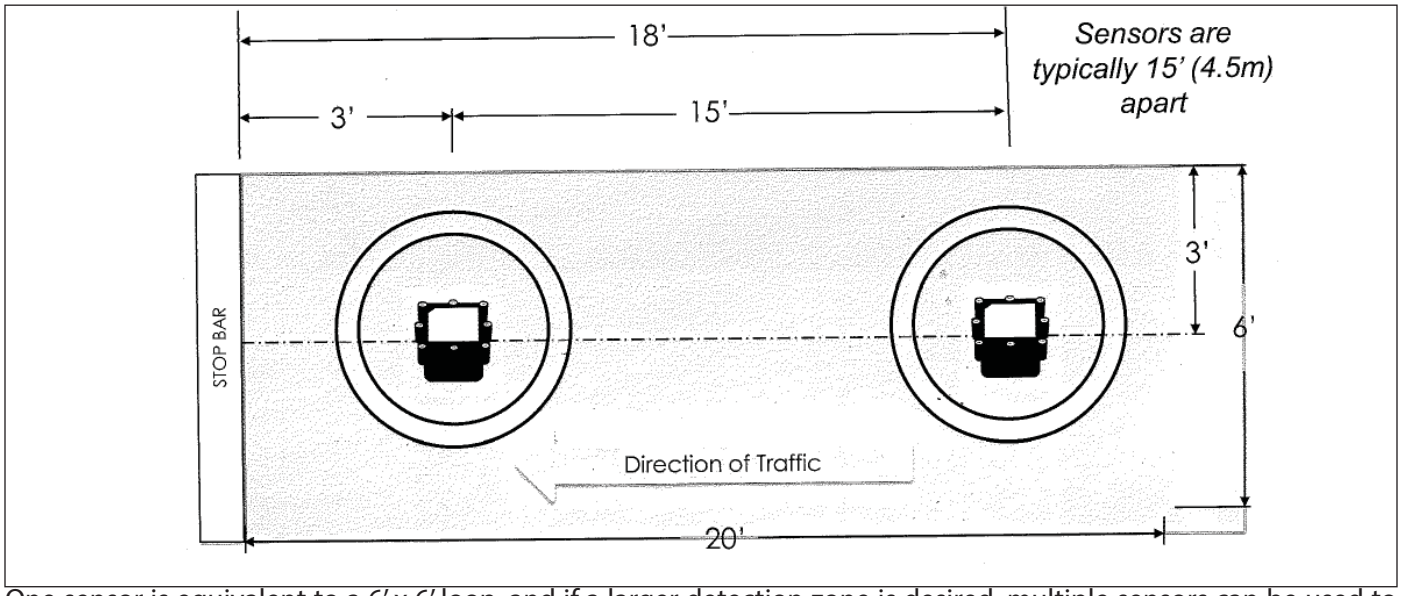


Receiver

Wireless Detection Antenna

Repeater

Recommended sensor spacing to emulate 20' loop



One sensor is equivalent to a 6' x 6' loop, and if a larger detection zone is desired, multiple sensors can be used to equate the larger zone.

Figure 4-45
Wireless Sensor Spacing

Uses for wireless detection:

- **Stop bar detection**
- **Advance detection**
- **System counts**
- **Adaptive control**

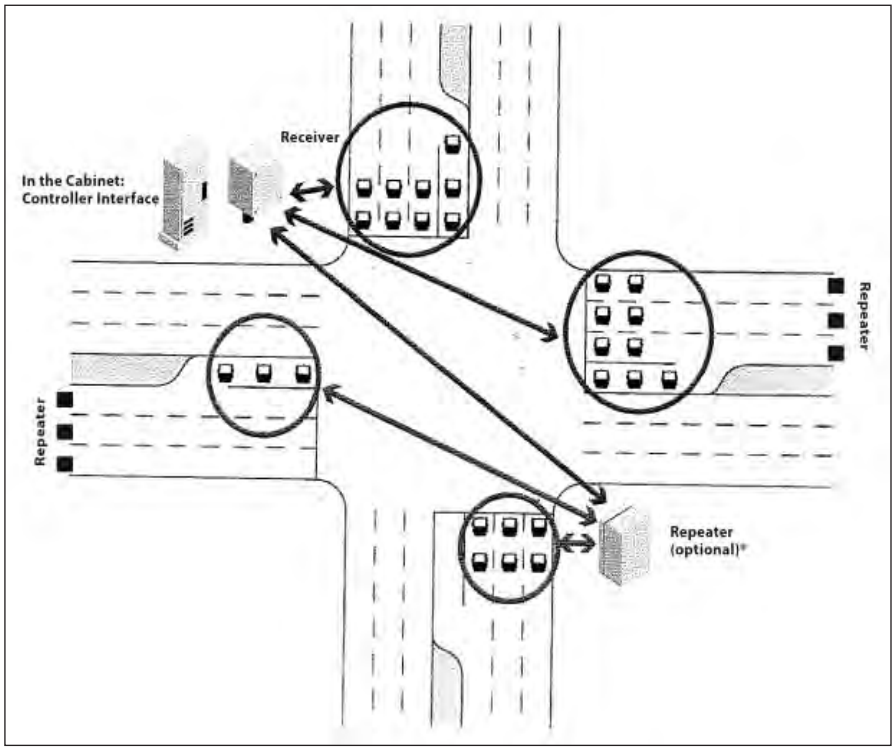


Figure 4-46
Comprehensive Stop Bar Control w/ Wireless Detection

Below are the 3 typical types of detection, Inductive loop detection, Video Detection and Wireless Detection; in addition, the pay item information, cost estimate and quantity calculation information:

678.1 Detector Loop				How to calculate quantities
6770413	LF	$0.42	FURNISH AND INSTALL NO. 14 COPPER WIRE, 1-CONDUCTOR FOR LOOP WIRE	6' x 6' loop = 100 LF + double the distance to splice box 6' x 30' quadrupole = 175 LF + double the dis. to splice box.
6780495	LF	$6.10	SAWCUT FOR LOOP DETECTOR	6' x 6' loop = 100 LF + double the distance to splice box. 6' x 30' quadrupole = 175 LF + double the dis. to splice box.
If new loops cannot be reconnected in existing junction boxes, the below pay items may be needed:				
6750275	LF	$7.25	FURNISH & INSTALL 1.0" SCHEDULE 80 PVC CONDUIT	Conduit measured from edge of pavement to splice box, and between splice boxes if needed, to the signal cabinet.
6750278	LF	$8.25	FURNISH & INSTALL 2.0" SCHEDULE 80 PVC CONDUIT	
6770389	LF	$2.05	FURNISH & INSTALL NO. 14 COPPER WIRE, 4 CONDUCTOR (GRAY)	Electrical cable to connect loop wire from splice box to the signal cabinet.
6770394	LF	$2.26	FURNISH & INSTALL NO. 14 COPPER WIRE, 8 CONDUCTOR (GRAY)	
6800518	EA	$385	FURNISH AND INSTALL 13"X24"X18"D.ELEC FLUSH UNDGRD.ENCLOSURE-(STR.POLY.CONC.)HD	Splice box placed adjacent to the loop off the roadway, as needed.
678.2 Wireless Detection				How to calculate quantities
677049C	EA	$8,182	FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (INC SETBACK DETECTION CAPABILITY FOR 2 DIRECTIONS	Includes all needed equipment, materials, hardware, cable, mounting equipment in both the signal cabinet and overhead receivers/antennas to provide system that can detect as indicated in pay item; Need 1 of the appropriate systems per signal. (Most signals require setback detection for 2 approaches for permanent installation; for detection during construction, typically only need detection at stop bar).
677049D	EA	$9,744	FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (INC SETBACK DETECTION CAPABILITY FOR 3 DIRECTIONS	
677049E	EA	$10,887	FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (INC SETBACK DETECTION CAPABILITY FOR 4 DIRECTIONS	
677049F	EA	$5,477	FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (w/o SETBACK DETECTION CAPABILITY)	
677049G	HR	$150	FURNISH MANUFACTURER TECHNICIAN ASSISTANCE	Recommended to ensure appropriate installation of detectors and programming of detection zone @ signal controller; Recommend a minimum of 8 hours per 3 signals;
6770494	EA	$595	FURNISH & INSTALL FLUSH MOUNTED WIRELESS SENSOR INC EPOXY	Includes sensor and all hardware, materials and equipment required for installation(including epoxy); Need 1 for each 6'x6' detection zone. Need 3 @ 15' spacing for each 6'x30' detection zone. Need 2 @ 15' spacing for 6'x20' detection zone.
677049B	EA	$300	REMOVE & REPLACE WIRELESS SENSOR W/NEW HOUSING	If existing wireless detection system is in place ; Need 1 per wireless detector (sensor)
688.3 VIDEO DETECTION - LOOP EMULATION SYSTEM				How to calculate quantities
6886040	EA	$5,600	FURNISH & INSTALL VIDEO DETECTION SYSTEM W/HARDWARE & LEAD-IN	Includes cabinet equipment & 1 video detection camera, all necessary hardware for mounting and cable for installation; Need 1 per signal if video detection system is not existing at signal.
6886041	EA	$575	INSTALL VIDEO DETECTION SYSTEM	If contractor owns cameras or if District provides cameras; need 1 per approach where detection is required.
6886042	EA	$2,500	FURNISH & INSTALL ADD'L CAMERAS W/ HARDWARE & LEAD-IN	Includes 1 video detection camera and all necessary hardware for mounting and cable for installation; Need 1 camera per approach where detection is required, minus the camera provided with the video detection system 6886040.

Figure 4-47

Typical Pay Items for Inductive Loops, Video Detection and Wireless Detection

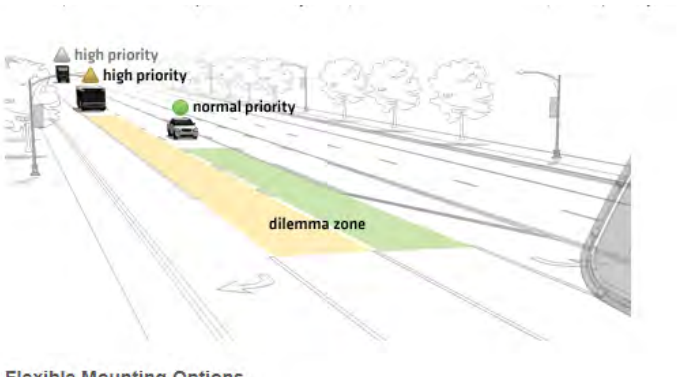
Radar Detection

Although radar detection technology has been around for years, SCDOT has just started utilizing it as an option for vehicle detection. An advantage of radar detection is the fact that it can be installed on signal support poles and can detect vehicles in all approach lanes without occlusion. Another advantage of radar detection is that lighting and weather conditions do not adversely affect the radar.

There are three types of radar detection available:

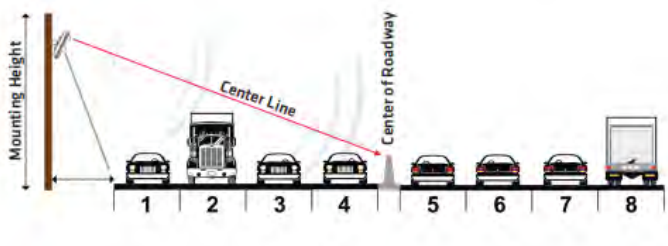
Stop bar detection
A radar is installed overhead on each corner to detect vehicles at the stop bar Depending on the installation one radar may be able to detect two approaches.

Setback detection
On mainline approaches, radars can be installed to detect both the stopbar and setback detection zones.



Side mounted detection (for counting by lanes)

Side mounted detection is typically used along interstates as permanent count equipment. Maintenance of this equipment is easier than traditional in lane detection, as maintenance personnel do not have to be in the roadway.



Traffic Signal letting package

The Traffic Signal Letting Package includes the following:

- SCDOT Construction Contract Boiler Plate (provided by SCDOT Letting Preparation Office)
    - Length of contract (to be determined by Traffic Signal Project Manager)
- Traffic Signal Design Plans -Designed in accordance with Chapter 4, Signal Design
- Cover Sheet including Table of Contents and Location map
- Quantitiy Sheet including Pay Items, Estimated Quantities, Cost Estimate - Common pay items for signals are included in the Traffic Signal Supplemental Technical Specifications. Additional pay items for signals are located in the SCDOT pay item list- 6750000-6990000.
- Specifications -
    - Special Provisions for Traffic Signals
        - schedule - does contractor set schedule or does SCDOT issue work orders assigning which signals are improved
        - list of signals and general description of work
        - differences from Supplemental Technical Specificatons....
    - Special Provisions for Traffic Control,
    - Special Provisions for Railroad ,
    - Traffic Signal Supplemental Technical Specifications - FHWA approved the Traffic Signal Supplemental Technical Specifications, latest revision and are automatically included in all SCDOT lettings.
    - Any other specification for specialized signal equipment or software applicable to the project, but not included in the Supplemental Technical Specifications
    - SCDOT also has Standard Drawings for Signal Construction that are applicable for all SCDOT projects.

Letting packages are submitted to the Pre-Construction Support group at SCDOT. Pay item quantities are entered into P2S. Engineering estimates are submitted to the Pre-Construction Support group at SCDOT.

In addition, the following certifications must also be provided, in coordination with other offices

- Utility Certification
- Railroad Certification (if applicable)
- Right of Way Certification
- Environmental Permit

Design Build Signal Scope

Design Build Projects are advertised in a Request for Proposal (RFP) and SCDOT selects a team consisting of Engineering firms and General Contractors. This team prepares a proposal based on a scope of work prepared by SCDOT. A comprehensive scope of work for signals included in the project should include specific requirements for signal design. Below are some common elements that should be addressed in the scope of work:

Does SCDOT want an advanced signal system installed at the signals?

- If so, the scope of work should detail what system is required and what this will generally entail; installation or upgrades to signal equipment, software, detection(type), traffic monitoring devices (monitoring cameras, origin-destination devices), communciations (fiber, wireless radios, Ethernet switches, cell modems, Point of Presence)

Do the signal(s) have communications?

- If so, communications must be maintained operational during the life of the project.
- Will the signal communications need to be updated to latest SCDOT standards or improved to addressed advanced technologies

If the signal(s) don't have communications, do the signal(s) need it?

- If so, specify the type of communications needed.

Will the project impact any of the signal structures (signal support poles, signal cabinet)?

- If so, at what point should the signal be rebuilt -generally if the cabinet signal pole or signal cabinet is impacted, the signal should be entirely rebuilt including all new signal span wire, electrical cable, signal heads, pedestrian treatments and signal cabinet and foundation.
- Specify if signal poles should be replaced and by what type (steel poles, concrete poles or mast arms)
- Specify if joint use pole attachments are permissable.

Will the project impact any of the detection?

- If so, is temporary detection required?
- If so, what type of detection should be installed to replace the detection?

Should the signal(s) be retimed to improve coordination?

Should the existing signals be studied to determine if phasing changes are warranted?

A statement about SCDOT provided equipment should be included, listing the type of equipment and indicating that the cost of equipment should be covered by the project charge codes. Generally this is equipment specified under SCDOT's Public Interest Finding (see Chaptter 2). This generally includes adaptive software licenses, network devices such as Ethernet switches, wireless radios, cell modems, and traffic monitoring cameras.

A general statement in the scope should include that the signal design should comply to SCDOT Signal Standards, including this SCDOT Signal Manual, SCDOT Signal Specifications, and SCDOT Standard Drawings. Any variences should be submitted to SCDOT Traffic Engineers with a justification for variance.

TYPICAL SCDOT TRAFFIC SIGNAL PAY ITEMS

ITEM	IDESCRL	UNITS
1031000	MOBILIZATION	LS
1031010	MOBILIZATION	EA
1071000	TRAFFIC CONTROL	LS
1071100	TRAFFIC CONTROL	EA
6885992	TEMPORARY ADJUSTMENT OF TRAFFIC SIGNAL EQUIPMENT	LS
CONDUIT PAY ITEMS		
6750005	FURNISH & INSTALL 1.0" GALVANIZED RIGID CONDUIT	LF
6750015	FURNISH & INSTALL 2.0" GALVANIZED RIGID CONDUIT	LF
6750275	FURNISH & INSTALL 1.0" SCHEDULE 80 PVC CONDUIT	LF
6750278	FURNISH & INSTALL 2.0" SCHEDULE 80 PVC CONDUIT	LF
675027C	FURNISH & INSTALL 3.0" SCHEDULE 80 PVC CONDUIT	LF
675027S	FURNISH & INSTALL 2.0" SCHD 80 PVC CONDUIT (DIRECTION.BORED)	LF
675027V	FURNISH & INSTALL 3.0" SCHD 80 PVC CONDUIT(DIRECTION BORED)	LF
ELECTRIC CABLE PAY ITEMS		
6770388	FURNISH & INSTALL NO. 14 COPPER WIRE, 4 CONDUCTOR - BLACK	LF
6770389	FURNISH & INSTALL NO. 14 COPPER WIRE, 4 CONDUCTOR - GRAY	LF
6770393	FURNISH & INSTALL NO. 14 COPPER WIRE, 8 CONDUCTOR (BLACK)	LF
6770394	FURNISH & INSTALL NO. 14 COPPER WIRE, 8 CONDUCTOR (GRAY)	LF
FIBER & COMMUNICATIONS PAY ITEMS		
6770470	FURNISH & INSTALL FIBER OPTIC CABLE-SINGLE MODE	LF
6770476	FURNISH & INSTALL FIBER OPTIC INTERCONNECT CENTER	EA
6888082	FURNISH & INSTALL FACTORY TERMINATED PATCH PANEL	EA
677048B	INSTALL WIRELESS NETWORK COMMUNICATIONS LINK BTWN TWO SIGNALS	EA
DETECTION PAY ITEMS		
6770413	FURNISH & INSTL NO. 14 COPPER WIRE,1-CONDUCTOR FOR LOOP WIRE	LF
6780495	SAWCUT FOR LOOP DETECTOR	LF
6886040	F&I - VIDEO DETECTION SYSTEM W/ONE CAMERA, HARDWARE & LEAD-IN	EA
6886042	F&I VIDEO DETECTION CAMERA W/ HARDWARE & LEAD-IN	EA
6770494	F&I WIRELESS DETECTOR	EA
677049C	F&I WIRELESS DETECTION SYSTEM W/O SENSORS (INC SET BACK DETECTION CAPABILITY FOR 2 APPROACHES)	EA
677049D	F&I WIRELESS DETECTION SYSTEM W/O SENSORS (INC SET BACK DETECTION CAPABILITY FOR 3 APPROACHES)	EA
677049E	F&I WIRELESS DETECTION SYSTEM W/O SENSORS (INC SET BACK DETECTION CAPABILITY FOR 4 APPROACHES)	EA
677049F	F&I WIRELESS DETECTION SYSTEM W/O SENSORS (W/O SET BACK DETECTION CAPABILITY)	EA

Figure 4-48a
Typical Traffic Signal Pay Items (page 1)

ELECTRIC SERVICE PAY ITEMS		
6800499	FURNISH & INSTALL ELECTRICAL SERVICE FOR TRAFFIC SIGNAL	EA
6800500	MOD. EXIST ELECTRICAL SERVICE FOR TRAFFIC SIGNAL	EA
SPLICE BOX PAY ITEMS		
6800508	F&I-12"X12"X12"D.ELEC.FLUSH UNDGRD.ENCLOS-(STR.POLY.CONC.)HD	EA
6800518	F&I-13"X24"X18"D.ELEC.FLUSH UNDGRD.ENCLOS-(STR.POLY.CONC.)HD	EA
SIGNAL SUPPORT POLE PAY ITEMS		
6825020	FURNISH & INSTALL - 35' WOOD POLE-CLASS II-CCA TR(0.60)	EA
6825045	FURNISH & INSTALL 3/8" BACK GUY FOR WOOD POLE	EA
6825046	FURNISH & INSTALL 3/8" SIDEWALK GUY	EA
6825050	F&I 13"X26' STEEL STRAIN POLE-POWDER COATED WITH FOUNDATION	EA
6825051	F&I 13 X28' STEEL STRAIN POLE-POWDER COATED AND FOUNDATION	EA
6825052	F&I 13"X32' STEEL STRAIN POLE-POWDER COATED AND FOUNDATION	EA
682505B	F&I 13" X 28' STEEL STRAIN POLE & FOUNDATION	EA
682505D	F&I 13"X32' STEEL STRAIN POLE & FOUNDATION	EA
6825061	FURNISH & INSTALL 35' CONCRETE STRAIN POLE	EA
6825062	FURNISH & INSTALL 40' CONCRETE STRAIN POLE	EA
6825064	FURNISH & INSTALL 45' CONCRETE STRAIN POLE	EA
6825090	FURNISH & INSTALL 1/4" GALVANIZED STEEL CABLE	LF
6825092	FURNISH & INSTALL 3/8" GALVANIZED STEEL CABLE	LF
MAST ARM PAY ITEMS		
6888166	POWDERCOATING PER MAST ARM OVER BASE	EA
6888168	DECORATIVE OPTION PER MAST ARM	EA
6888169	LUMINAIRE OPTION FOR MAST ARM - TO ACCOUNT FOR TALLER POLE	EA
6888177	DESIGN, FURNISH & INSTALL STEEL POLE WITH TWIN MAST ARMS INCLUDING FOUNDATION	EA
6888179	DESIGN, FURNISH & INSTALL STEEL POLE WITH MAST ARM INCLUDING FOUNDATION	EA
PEDESTRIAN PAY ITEMS		
6825480	FURNISH & INSTALL 4' BREAK-AWAY ALUMINUM PEDESTAL POLE	EA
6825484	FURNISH & INSTALL 10' BREAK-AWAY ALUM PEDESTAL POLE AND BASE	EA
6888192	POWDERCOATING OPTION FOR 4' ALUMINUM PEDESTAL POLE	EA
6888194	POWDERCOATING OPTION FOR 10' ALUMINUM PEDESTAL POLE	EA
6865782	F&I PEDESTRIAN SIGNAL HEAD	EA
6865783	F&I COUNTDOWN PEDESTRIAN SIGNAL HEAD	EA
6865794	F&I-PED PUSH BUTTON MICRO ASSEMBLY(9"X15")AND SIGN(R-10-3E)	EA
6865795	FURNISH & INSTALL-PEDESTRIAN PUSH BUTTON MICROSWITCH TYPE	EA
6865797	F&I PED PUSHBUTTON SOLID STATE W/LIGHT & TONE STATION ASSEMBLY (9X15) AND SIGN (R10-3E)	EA

Figure 4-48b
Typical Traffic Signal Pay Items (page 2)

CABINET PAY ITEMS		
6845510	F&I - CONTR 332/336 CABINET ASSEMBLY - POLE MOUNTED	EA
6845511	F&I - CONTR 332/336 CABINET ASSEMBLY - BASE MOUNTED	EA
6845520	FURNISH & INSTALL 2070L CONTROLLER UNIT IN EXISTING CABINET	EA
6845655	FURNISH & INSTALL SPLICE-CABINET/FLASHER CABINET	EA
6887951	FURNISH & INSTALL CONCRETE CABINET FOUNDATION	EA
SOLAR FLASHERS		
6865700	F&I SOLAR POWERED FLASHER ASSEMBLY - SINGLE BEACON	EA
6865701	F&I SOLAR POWERED FLASHER ASSEMBLY - DUAL BEACON	EA
SIGNAL HEAD PAY ITEMS		
6865710	F&I 12" 5 SECTION SIGNAL HEAD	EA
6865720	F&I 12" 4 SECTION SIGNAL HEAD	EA
6865723	F&I - 12" 3 SECTION SIGNAL HEAD	EA
6865834	BACKPLATE W/ RETROREFL.BORDERS FOR TRAFF. SIG.	EA
REMOVE AND SALVAGE PAY ITEMS		
6885982	REMOVE FOUNDATION OF STEEL STRAIN POLE - 18" BELOW GRADE	LS
6885990	REMOVAL,SALVAGE,&DISP.OF EXISTING TRAF. SIGNAL EQUIPMENT	LS
6885991	REMOVAL,SALVAGE,&DISP.OF EXISTING TRAF. SIGNAL EQUIPMENT	EA

* The pay items listed below are the ones most commonly used on jSCDOT traffic signal plans. These items should cover at least 80% of traffic signal plans. If additional or speciality items are to be included, please contact SCDOT Traffic Signals for correct pay item number and description

Figure 4-48c
Typical Traffic Signal Pay Items (page 3)

TYPICAL SIGNAL COSTS

ITEM	APPROXIMATE COST/SIGNAL	
New Installs		
• Steel pole and span wire	$ 80,000	
• Mast arms	$130,000	
Rebuilds		
• Full (including poles)	$ 80,000	
• Detection only	$ 10,000	
• Signal heads/cable	$ 15,000	
• Pedestrian treatments (heads/buttons)	$ 12,000	
• Cabinet Assembly	$ 12,000	
• 4 steel poles/span wire	$ 15,000	
• Conduit/splice boxes	$ 6,000	
• Mobilization/Traffic Control	$ 10,000	
Possible Additional Items		
• Curb Ramps	$ 15,000	
• Pavement Markings	$ 8,000	
• Wireless Communications	$ 5,000	
• Ethernet Equipment	$ 2,000	
• Traffic Monitoirn Cameras	$ 7,000	
• Fiber Communications		
overhead		$ 4.00/LF
underground		$ 18.00/LF

Figure 4-49
Typical Traffic Signal Costs

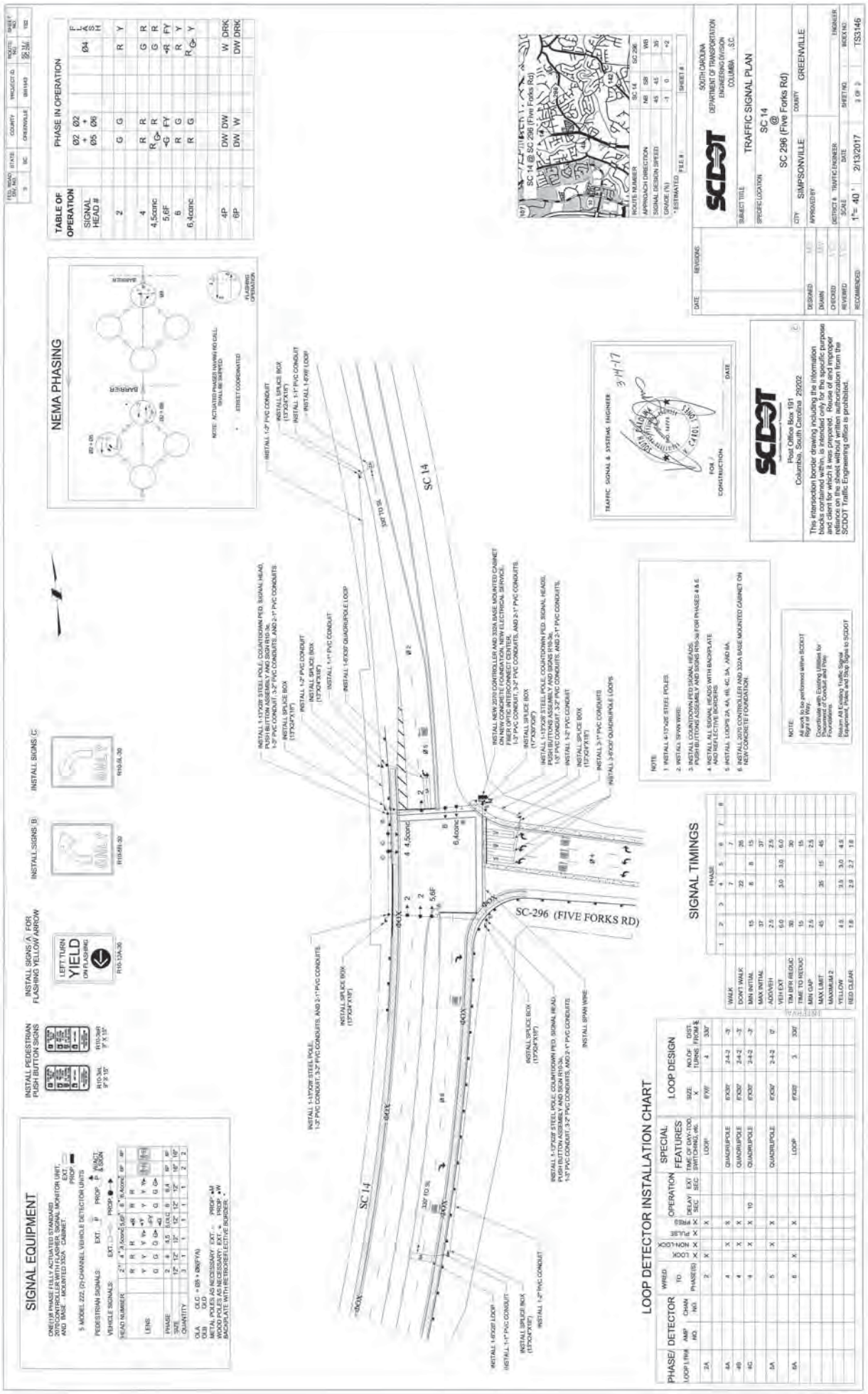


Figure 4-50 a
Example Signal Plan

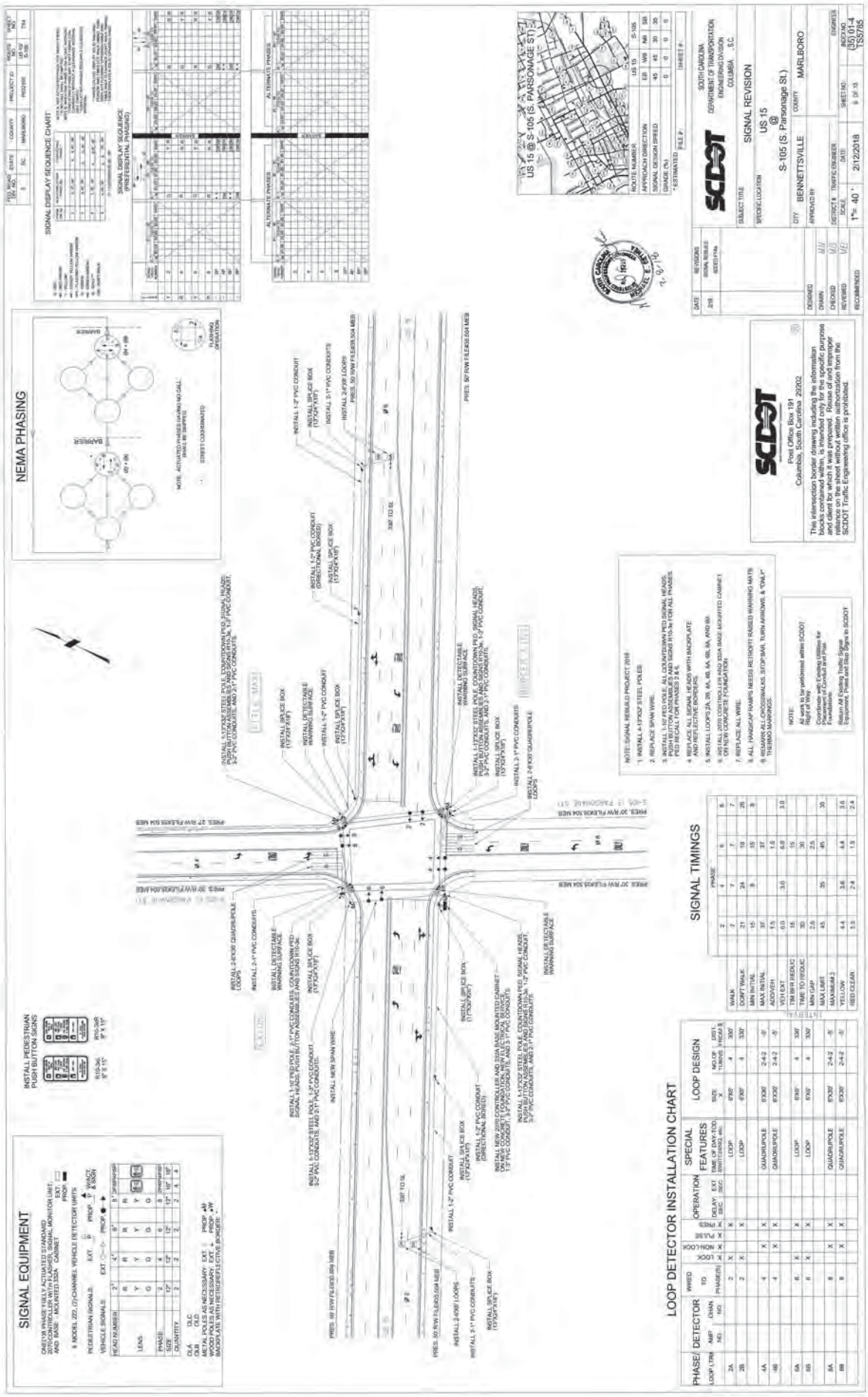


Figure 4-50b
Example Signal Plan

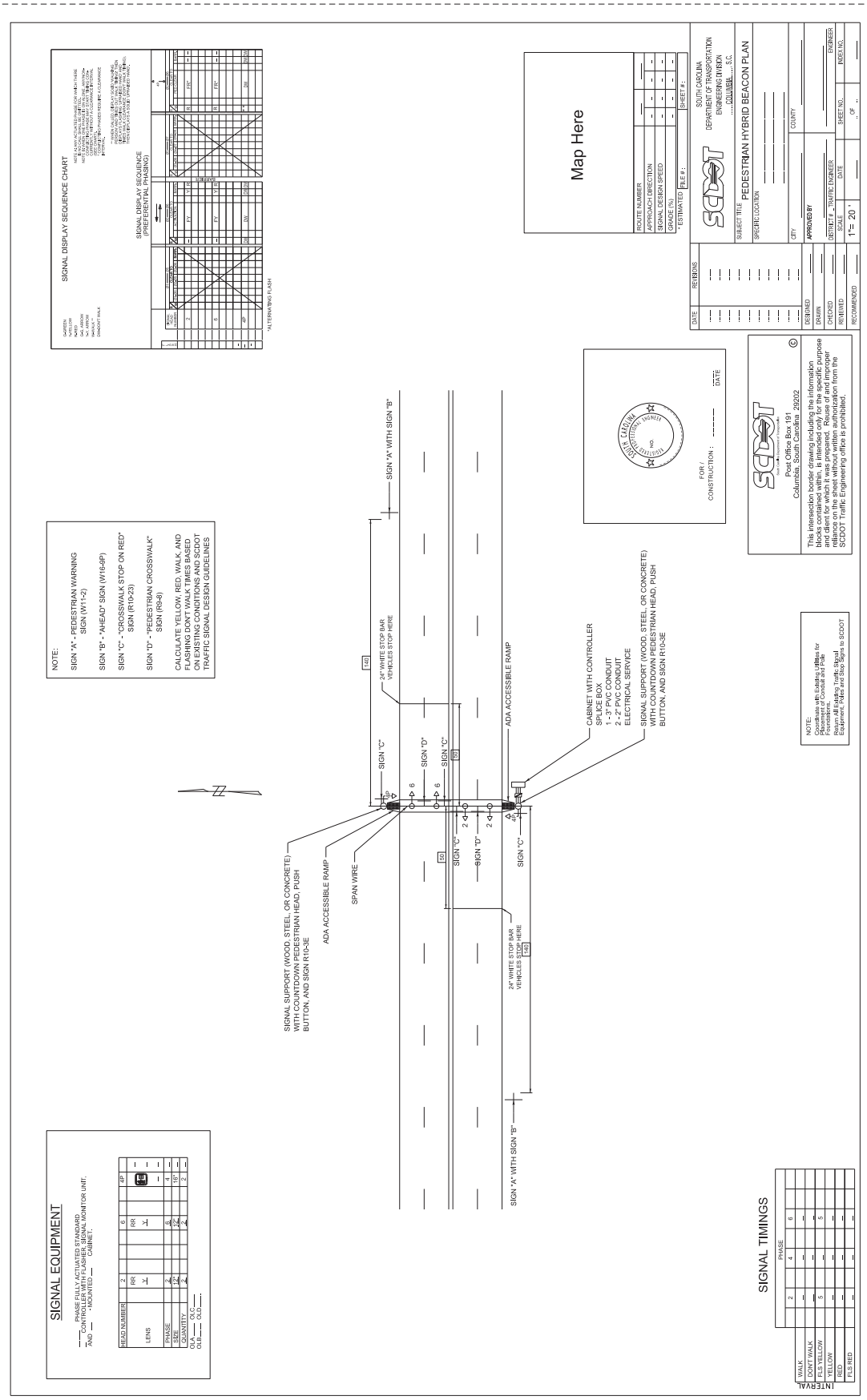


Figure 4-50c
Example Signal Plan

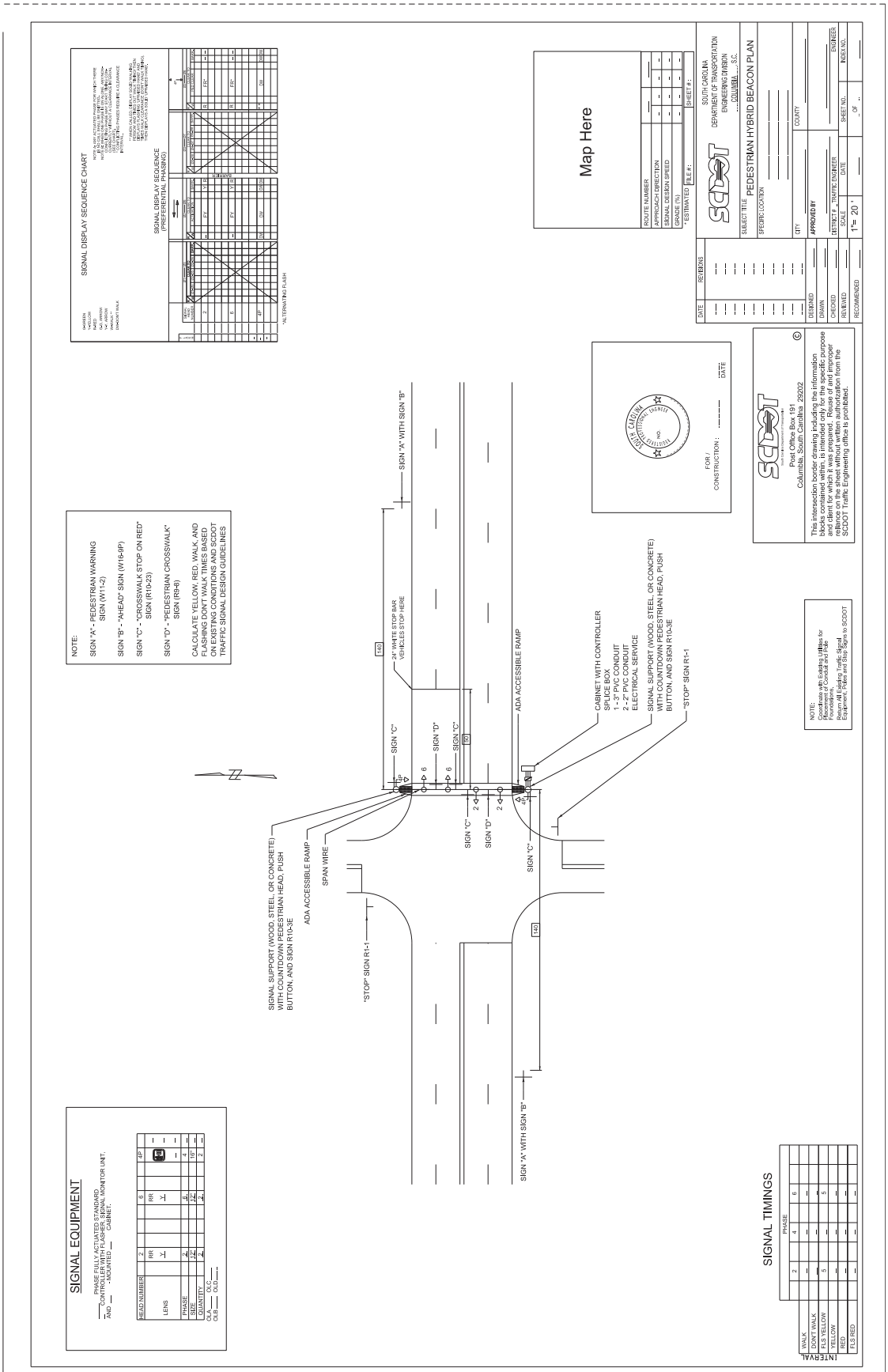


Figure 4-50d
Example Signal Plan

Phase 1 FYA program only the following:

Turn run timer off in MM->1->7.

Set the IO parameters to USER mode with in MM->1->8->6.

```
                I/O Parameters

C1-C11-ABC IO Mode: USER
    D Conn Mapping: NONE
       T&F Biu Map: DEFAULT
Invert Rail Inputs: ON
   EVP Ped Confirm: OFF
```

Initialize the IO map with MODE 0 in MM->1->8->9->3.

```
          Initialize User I/O Maps
      Init ABC with: NONE
        Init D with: NONE
       Init 2A with: MODE 0
 Init TF BIUs with: NONE
```

In MM->1->8->9->2->5

	DEFAULT		CHANGE TO	
PIN	FCN	DESCRIPTION	FCN	DESCRIPTION
2-8	49	CH1 Green	57	CH9 Green
5-1	37	CH13 Yellow	0	UNUSED
7-8	57	CH9 Green	37	CH13 Yellow

In MM->1->5->2 OL# -1

OVERLAP A-1

```
  Ovrlp A-1   Ps.....................
Included Ps     1  0  0  0  0  0  0  0
Modifier Ps     2  0  0  0  0  0  0  0
Type:FYA-4   Grn:  0  Yel: 3.5  Red: 1.5
```

In MM->1->8->4.

*ONLY PROGRAM WHAT IS SOWN FOR CHANNEL 13

```
<    Chan.9..10..11..12..13..14..15..16
Flash Red .   .   .   .   .   .   .   .
Flash Yel .   .   .   .   X   X   X   X
Flash Grn .   .   .   .   .   .   .   .
Inhibit Red Flash in
  Preempt .   .   .   .   .   .   .   .
Olap Ovrd 0   0   0   0   1   2   3   4
```

***(Monitor settings FYA = 1-9, SSM OFF on PH 1 and if no PH 1 Concurrent strap PH 1 Yellow)**

Left Turn Arrow GYR-Phase #	Overlap #	Left Turn Arrow-RED Controller Channel #	Left Turn Arrow-YELLOW Controller Channel #	Left Turn Arrow Flashing Yellow Channel #	Left Turn Arrow-GREEN Controller Channel #
1	A-1	9R	9Y	9G	1G

Turn run timer back on in MM->1->7 and cycle power.

Figure 4-51a
Guidance on Programming Phase 1 FYA

Phase 3 FYA program only the following:

Turn run timer off in MM->1->7.

Set the IO parameters to USER mode with in MM->1->8->6.

```
                I/O Parameters

C1-C11-ABC IO Mode: USER
    D Conn Mapping: NONE
       T&F Biu Map: DEFAULT
Invert Rail Inputs: ON
   EVP Ped Confirm: OFF
```

Initialize the IO map with MODE 0 in MM->1->8->9->3.

```
          Initialize User I/O Maps
      Init ABC with: NONE
        Init D with: NONE
       Init 2A with: MODE 0
  Init TF BIUs with: NONE
```

In MM->1->8->9->2->5

	DEFAULT		CHANGE TO	
PIN	FCN	DESCRIPTION	FCN	DESCRIPTION
1-8	51	CH3 Green	58	CH10 Green
5-3	38	CH14 Yellow	0	UNUSED
7-5	58	CH10 Green	38	CH14 Yellow

In MM->1->5->2 OL# -1

OVERLAP B-2

```
  Ovrlp B-2   Ps.....................
Included Ps    3  0  0  0  0  0  0  0
Modifier Ps    4  0  0  0  0  0  0  0
Type:FYA-4   Grn:  0  Yel: 3.5  Red: 1.5
```

In MM->1->8->4.

*ONLY PROGRAM WHAT IS SOWN FOR CHANNEL 14

```
<     Chan.9..10..11..12..13..14..15..16
Flash Red .    .    .    .    .    .    .    .
Flash Yel .    .    .    .    X    X    X    X
Flash Grn .    .    .    .    .    .    .    .
Inhibit Red Flash in
  Preempt .    .    .    .    .    .    .    .
Olap Ovrd 0    0    0    0    1    2    3    4
```

***(Monitor settings FYA = 3-10, SSM OFF on PH 3 and if no PH 3 Concurrent strap PH 3 Yellow)**

Left Turn Arrow GYR-Phase #	Overlap #	Left Turn Arrow-RED Controller Channel #	Left Turn Arrow-YELLOW Controller Channel #	Left Turn Arrow Flashing Yellow Channel #	Left Turn Arrow-GREEN Controller Channel #
3	B-2	10R	10Y	10G	3G

Turn run timer back on in MM->1->7 and cycle power.

Figure 4-51b
Guidance on Programming Phase 3 FYA

Phase 5 FYA program only the following:

Turn run timer off in MM->1->7.

Set the IO parameters to USER mode with in MM->1->8->6.

```
                I/O Parameters

C1-C11-ABC IO Mode: USER
    D Conn Mapping: NONE
      T&F Biu Map: DEFAULT
Invert Rail Inputs: ON
   EVP Ped Confirm: OFF
```

Initialize the IO map with MODE 0 in MM->1->8->9->3.

```
          Initialize User I/O Maps
     Init ABC with: NONE
       Init D with: NONE
      Init 2A with: MODE 0
 Init TF BIUs with: NONE
```

In MM->1->8->9->2->5

	DEFAULT		CHANGE TO
4-8	53	CH5 Green	59 CH11 Green
5-2	39	CH15 Yellow	0 UNUSED
6-8	59	CH11 Green	39 CH15 Yellow

In MM->1->5->2 OL# -1

OVERLAP C-3

```
  Ovrlp C-3   Ps.....................
Included Ps    5  0  0  0  0  0  0  0
Modifier Ps    6  0  0  0  0  0  0  0
Type:FYA-4   Grn:  0  Yel: 3.5  Red: 1.5
```

In MM->1->8->4.

*ONLY PROGRAM WHAT IS SOWN FOR CHANNEL 15

```
<    Chan.9..10..11..12..13..14..15..16
Flash Red .    .   .   .   .   .   .   .
Flash Yel .    .   .   .   X   X   X   X
Flash Grn .    .   .   .   .   .   .   .
Inhibit Red Flash in
  Preempt .    .   .   .   .   .   .   .
Olap Ovrd 0    0   0   0   1   2   3   4
```

***(Monitor settings FYA = 5-11, SSM OFF on PH 5 and if no PH 5 Concurrent strap PH 5 Yellow)**

Left Turn Arrow GYR-Phase #	Overlap #	Left Turn Arrow-RED Controller Channel #	Left Turn Arrow-YELLOW Controller Channel #	Left Turn Arrow Flashing Yellow Channel #	Left Turn Arrow-GREEN Controller Channel #
5	C-3	11R	11Y	11G	5G

Turn run timer back on in MM->1->7 and cycle power.

Figure 4-51c
Guidance on Programming Phase 5 FYA

Phase 7 FYA program only the following:

Turn run timer off in MM->1->7.

Set the IO parameters to USER mode with in MM->1->8->6.

```
              I/O Parameters

C1-C11-ABC IO Mode: USER
    D Conn Mapping: NONE
       T&F Biu Map: DEFAULT
Invert Rail Inputs: ON
   EVP Ped Confirm: OFF
```

Initialize the IO map with MODE 0 in MM->1->8->9->3.

```
        Initialize User I/O Maps
     Init ABC with: NONE
       Init D with: NONE
      Init 2A with: MODE 0
 Init TF BIUs with: NONE
```

In MM->1->8->9->2->5

	DEFAULT		CHANGE TO	
3-8	55	CH7 Green	60	CH12 Green
5-4	40	CH16 Yellow	0	UNUSED
6-5	60	CH12 Green	40	CH16 Yellow

In MM->1->5->2 OL# -1

OVERLAP D-4

```
 Ovrlp D-4   Ps.....................
Included Ps    7  0  0  0  0  0  0  0
Modifier Ps    8  0  0  0  0  0  0  0
Type:FYA-4   Grn:  0  Yel: 3.5  Red: 1.5
```

In MM->1->8->4.

*ONLY PROGRAM WHAT IS SOWN FOR CHANNEL 16

```
<    Chan.9..10..11..12..13..14..15..16
Flash Red .    .    .    .    .    .    .
Flash Yel .    .    .    .    X    X    X    X
Flash Grn .    .    .    .    .    .    .    .
Inhibit Red Flash in
  Preempt .    .    .    .    .    .    .    .
Olap Ovrd 0    0    0    0    1    2    3    4
```

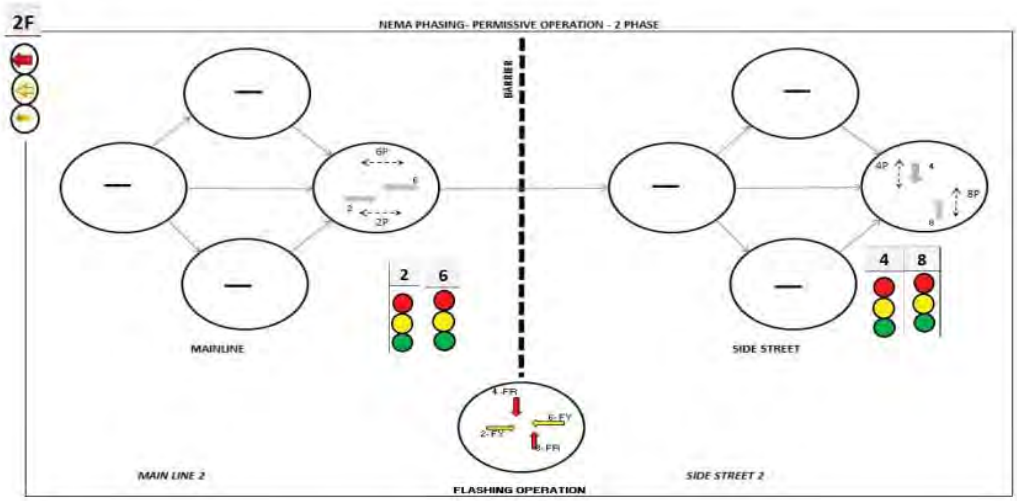
***(Monitor settings FYA = 7-12, SSM OFF on PH 7 and if no PH 7 Concurrent strap PH 7 Yellow)**

Left Turn Arrow GYR-Phase #	Overlap #	Left Turn Arrow-RED Controller Channel #	Left Turn Arrow-YELLOW Controller Channel #	Left Turn Arrow Flashing Yellow Channel #	Left Turn Arrow-GREEN Controller Channel #
7	D-4	12R	12Y	12G	7G

Turn run timer back on in MM->1->7 and cycle power.

Figure 4-51d
Guidance on Programming Phase 7 FYA

NEMA PHASING



flash	signal head #	phase 2/6										phase 4/8									
		r/w	clears to barrier	clears to	clears to	clears to	r/w	clears to barrier	clears to	clears to	clears to barrier	r/w	clears to barrier	clears to	clears to	clears to barrier	r/w	clears to barrier	clears to	clears to	clears to barrier
Y	2						G				Y,R						R				R,R
-	2P						*				DW						DW				DW
R	4						R				R,R						G				Y,R
-	4P						DW				DW						*				DW
Y	6						G				Y,R						R				R,R
-	6P						*				DW						DW				DW
R	8						R				R,R						G				Y,R
-	8P	-	-	-	-	-	DW				DW	-	-	-	-	-	*				DW
		alterate phases																			
	signal head #	r/w	clears to 1/5	clears to 5/2	clears to 2/6	clears to barrier	r/w	clears to 1/5	clears to 1/6	clears to 2/6	clears to barrier	r/w	clears to 3/7	clears to 7/4	clears to 4/8	clears to barrier	r/w	clears to 3/7	clears to 3/8	clears to 4/8	clears to barrier

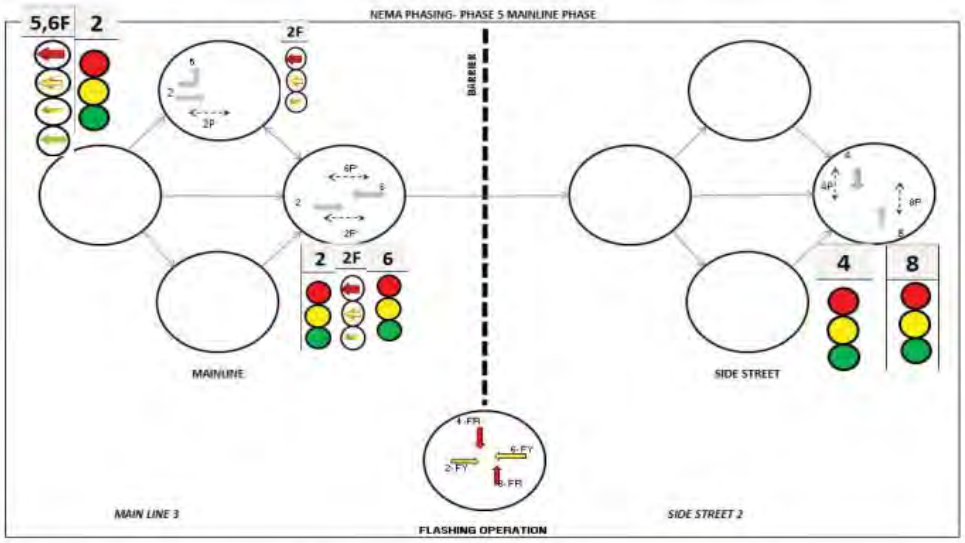
** When called, displays solid 'Walking Person' and times out Walk Timing, then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

MAIN LINE 2 SIDE STREET 2

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	-	-	-	2 + 6	-	-	-	4 + 8	FLASH
2				G				R	Y
4				R				G	R
6				G				R	Y
8				R				G	R
2P				W				DW	DRK
4P				DW				W	DRK
6P				W				DW	DRK
8P				DW				W	DRK

Figure 4-52
2 Phase NEMA / Sequence Table of Operations Charts

NEMA PHASING



flash	signal head #	phase 2/6(RECALL)										phase 4/8									
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		1/w				barrier	1/w	1/5	5/2	1/6	barrier	1/w	1/8	7/4	4/8	barrier	1/w	1/7	1/8	7/4	barrier
Y	2						G		G,G		Y,R						R				R,R
FYA	2F						FYA		FYA		YA,RA						RA				RA,RA
-	2P						**		**		DW						DW				DW
R	4						R		R,R		R,R						G				Y,R
-	4P						DW		DW		DW						**				DW
FYA	5,6F						FYA		FYA,FYA		YA,RA						RA				RA,RA
Y	6						G		R,R		Y,R						R				R,R
-	6P						**		DW		DW						DW				DW
R	8						R		R,R		R,R						G				Y,R
-	8P						DW		DW		DW						**				DW
		alterate phases																			
	signal head #	phase 5/2										phase 3/8									
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		1/w				barrier	1/w	1/5	1/6	2/6	barrier	1/w	1/7	7/4	4/8	barrier	1/w	1/7	5/8	4/8	barrier
Y	2						G			G,G											
FYA	2F						FYA			FYA,FYA											
-	2P						**			**											
R	4						R			R,R											
-	4P						DW			DW											
FYA	5,6F						GA			YA,RA											
Y	6						R			R,R											
-	6P						DW			DW											
R	8						R			R,R											
-	8P						DW			DW											

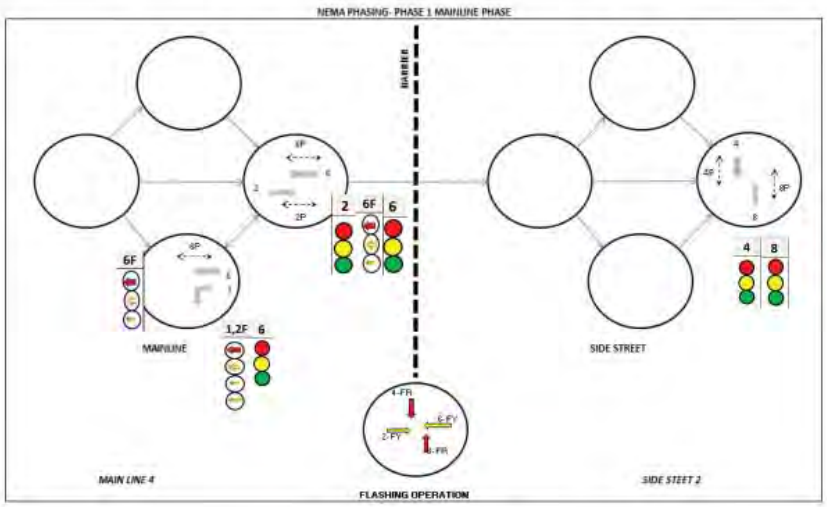
** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

MAIN LINE 3 SIDE STREET 2

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	1+5	1+6	2+5	2+6	3+7	3+8	4+7	4+8	FLASH
2			G	G				R	Y
2F			FYA	FYA				RA	FYA
4			R	R				G	R
5,6F			GA	FYA				RA	FYA
6			R	G				R	Y
8			R	R				G	R
2P			W	W				DW	DRK
4P			DW	DW				W	DRK
6P			DW	W				DW	DRK
8P			DW	DW				W	DRK

Figure 4-53
3 Phase NEMA / Sequence Table of Operations Charts - Protected/Permissive Left Turn Phase w/ FYA

NEMA PHASING



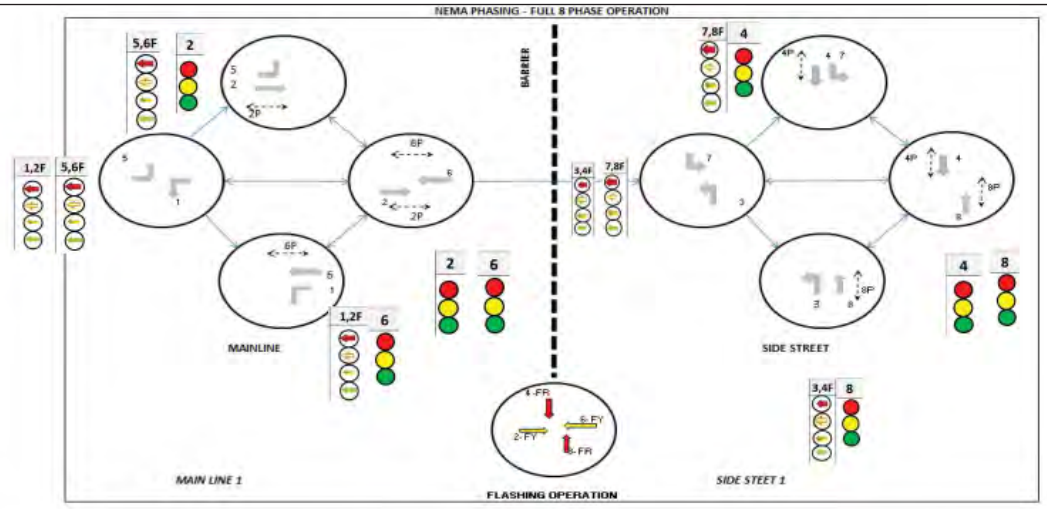
flash	signal head #						phase 2/6 (RECALL)					phase 3/7					phase 4/8				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w				barrier	r/w		5/2	1/6	barrier	r/w	3/8	7/4	4/8	barrier	r/w	3/7	3/8	7/4	barrier
FYA	1,2F						FYA			FYA,FYA	YA,RA						RA				RA,RA
Y	2						G			Y,R	Y,R						R				R,R
-	2P						**			DW	DW						DW				DW
R	4						R			R,R	R,R						G				Y,R
-	4P						DW			DW	DW						**				DW
Y	6						G			G,G	Y,R						R				R,R
FYA	6F						FYA			FYA,FYA	YA,RA						RA				RA,RA
-	6P						**			DW	DW						DW				DW
R	8						R			R,R	R,R						G				Y,R
-	8P						DW			DW	DW						**				DW
		alterate phases																			
	signal head #	phase 1/6										phase 3/8					phase 7/4				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w	1/5	5/2	2/6	barrier	r/w				barrier	r/w	3/7	7/4	4/8	barrier	r/w	3/7	3/8	4/8	barrier
FYA	1,2F	GA			YA,FYA																
Y	2	R			R,R																
-	2P	DW			DW																
R	4	R			R,R																
-	4P	DW			DW																
Y	6	G			G,G																
FYA	6F	FYA			FYA,FYA																
-	6P	**			**																
R	8	R			R,R																
-	8P	DW			DW																

** When called, displays solid 'Walking Person' and times out Walk Timing, then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	-	1 + 6	-	2 + 6	3 + 7	3 + 8	4 + 7	4 + 8	FLASH
1,2F		GA		FYA				RA	FYA
2		R		G				R	Y
4		R		R				G	R
6		G		G				R	Y
6F		FYA		FYA				RA	FYA
8		R		R				G	R
2P		DW		W				DW	DRK
4P		DW		DW				W	DRK
6P		W		W				DW	DRK
8P		DW		DW				W	DRK

Figure 4-54
3 Phase NEMA / Sequence Table of Operations Charts - Protected/Permissive Left Turn Phase w/ FYA

NEMA PHASING



flash	signal head #	phase 1/5					phase 2/6 (RECALL)					phase 3/7					phase 4/8				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w	5/2	1/6	2/6	barrier	r/w	1/5	5/2	1/6	barrier	r/w	3/8	7/4	4/8	barrier	r/w	3/7	3/8	7/4	barrier
FYA	1,2F	GA	YA,RA	GA,GA	YA,RA		FYA	FYA,FYA	FYA,FYA	FYA,FYA	YA,RA	RA	RA,RA	RA,RA	RA,RA	RA,RA	RA				RA,RA
Y	2	R	R,R	R,R	R,R		G	Y,R	G,G	Y,R	Y,R	R	R,R	R,R	R,R	R,R	R				R,R
-	2P	DW	DW	DW	DW		**	DW	**	DW	DW	DW	DW	DW	DW	DW	DW				DW
FRA	3,4F	RA	RA,RA	RA,RA	RA,RA		RA	RA,RA	RA,RA	RA,RA	RA,RA	GA	GA,GA	YA,RA	YA,RA	YA,RA	FYA				YA,RA
R	4	R	R,R	R,R	R,R		R	R,R	R,R	R,R	R,R	R	R,R	R,R	R,R	R,R	G				Y,R
-	4P	DW	DW	DW	DW		DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	**				DW
FYA	5,6F	GA	GA,GA	YA,RA	YA,RA		FYA	FYA,FYA	FYA,FYA	FYA,FYA	YA,RA	RA	RA,RA	RA,RA	RA,RA	RA,RA	RA				RA,RA
Y	6	R	R,R	R,R	R,R		G	Y,R	R,R	G,G	Y,R	R	R,R	R,R	R,R	R,R	R				R,R
-	6P	DW	DW	DW	DW		**	DW	DW	**	DW	DW	DW	DW	DW	DW	DW				DW
FRA	7,8F	RA	RA,RA	RA,RA	RA,RA		RA	RA,RA	RA,RA	RA,RA	RA,RA	GA	YA,RA	GA,GA	YA,RA	YA,RA	FYA				YA,RA
R	8	R	R,R	R,R	R,R		R	R,R	R,R	R,R	R,R	R	R,R	R,R	R,R	R,R	G				Y,R
-	8P	DW	DW	DW	DW		DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	**				DW

alterate phases

	signal head #	phase 1/6					phase 5/2					phase 3/8					phase 7/4				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w	1/5	5/2	2/6	barrier	r/w	1/5	1/6	2/6	barrier	r/w	3/7	7/4	4/8	barrier	r/w	3/7	3/8	4/8	barrier
FYA	1,2F	GA			YA,RA		FYA			FYA,FYA		RA			RA,RA	RA,RA	RA			RA,RA	RA,RA
Y	2	R			R,R		G			G,G		R			R,R	R,R	R			R,R	R,R
-	2P	DW			DW		**			**		DW			DW	DW	DW			DW	DW
FRA	3,4F	RA			RA,RA		RA			RA,RA		GA			YA,RA	YA,RA	FYA			FYA,FYA	YA,RA
R	4	R			R,R		R			R,R		R			R,R	R,R	G			G,G	Y,R
-	4P	DW			DW		DW			DW		DW			DW	DW	**			**	DW
FYA	5,6F	FYA			FYA,FYA		GA			YA,RA		RA			RA,RA	RA,RA	RA			RA,RA	RA,RA
Y	6	G			G,G		R			R,R		R			R,R	R,R	R			R,R	R,R
-	6P	**			**		DW			DW		DW			DW	DW	DW			DW	DW
FRA	7,8F	RA			RA,RA		RA			RA,RA		FYA			FYA,FYA	YA,RA	GA			YA,RA	YA,RA
R	8	R			R,R		R			R,R		G			G,G	Y,R	R			R,R	R,R
-	8P	DW			DW		DW			DW		**			**	DW	DW			DW	DW

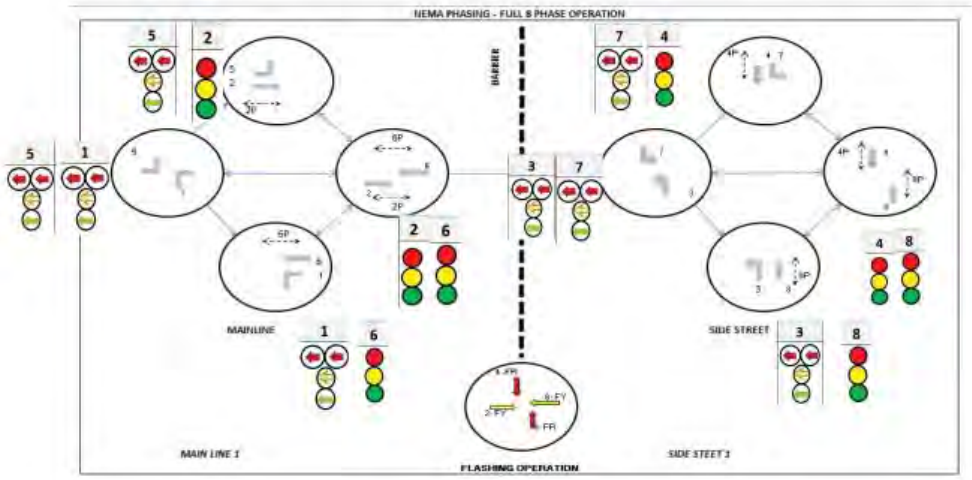
** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

MAIN LINE 1 SIDE STREET 1

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	1+5	1+6	2+5	2+6	3+7	3+8	4+7	4+8	FLASH
1,2F	GA	GA	FYA	FYA	RA	RA	RA	RA	FYA
2	R	R	G	G	R	R	R	R	Y
3,4F	RA	RA	RA	RA	GA	GA	FYA	FYA	FRA
4	R	R	RA	R	R	R	G	G	R
5,6F	GA	FYA	GA	FYA	RA	RA	RA	RA	FYA
6	R	G	R	G	R	R	R	R	Y
7,8F	RA	RA	RA	RA	GA	FYA	GA	FYA	FRA
8	R	R	R	R	R	G	R	G	R
2P	DW	DW	W	W	DW	DW	DW	DW	DRK
4P	DW	DW	DW	DW	DW	DW	W	W	DRK
6P	DW	W	DW	W	DW	DW	DW	DW	DRK
8P	DW	DW	DW	DW	DW	W	DW	W	DRK

Figure 4-55
8 Phase NEMA / Sequence Table of Operations Charts - Protected/Permissive Left Turn Phase w/ FYA

NEMA PHASING



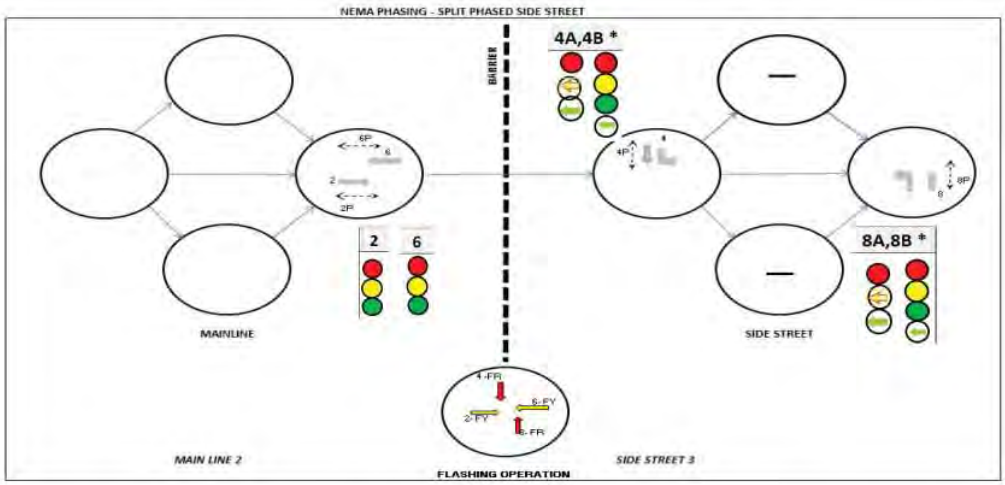
flash	signal head #	phase 1/5					phase 2/6(RECALL)					phase 3/7					phase 4/8				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w	1/2	1/6	2/6	barrier	r/w	1/5	5/2	1/6	barrier	r/w	3/8	7/8	8/8	barrier	r/w	3/7	3/8	7/8	barrier
RARA	1	GA	YA,RARA	GA,GA	YA,RARA		RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA				RARA,RARA
Y	2	R	R,R	R,R	R,R		G	Y,R	G,G	Y,R	Y,R	R	R,R	R,R	R,R	R,R	R				R,R
--	2P	DW	DW	DW	DW		**	DW	**	DW	DW	DW	DW	DW	DW	DW	DW				DW
RARA	3	RARA	RARA,RARA	RARA,RARA	RARA,RARA		RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA,RARA	GA	GA,GA	YA,RARA	YA,RARA	YA,RARA	RARA				RARA,RARA
R	4	R	R,R	R,R	R,R		R	R,R	R,R	R,R	R,R	R	R,R	R,R	R,R	R,R	G				Y,R
--	4P	DW	DW	DW	DW		DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	**				DW
RARA	5	GA	GA,GA	YA,RARA	YA,RARA		RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA				RARA,RARA
Y	6	R	R,R	R,R	R,R		G	Y,R	R,R	G,G	Y,R	R	R,R	R,R	R,R	R,R	R				R,R
--	6P	DW	DW	DW	DW		**	DW	DW	**	DW	DW	DW	DW	DW	DW	DW				DW
RARA	7	RARA	RARA,RARA	RARA,RARA	RARA,RARA		RARA	RARA,RARA	RARA,RARA	RARA,RARA	RARA,RARA	GA	YA,RARA	GA,GA	YA,RARA	YA,RARA	RARA				RARA,RARA
R	8	R	R,R	R,R	R,R		R	R,R	R,R	R,R	R,R	R	R,R	R,R	R,R	R,R	G				Y,R
--	8P	DW	DW	DW	DW		DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	**				DW
		alterate phases																			
	signal head #	phase 1/6					phase 5/2					phase 3/8					phase 7/4				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w	1/5	5/2	2/6	barrier	r/w	1/5	1/6	2/6	barrier	r/w	3/7	7/3	4/8	barrier	r/w	1/7	1/8	4/8	barrier
RARA	1	GA			YA,RARA		RARA			RARA,RARA		RARA			RARA,RARA	RARA,RARA	RARA			RARA,RARA	RARA,RARA
Y	2	R			R,R		G			G,G		R			R,R	R,R	R			R,R	R,R
--	2P	DW			DW		**			**		DW			DW	DW	DW			DW	DW
RARA	3	RARA			RARA,RARA		RARA			RARA,RARA		GA			YA,RARA	YA,RARA	RARA			RARA,RARA	RARA,RARA
R	4	R			R,R		R			R,R		R			R,R	R,R	G			G,G	Y,R
--	4P	DW			DW		DW			DW		DW			DW	DW	**			**	DW
RARA	5	RARA			RARA,RARA		GA			YA,RARA		RARA			RARA,RARA	RARA,RARA	RARA			RARA,RARA	RARA,RARA
Y	6	G			G,G		R			R,R		R			R,R	R,R	R			R,R	R,R
--	6P	**			**		DW			DW		DW			DW	DW	DW			DW	DW
RARA	7	RARA			RARA,RARA		RARA			RARA,RARA		RARA			RARA,RARA	RARA,RARA	GA			YA,RARA	YA,RARA
R	8	R			R,R		R			R,R		G			G,G	Y,R	R			R,R	R,R
--	8P	DW			DW		DW			DW		**			**	DW	DW			DW	DW

** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown'

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	1+5	1+6	2+5	2+6	3+7	3+8	4+7	4+8	FLASH
1	GA	GA	RARA	RARA	RARA	RARA	RARA	RARA	FRAFRA
2	R	R	G	G	R	R	R	R	Y
3	RARA	RARA	RARA	RARA	GA	GA	RARA	RARA	FRAFRA
4	R	R	R	R	R	R	G	G	R
5	GA	RARA	GA	RARA	RARA	RARA	RARA	RARA	FRAFRA
6	R	G	R	G	R	R	R	R	Y
7	RARA	RARA	RARA	RARA	GA	RARA	GA	RARA	FRAFRA
8	R	R	R	R	R	G	R	G	R
2P	DW	DW	W	W	DW	DW	DW	DW	DRK
4P	DW	DW	DW	DW	DW	DW	W	W	DRK
6P	DW	W	DW	W	DW	DW	DW	DW	DRK
8P	DW	DW	DW	DW	DW	W	DW	W	DRK

Figure 4-56
8 Phase NEMA / Sequence Table of Operations Charts-Protected Only Left Turn Phases

NEMA PHASING



flash	signal head #	phase 1/5					phase 2/6					phase 4					phase 8				
		r/w	clears to 5/2	clears to 1/6	clears to 2/6	clears to barrier	r/w	clears to 1/5	clears to 5/2	clears to 1/6	clears to barrier	r/w	clears to	clears to	clears to 8	clears to barrier	r/w	clears to	clears to	clears to 4	clears to barrier
Y	2						G				Y,R	R			R	R	R			R	R
-	2P						**				DW	DW			DW	DW	DW			DW	DW
R	4a						R				R,R	GA			YA,R	YA,R	R			R,R	R,R
R	4b						R				R,R	GGA			YA,R	YA,R	R			R,R	R,R
-	4P						DW				DW	*			DW	DW	-			-	-
Y	6						G				Y,R	R			R	R	R			R	R
-	6P						**				DW	DW			DW	DW	DW			DW	DW
R	8a						R				R,R	R			R,R	R,R	GA			YA,R	YA,R
R	8b						R				R,R	R			R,R	R,R	GGA			YA,R	YA,R
-	8P						DW				DW	-			-	-	*			DW	DW
		alterate phases																			
	signal head #	phase 1/6					phase 5/2					phase 3/8					phase 7/4				
		r/w	clears to 1/5	clears to 5/2	clears to 2/6	clears to barrier	r/w	clears to 1/5	clears to 1/6	clears to 2/6	clears to barrier	r/w	clears to 3/7	clears to 7/4	clears to 4/8	clears to barrier	r/w	clears to 3/7	clears to 3/8	clears to 4/8	clears to barrier
Y	2																				
-	2P																				
R	4a																				
R	4b																				
-	4P																				
Y	6																				
-	6P																				
R	8a																				
R	8b																				
-	8P																				

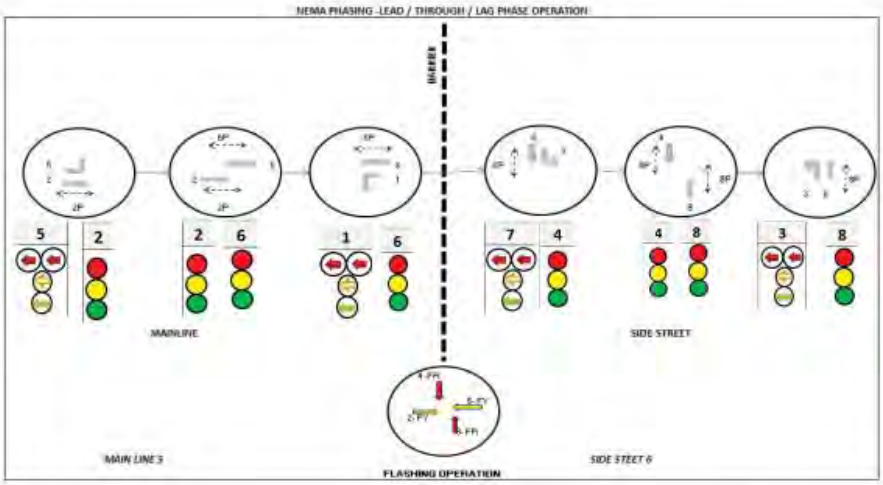
** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

MAIN LINE 2 SIDE STREET 3

TABLE OF OPERATION	PHASE IN OPERATION						
SIGNAL HEAD #	1+5	1+6	2+5	2+6	PHASE 4	PHASE 8	FLASH
2				G	R	R	Y
4A				R	G,GA	R	R
4B				R	G	R	R
6				G	R	R	Y
8A				R	R	G,GA	R
8B				R	R	G	R
2P				W	DW	DW	DRK
4P				DW	W	DW	DRK
6P				W	DW	DW	DRK
8P				DW	DW	W	DRK

Figure 4-57
3 Phase NEMA / Sequence Table of Operations Charts-Split Phased Side Street

NEMA PHASING



flash	signal head #	phase 2/6										phase 4/8									
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w				barrier	r/w			1/6	barrier	r/w	3/8	2/4	4/8	barrier	r/w		3/8		barrier
RARA	1						RARA			RARA,RARA	RARA,RARA						RARA		RARA,RARA		RARA,RARA
Y	2						G			Y,R	Y,R						R		R,R		R,R
-	2P						**			DW	DW						DW		DW		DW
RARA	3						RARA			RARA,RARA	RARA,RARA						RARA		RARA,RARA		RARA,RARA
R	4						R			R,R	R,R						G		Y,R		Y,R
-	4P						DW			DW	DW						**		DW		DW
RARA	5						RARA			RARA,RARA	RARA,RARA						RARA		RARA,RARA		RARA,RARA
Y	6						G			G,G	Y,R						R		R,R		R,R
-	6P						**			**	DW						DW		DW		DW
RARA	7						RARA			RARA,RARA	RARA,RARA						RARA		RARA,RARA		RARA,RARA
R	8						R			R,R	R,R						G		G,G		Y,R
-	8P						DW			DW	DW						**		**		DW

alterate phases

	signal head #	phase 1/6					phase 5/2					phase 3/8					phase 7/4				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w				barrier	r/w			2/6	barrier	r/w				barrier	r/w			4/8	barrier
RARA	1	GA				YA,RARA	RARA			RARA,RARA		RARA				RARA,RARA	RARA			RARA,RARA	RARA,RARA
YA	2	R				R,R	G			G,G		R				R,R	R			R,R	R,R
-	2P	DW				DW	**			**		DW				DW	DW			DW	DW
RARA	3	RARA				RARA,RARA	RARA			RARA,RARA		GA				YA,RARA	RARA			RARA,RARA	RARA,RARA
R	4	R				R,R	R			R,R		R				R,R	G			G,G	Y,R
-	4P	DW				DW	DW			DW		DW				DW	**			**	DW
RARA	5	RARA				RARA,RARA	GA			YA,RARA		RARA				RARA,RARA	RARA			RARA,RARA	RARA,RARA
Y	6	G				Y,R	R			R,R		R				R,R	R			R,R	R,R
-	6P	**				DW	DW			DW		DW				DW	DW			DW	DW
RARA	7	RARA				RARA,RARA	RARA			RARA,RARA		RARA				RARA,RARA	GA			YA,RARA	YA,RARA
R	8	R				R,R	R			R,R		G				Y,R	R			R,R	R,R
-	8P	DW				DW	DW			DW		**				DW	DW			DW	DW

** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

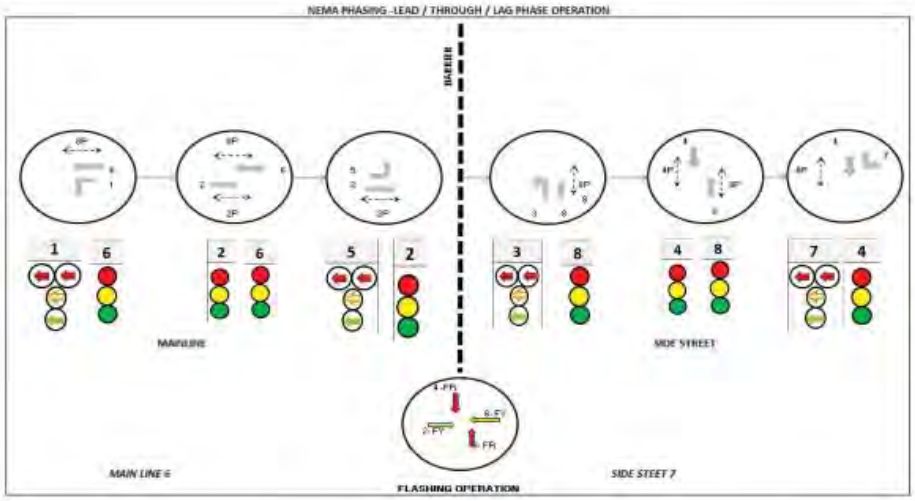
LEAD THRU LAG
MAIN LINE 5

LEAD THRU LAG
SIDE STREET 6

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	1+5	1+6	2+5	2+6	3+7	3+8	4+7	4+8	FLASH
1		GA	RARA	RARA		RARA	RARA	RARA	FRAFRA
2		R	G	G		R	R	R	Y
3		RARA	RARA	RARA		GA	RARA	RARA	FRAFRA
4		R	R	R		R	G	G	R
5		RARA	GA	RARA		RARA	RARA	RARA	FRAFRA
6		G	R	G		R	R	R	Y
7		RARA	RARA	RARA		RARA	GA	RARA	FRAFRA
8		R	R	R		G	R	G	R
2P		DW	W	W		DW	DW	DW	DRK
4P		DW	DW	DW		DW	W	W	DRK
6P		W	DW	W		DW	DW	DW	DRK
8P		DW	DW	DW		W	DW	W	DRK

Figure 4-58
8 Phase NEMA / Sequence Table of Operations Charts-Lead / Lag Protected Left Turn Phases

NEMA PHASING



flash	signal head #	phase 2/6										phase 4/8									
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w				barrier	r/w		5/2		barrier	r/w	1/8	7/4	4/8	barrier	r/w			4/7	barrier
RARA	1						RARA		RARA,RARA		RARA,RARA						RARA			RARA,RARA	RARA,RARA
Y	2						G		G,G		Y,R						R			R,R	R,R
-	2P						**		**		DW						DW			DW	DW
RARA	3						RARA		RARA,RARA		RARA,RARA						RARA			RARA,RARA	RARA,RARA
R	4						R		R,R		R,R						G			G,G	Y,R
-	4P						DW		DW		DW						**			**	DW
RARA	5						RARA		RARA,RARA		RARA,RARA						RARA			RARA,RARA	RARA,RARA
Y	6						G		Y,R		Y,R						R			R,R	R,R
-	6P						**		DW		DW						DW			DW	DW
RARA	7						RARA		RARA,RARA		RARA,RARA						RARA			RARA,RARA	RARA,RARA
R	8						R		R,R		R,R						G			Y,R	Y,R
-	8P						DW		DW		DW						**			DW	DW

alterate phases

	signal head #	phase 1/6					phase 5/2					phase 3/8					phase 7/4				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w			2/6	barrier	r/w				barrier	r/w			8/8	barrier	r/w			4/8	barrier
RARA	1	GA			YA,RARA		RARA				RARA,RARA	RARA			RARA,RARA	RARA,RARA	RARA				RARA,RARA
Y	2	R			R,R		G				Y,R	R			R,R	R,R	R				R,R
-	2P	DW			DW		**				DW	DW			DW	DW	DW				DW
RARA	3	RARA			RARA,RARA		RARA				RARA,RARA	GA			YA,RARA	YA,RARA	RARA				RARA,RARA
R	4	R			R,R		R				R,R	R			R,R	R,R	G				Y,R
-	4P	DW			DW		DW				DW	DW			DW	DW	**				DW
RARA	5	RARA			RARA,RARA		GA				YA,RARA	RARA			RARA,RARA	RARA,RARA	RARA				RARA,RARA
Y	6	G			G,G		R				R,R	R			R,R	R,R	R				R,R
-	6P	**			**		DW				DW	DW			DW	DW	DW				DW
RARA	7	RARA			RARA,RARA		RARA				RARA,RARA	RARA			RARA,RARA	RARA,RARA	GA				YA,RARA
R	8	R			R,R		R				R,R	G			G,G	Y,R	R				R,R
-	8P	DW			DW		DW				DW	**			**	DW	DW				DW

** When called, displays solid 'Walking Person' and times out Walk Timing; then displays Flashing 'Upraised Hand' for the duration of the Pedestrian Clearance. Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

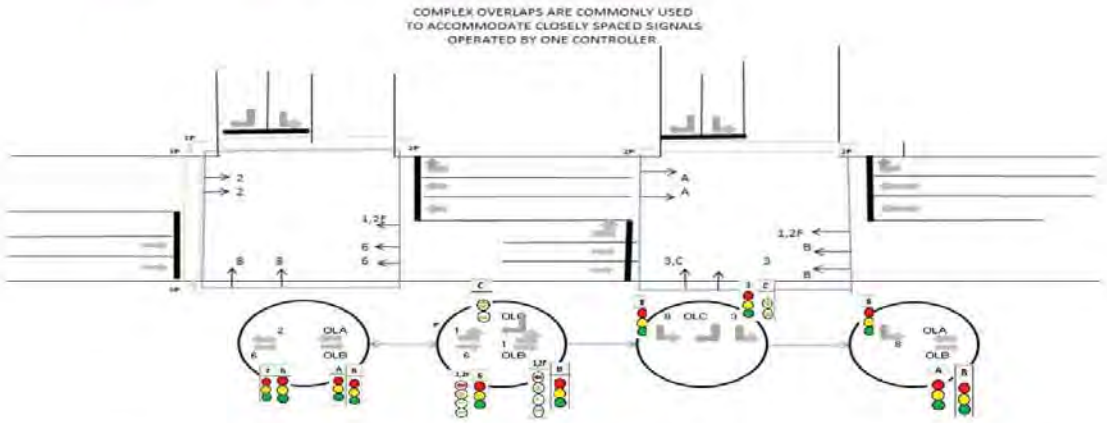
LEAD THRU LAG
MAIN LINE 6

LEAD THRU LAG
SIDE STREET 7

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	1+5	1+6	2+5	2+6	3+7	3+8	4+7	4+8	FLASH
1		GA	RARA	RARA		RARA	RARA	RARA	FRAFRA
2		R	G	G		R	R	R	Y
3		RARA	RARA	RARA		GA	RARA	RARA	FRAFRA
4		R	R	R		R	G	G	R
5		RARA	GA	RARA		RARA	RARA	RARA	FRAFRA
6		G	R	G		R	R	R	Y
7		RARA	RARA	RARA		RARA	GA	RARA	FRAFRA
8		R	R	R		G	R	G	R
2P		DW	W	W		DW	DW	DW	DRK
4P		DW	DW	DW		DW	W	W	DRK
6P		W	DW	W		DW	DW	DW	DRK
8P		DW	DW	DW		W	DW	W	DRK

Figure 4-59
8 Phase NEMA / Sequence Table of Operations Charts-Lead / Lag Protected Left Turn Phases

NEMA PHASING



flash	signal head #						phase 2/6 (RECALL)- OLA/OLB										phase 8- OLA/OLB				
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to		clears to	clears to
		r/w	5/2	1/6	2/6	barrier	r/w			1/6	barrier	r/w					r/w				barrier
FYA	1,2F						FYA			FYA,FYA	YA,RA						RA				RA,RA
Y	2						G			Y,R	Y,R						R				R,R
Y	A						G			Y,R	Y,R						G				Y,R
–	2P						**			DW	DW						DW				DW
RARA	3						R			R,R	R,R						R				R,R
–	C						–			–	–						–				–
Y	6						G			G,G	Y,R						R				R,R
Y	B						G			G,G	Y,R						G				G,G
R	8						R			R,R	R,R						G				Y,R
–	8P						DW			DW	DW						**				DW
		alterate phases																			
	signal head #	phase 1/6- OLB, OLC										phase 3/8 -OLC									
			clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to		clears to	clears to	clears to	clears to
		r/w		2/6		barrier						r/w		8 - OLA/OLB		barrier	r/w				
FYA	1,2F	GA		YA,RA		YA,RA						RA		RA,RA		RA,RA					
Y	2	R		R,R		R,R						R		R,R		R,R					
Y	A	R		R,R		R,R						R		R,R		R,R					
–	2P	DW		DW		DW						DW		DW		DW					
RARA	3	R		R,R		R,R						G		Y,R		Y,R					
–	C	GA		YA,-		YA,-						GA		YA,-		YA,R					
Y	6	G		G,G		Y,R						R		R,R		R,R					
Y	B	G		G,G		Y,R						R		R,R		R,R					
R	8	R		R,R		R,R						G		G,G		Y,R					
–	8P	DW		DW		DW						**		**		DW					

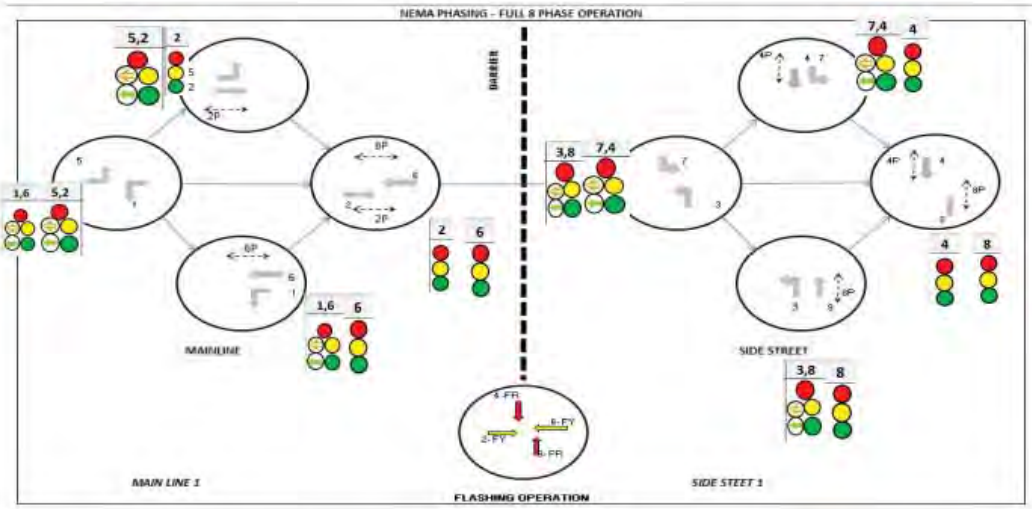
** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance; Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display.

TABLE OF OPERATION	PHASE IN OPERATION									
SIGNAL HEAD #		1 + 6 - OLB + OLC		2 + 6 - OLA + OLB		3 + 8 - OLC		8 - OLA + OLB	FLASH
1,2F		GA		FYA		RA		RA	YA
2		R		G		R		R	Y
A		R		G		R		G	Y
3		R		R		G		R	R
C		GA		-		GA		-	-
6		G		G		R		R	Y
B		G		G		R		G	Y
8		R		R		G		G	R
2P		DW		W		DW		DW	DRK
8P		W		DW		W		W	DRK

Figure 4-60

4 Phase NEMA / Sequence Table of Operations Charts-Complex Overlap

NEMA PHASING



flash	signal head #	phase 1/5					phase 2/6 (RECALL)					phase 3/7					phase 4/8				
		r/w	clears to 5/2	clears to 1/8	clears to 2/6	clears to barrier	r/w	clears to	clears to	clears to	clears to barrier	r/w	clears to 1/8	clears to 7/4	clears to 4/8	clears to barrier	r/w	clears to 3/7	clears to 3/8	clears to 7/4	clears to barrier
Y	1/6	GA/R	YA/R,R	GA/R,GA/R	YA/R,R		-/G				-/Y,R	R	R,R	R,R	R,R	R,R	R				R,R
Y	2	R	R,R	R,R	R,R		G				Y,R	R	R,R	R,R	R,R	R,R	R				R,R
-	2P	DW	DW	DW	DW		**				DW	DW	DW	DW	DW	DW	DW				DW
R	3/8	R	R,R	R,R	R,R		R				R,R	GA/R	GA/R,GA/R	YA/Y,R	YA/R,R	YA/R,R	-/G				-/Y,R
R	4	R	R,R	R,R	R,R		R				R,R	R	R,R	R,R	R,R	R,R	G				Y,R
-	4P	DW	DW	DW	DW		DW				DW	DW	DW	DW	DW	DW	**				DW
Y	5/2	GA/R	GA/R,GA/R	YA/R,R	YA/R,R		-/G				-/Y,R	R	R,R	R,R	R,R	R,R	R				R,R
Y	6	R	R,R	R,R	R,R		G				Y,R	R	R,R	R,R	R,R	R,R	R				R,R
-	6P	DW	DW	DW	DW		**				DW	DW	DW	DW	DW	DW	DW				DW
R	7/4	R	R,R	R,R	R,R		R				R,R	GA/R	YA/R,R	GA/R,GA/R	YA/R,R	YA/R,R	-/G				-/Y,R
R	8	R	R,R	R,R	R,R		R				R,R	R	R,R	R,R	R,R	R,R	G				Y,R
-	8P	DW	DW	DW	DW		DW				DW	DW	DW	DW	DW	DW	**				DW

alterate phases

	signal head #	phase 1/6					phase 5/2					phase 3/8					phase 7/4				
		r/w	clears to 1/5	clears to 5/2	clears to 2/6	clears to barrier	r/w	clears to 1/5	clears to 1/6	clears to 2/6	clears to barrier	r/w	clears to	clears to	clears to 4/8	clears to barrier	r/w	clears to	clears to	clears to 4/8	clears to barrier
Y	1/6	GA/G			YA/G, G		R			R,R		R			R,R	R,R	R			R,R	R,R
YA	2	R			R,R		G			G,G		R			R,R	R,R	R			R,R	R,R
-	2P	DW			DW		**			**		DW			DW	DW	DW			DW	DW
R	3/8	R			R,R		R			R,R		GA/G			YA/G, G	YA/Y,R	R			R,R	R,R
R	4	R			R,R		R			R,R		R			R,R	R,R	G			G,G	Y,R
-	4P	DW			DW		DW			DW		DW			DW	DW	**			**	DW
Y	5/2	R			R,R		GA/G			YA/G, G		R			R,R	R,R	R			R,R	R,R
Y	6	G			G,G		R			R,R		R			R,R	R,R	R			R,R	R,R
-	6P	**			**		DW			DW		DW			DW	DW	DW			DW	DW
R	7/4	R			R,R		R			R,R		R			R,R	R,R	GA/G			YA/G, G	YA/Y,R
R	8	R			R,R		R			R,R		G			G,G	Y,R	R			R,R	R,R
-	8P	DW			DW		DW			DW		**			**	DW	DW			DW	DW

** When called, displays solid 'Walking Person' and times out Walk Timing; then displays flashing 'Upraised Hand' for the duration of the Pedestrian Clearance! Count down pedestrian heads display the 'countdown' Pedestrian Clearance, simultaneous and adjacent to the flashing 'Upraised Hand' display..

MAIN LINE 1 SIDE STREET 1

TABLE OF OPERATION	PHASE IN OPERATION								
SIGNAL HEAD #	1+5	1+6	2+5	2+6	3+7	3+8	4+7	4+8	FLASH
1,6	GA	GAG	R	G	R	R	R	R	Y
2	R	R	G	G	R	R	R	R	Y
3,8	R	R	R	R	GA	GAG	R	G	R
4	R	R	RA	R	R	R	G	G	R
5,2	GA	R	GAG	G	R	R	R	R	R
6	R	G	R	G	R	R	R	R	Y
7,4	R	R	R	R	GA	R	GAG	G	R
8	R	R	R	R	R	G	R	G	R
2P	DW	DW	W	W	DW	DW	DW	DW	DRK
4P	DW	DW	DW	DW	DW	DW	W	W	DRK
6P	DW	W	DW	W	DW	DW	DW	DW	DRK
8P	DW	DW	DW	DW	DW	W	DW	W	DRK

Figure 4-61

8 Phase NEMA / Sequence Table of Operations Charts-Protected Permissive Left Turns w/ 5 section heads

Task 6 - Signal Design - Level 1 - 1-5 Intersection (per Intersection)		
Task 7 - Signal Design - Level 1 - 6-10 Intersection (per Intersection)		
Task 8 - Signal Design - Level 1 - 11+ Intersection (per Intersection)		
Scope of Work: Preparation of traffic signal plans on an on-call basis. If CAD files are available, SCDOT will provide them to consultant. If not, consultant should develop base mapping from digitized hardcopy signal plans or existing aerial photography, GIS and/or field inventory. Although task order is per intersection, cost per intersection shall be categorized by systems with (0-5) (6-10) and (11 plus) intersections and level of design. **Level 1 Signal Design** will be performed using count data and a capacity analysis that has already been completed and will be provided by the SCDOT. The designs will be prepared at a scale of 1"=30' and will include equipment placement, general and intersection specific notes, phasing diagrams, loop placement and isolated signal timings. It is assumed that all designs will be on strain poles and no geotechnical investigations will be required.		
#	**Project Tasks**	**Task Description**
1	Project Management	Management of the project to conform to SCDOT requirements for monitoring and controlling the engineering budget, project schedule and invoicing procedures. Project management for all of the tasks detailed below including the submission of monthly invoices and progress reports. Designation of a Project Manager to serve as the primary contact for communications with SCDOT. Coordination of a Kick Off meeting with all parties to identify and review project issues, expectations, goals, and objectives for each task orders.
2	Utility Coordination	The ***CONSULTANT*** will utilize information provided by SC 811 and visual observations during field reviews as well as information provided by the **SCDOT** to develop a list of utilities that may be affected by the project. The ***CONSULTANT*** will provide a list of affected utilities by intersection to the **SCDOT** as part of the submittal, including a list and location per signal [i.e. which quadrant or which side]. Assumptions: No SUE will be performed for this project; If needed, SCDOT will issue an additional work order for Utility Agreement services (see Task 12 for scope) including preliminary and final utility reports, collection of utility records, incorporation of approximate locations of any field locates provided by SC 811, utility relocation sheets, Utility Agreement Coordination, prior rights research and determining relocations required.
3	Right of Way Verification /Identification	The ***CONSULTANT*** will verify existing right of way at each of the intersections utilizing a combination of field reviews, the **SCDOT**'s online plan library, information received from the **SCDOT**, and property deeds research. The ***CONSULTANT*** will document the new right of way and/or permissions required for project construction on the design plans consistent with **SCDOT** guidelines and requirements. Where existing signal plans exist, the ***CONSULTANT*** will verify the right-of-way shown on the plans. Where existing signal plans do not exist, the ***CONSULTANT*** will develop base mapping to show the existing right-of-way. Where existing right-of-way documentation is not available, the ***CONSULTANT*** will work with the **SCDOT** to determine the most appropriate estimate of the existing right-of-way. Where existing right-of-way information is not readily available, the ***CONSULTANT*** will not be responsible for performing surveying to locate right-of-way. Where existing right-of-way information is not available from plats or SCDOT plans, and it appears obtaining additional r/w is necessary for signal upgrade, SCDOT may negotiate with consultant under new task order to develop right of way plans.

Figure 4-62a
Typical Traffic Signal Pay Items (page 1)

4	Field Review	The ***CONSULTANT*** shall visit each intersection with representatives of the **SCDOT** (if necessary) to discuss the project goals and objectives. As part of this field visit, the ***CONSULTANT*** will collect site specific information, take digital photos of the intersections and existing signal equipment, and field check copies of the existing signal plans.
7	Design & Plan Preparation of Signal Plan	The ***CONSULTANT*** will use aerial photography, GIS or existing signal plans to develop digital base mapping for the traffic signal designs. Utilizing digital base mapping, the ***CONSULTANT*** will prepare traffic signal design and plans for each intersection. Traffic signal plans shall be designed in accordance with the South Carolina Department of Transportation Traffic Signal Design Guidelines (latest edition), the Manual on Uniform Traffic Control Devices (2009 Edition), Standard Signal Specifications and Special Provisions (latest edition), SCDOT Standard Drawings, and SCDOT design specifications. Traffic signal plans shall also be designed in accordance with a detailed scope list for each intersection provided by SCDOT. All work is to be performed within existing right of way where possible. If additional right-of-way is needed, the ***CONSULTANT*** will make recommendations and coordinate with the **SCDOT**. The ***CONSULTANT*** will prepare a set of signal plans that identifies the location of signal poles, pedestrian poles, signal heads, pushbuttons and signs, sidewalk ramps and crosswalks, pull boxes, conduits, pavement markings, and ~~loops~~ vehicle detection. Phasing diagrams, pay items and quantities will also be provided by the ***CONSULTANT***. The plans shall be plotted at a scale not smaller than 1" = 40'. Assumptions: The **SCDOT** will provide available CAD files for the intersections; The **SCDOT** will provide any available hardcopies of existing signal plans; The ***CONSULTANT*** will not be required to provide survey services.
8	Cost Estimate	The ***CONSULTANT*** will calculate quantities and cost estimates for each intersection, utilizing pay items provided by SCDOT. The ***CONSULTANT*** will develop an excel spreadsheet for each intersection to show quantities required and anticipated costs. Anticipated costs will be based on the cost estimate file provided by the **SCDOT**.
9	Title Sheet/Quantity Sheet	The ***CONSULTANT*** will provide a Title sheet and Quantity Sheet [if required] for the purposes of project letting. Once project bundling is determined, the ***CONSULTANT*** will summarize quantities by intersection and by bundle.
10	Specifications Package	The ***CONSULTANT*** will provide Special Provisions and any other project specific specifications for work included in project. Standard traffic signal specifications will be used. The ***CONSULTANT*** will enter project details into the standard traffic signal special provision once project bundling is determined. Supplemental Specifications, Material Specifications, Special Provisions for Traffic Control will be provided by the **SCDOT**.
11	Signal Plan Files	***CONSULTANT*** will ensure cadd file and sealed pdf is loaded onto SCDOT signal inventory software.

Figure 4-62b
Typical Traffic Signal Pay Items (page 2)

Task 9 - Signal Design - Level 2 - 1-5 Intersection (per Intersection)		
Task 10 - Signal Design - Level 2 - 6-10 Intersection (per Intersection)		
Task 11 - Signal Design - Level 2 - 11+ Intersection (per Intersection)		
Scope of Work: Preparation of traffic signal plans on an on-call basis. If CAD files are available, SCDOT will provide them to consultant. If not, consultant should develop base mapping from digitized hardcopy signal plans or existing aerial photography, GIS and/or field inventory. Although task order is per intersection, cost per intersection shall be categorized by systems with (0-5) (6-10) and (11 plus) intersections and level of design. **Level 2 Signal Design:** A signal design at this level will require the team to obtain additional traffic counts and complete a capacity analysis of the intersection. The designs will be prepared at a scale of 1"=30' and will include equipment placement, general and intersection specific notes, phasing diagrams, loop placement and isolated signal timings. It is assumed that all designs will be on strain poles and no geotechnical investigations will be required.		
#	**Project Tasks**	**Task Description**
1	Project Management	Management of the project to conform to SCDOT requirements for monitoring and controlling the engineering budget, project schedule and invoicing procedures. Project management for all of the tasks detailed below including the submission of monthly invoices and progress reports. Designation of a Project Manager to serve as the primary contact for communications with SCDOT. Coordination of a Kick Off meeting with all parties to identify and review project issues, expectations, goals, and objectives for each task orders.
2	Utility Coordination	The ***CONSULTANT*** will utilize information provided by SC 811 and visual observations during field reviews as well as information provided by the **SCDOT** to develop a list of utilities that may be affected by the project. The ***CONSULTANT*** will provide a list of affected utilities by intersection to the **SCDOT** as part of the submittal, including a list and location per signal [i.e. which quadrant or which side]. Assumptions: No SUE will be performed for this project; If needed, SCDOT will issue an additional work order for Utility Agreement services (see Task 12 for scope) including preliminary and final utility reports, collection of utility records, incorporation of approximate locations of any field locates provided by SC 811, utility relocation sheets, Utility Agreement Coordination, prior rights research and determining relocations required.
3	Right of Way Verification /Identification	The ***CONSULTANT*** will verify existing right of way at each of the intersections utilizing a combination of field reviews, the **SCDOT**'s online plan library, information received from the **SCDOT**, and property deeds research. The ***CONSULTANT*** will document the new right of way and/or permissions required for project construction on the design plans consistent with **SCDOT** guidelines and requirements. Where existing signal plans exist, the ***CONSULTANT*** will verify the right-of-way shown on the plans. Where existing signal plans do not exist, the ***CONSULTANT*** will develop base mapping to show the existing right-of-way. Where existing right-of-way documentation is not available, the ***CONSULTANT*** will work with the **SCDOT** to determine the most appropriate estimate of the existing right-of-way. Where existing right-of-way information is not readily available, the ***CONSULTANT*** will not be responsible for performing surveying to locate right-of-way. Where existing right-of-way information is not available from plats or SCDOT plans, and it appears obtaining additional r/w is necessary for signal upgrade, SCDOT may negotiate with consultant under new task order to develop right of way plans.

Figure 4-63a
Signal Design Scope of Services and Task Descriptions (page 1)

4	Field Review	The ***CONSULTANT*** shall visit each intersection with representatives of the **SCDOT** (if necessary) to discuss the project goals and objectives. As part of this field visit, the ***CONSULTANT*** will collect site specific information, take digital photos of the intersections and existing signal equipment, and field check copies of the existing signal plans.
5	Data Collection – Traffic Counts	The ***CONSULTANT*** will conduct turning movement counts at each intersection for selected peak periods (up to four). The type of count data collected (vehicle, trucks/buses, and pedestrians) and duration of peak periods will be coordinated with the **SCDOT** prior to obtaining counts.
6	Capacity Analysis	The ***CONSULTANT*** will utilize Synchro to model peak periods, as determined in coordination with the **SCDOT**, to determine the recommended phasing and timings. This will include modeling existing conditions and recommended improvements. The recommended improvements will be modeled based on a projected horizon year and growth rate coordinated with the **SCDOT**. The capacity analysis results will be provided to the **SCDOT** as part of the design submittal.
7	Design & Plan Preparation of Signal Plan	The ***CONSULTANT*** will use aerial photography, GIS or existing signal plans to develop digital base mapping for the traffic signal designs. Utilizing digital base mapping, the ***CONSULTANT*** will prepare traffic signal design and plans for each intersection. Traffic signal plans shall be designed in accordance with the South Carolina Department of Transportation Traffic Signal Design Guidelines (latest edition), the Manual on Uniform Traffic Control Devices (2009 Edition), Standard Signal Specifications and Special Provisions (latest edition), SCDOT Standard Drawings, and SCDOT design specifications. Traffic signal plans shall also be designed in accordance with a detailed scope list for each intersection provided by SCDOT. All work is to be performed within existing right of way where possible. If additional right-of-way is needed, the ***CONSULTANT*** will make recommendations and coordinate with the **SCDOT**. The ***CONSULTANT*** will prepare a set of signal plans that identifies the location of signal poles, pedestrian poles, signal heads, pushbuttons and signs, sidewalk ramps and crosswalks, pull boxes, conduits, pavement markings, and ~~loops~~ vehicle detection. Phasing diagrams, pay items and quantities will also be provided by the ***CONSULTANT***. The plans shall be plotted at a scale not smaller than 1" = 40'. Assumptions: The **SCDOT** will provide available CAD files for the intersections; The **SCDOT** will provide any available hardcopies of existing signal plans; The ***CONSULTANT*** will not be required to provide survey services.
8	Cost Estimate	The ***CONSULTANT*** will calculate quantities and cost estimates for each intersection, utilizing pay items provided by SCDOT. The ***CONSULTANT*** will develop an excel spreadsheet for each intersection to show quantities required and anticipated costs. Anticipated costs will be based on the cost estimate file provided by the **SCDOT**.
9	Title Sheet/ Quantity Sheet	The ***CONSULTANT*** will provide a Title sheet and Quantity Sheet [if required] for the purposes of project letting. Once project bundling is determined, the ***CONSULTANT*** will summarize quantities by intersection and by bundle.
10	Specifications Package	The ***CONSULTANT*** will provide Special Provisions and any other project specific specifications for work included in project. Standard traffic signal specifications will be used. The ***CONSULTANT*** will enter project details into the standard traffic signal special provision once project bundling is determined. Supplemental Specifications, Material Specifications, Special Provisions for Traffic Control will be provided by the **SCDOT**.
11	Signal Plan Files	***CONSULTANT*** will ensure cadd file and sealed pdf is loaded onto SCDOT signal inventory software.

Figure 4-63b
Signal Design Scope of Services and Task Descriptions (page 2)

Task 12 - Utility Agreement - Scope of Services-(Per Intersection)		
Scope of Work: This task shall be an add-on if needed after the initial field review and preliminary design in Signal Design tasks 6-11. During signal design task (6-11) the ***CONSULTANT*** will utilize information provided by PUPS and visual observations during field reviews as well as information provided by the **SCDOT** to field locate and develop a list of utilities that may be affected by the project. If the signal cannot be designed to avoid existing utility conflicts, task 12 will be added to task order as a modification. Task 12 is not a stand-alone task. The scope of work for this contract will be to prepare Utility Agreements and Utility Certification document. Such services will consist of coordination with District Utility Engineer and affected utility providers.		
#	**Project Tasks**	**Task Description**
1	Project Management	The ***CONSULTANT*** will manage the project to conform to the **SCDOT** requirements for monitoring and controlling the engineering budget, project schedule and invoicing procedures. The ***CONSULTANT*** shall provide project management for all of the tasks detailed below including the submission of invoices and progress reports to the **SCDOT**. The ***CONSULTANT*** will assign a Project Manager to serve as the primary contact for communications with the **SCDOT**
2	Field Review with Utility Providers	The ***CONSULTANT*** will meet with utility providers to discuss the most feasible solution to implement the proposed signal improvements including possible relocation of signal poles, impact of adjustments to overhead or underground utilities. ***CONSULTANT*** shall provide a single report including the following: • listing affected utilities by intersection, (obtained in task 6-11 • a summary of utilities located in each intersection quadrant (obtained in task 6-11 • One of the following for each utility provider o Encroachment permit- with utility provided relocation plan o Agreement – with utility provided cost estimate and relocation plan o No Conflict Letter
3	Preparation of Agreements / Cost Estimates	The ***CONSULTANT*** will obtain cost estimates for each utility relocation/agreement. The ***CONSULTANT*** will coordinate with the Utility Provider and SCDOT to prepare and execute the Utility Agreement, including a scope of work and schedule for completion.
4	Coordination with District Utility office	The ***CONSULTANT*** shall coordinate with SCDOT District Utility/Traffic Engineering staff including them in discussions and meetings with Utility providers. Consultant shall provide sufficient documentation for District staff to initiate Utility agreements, if needed.
5	Certification Document Report	The ***CONSULTANT*** will provide Utility Certification report for inclusion in letting submittal package.

Figure 4-64
Traffic Signal Utility Coordination Scope of Services

Task 18 RR Coordination (per Intersection)		
Scope of Work: This task shall be an add on to Signal Design tasks 6-11, if signal is within RR R/W; This task may also be an add on if signal is preempted by RR or within 300' of RR. Task 18 is not a standalone task. The ***CONSULTANT*** will coordinate with railroad companies to secure needed information for contractor to obtain right of entry permits for signal upgrades. The ***CONSULTANT*** will provide all necessary drawings and documentation within the letting package to facilitate the execution of appropriate agreements between the Contractor and the railroad company. [unit is per Intersection]		
#	**Project Tasks**	**Task Description**
1	Project Management	The ***CONSULTANT*** will manage the project to conform to the **SCDOT** requirements for monitoring and controlling the engineering budget, project schedule and invoicing procedures. The ***CONSULTANT*** shall provide project management for all of the tasks detailed below including the submission of invoices and progress reports to the **SCDOT**.
2	Evaluation of Existing RR ROW and ranking of RR Crossing.	Staff shall perform a preliminary check of plats and plans for discrepancies or anomalies that will require special attention (humped crossing, need for interconnection, etc.) and report any concerns to SCDOT. Staff shall coordinate with SCDOT RR staff to determine if RR crossing requires upgrades/improvements to RR crossing warning devices.
3	Identification of RR ROW Encroachment Needed.	Staff shall identify the type of RR ROW encroachment permit needed (Right of Entry, Flagging, Interconnection Agreement, etc.).
4	Coordination with RR for Permits.	Staff shall initiate initial contact with RR ROW personnel describing proposed signal work to determine if right of entry permit is sufficient for contractor to perform work.
5	Development of Drawings/Documentation for RR permit.	Staff shall prepare documents conveying the required work within RR R/W, necessary for contractor to obtain right of entry permit, including dimensioned plan/profile of signal equipment within RR r/w.

Figure 4-65
Traffic Signal Railroad Coordination Scope of Services

Other Signal Design Elements

Battery Back Up System (BBS)

A Battery Back Up System provides a stable supply of power to the signal (for 4- 8 hours) during outages. In addition, BBS conditions power during surges or other power disruptions. Although BBS will not provide power over multiple days, in general, powere outages are repaired within the the 4 - 8 hours. If the outages last multiple days, it is generally in an emergengy situation where law enforcement is present and travel is limited by the general public.

A BBS should be included in the design of signals interconnected with railroad devices. Other considerations for BBS include the following:

- Signal will have Ethernet communications; Ethernet communications is very sensitive to power disruptions and the BBS conditions power.
- Signalized intersection may be difficult to control traffic with emergency personnel during power outages. Some intersections are so large and have such complex phasing that multiple law enforcement personnel is required to operate the signal.
- Signalized intersections that are significant along evacuation routes.
- Signalized locations with traffic monitoring cameras.

BBS is standard SCDOT equipment and SCDOT has a material and construction specification for this equipment. The installation consists of a BBS cabinet and foundation for the batteries. This BBS cabinet is connected to or in some cases attached to the signal cabinet. See **Chapter 5 Equipment** for photos.

Emergency Preemption System

Some local governments operate preemption systems for emergency vehicles, generally fire trucks. Emergency preemption Systems include receivers installed at signals that when activated by transmitters, preempt normal signal operations and activate a designated preemption hold interval. The intent is to provide a green signal in the direction of oncoming emergency vehicles. Transmitters are generally installed in emergency vehicles. Emergency Preemption Systems are not standard SCDOT equipment and both transmitters and recievers are the property of the local government. Local governments are responsible for any equipment replacement. If the preemption system malfunctions, SCDOT will remove it and contact the local government for pick up and replacement. It is the local governments responsibility to notify emergency personnel accordingly.

SCDOT does not have a material specification or construction specification for preemption systems. Therefore, this information must be obtained from the local government. In general, the type of preemptions system currently in use by the local government determines what type of receiver is installed at the signal.

If local authorities want to include emergency preemption system to the signal design, there are various method to accomplish this:

- Emergency Preemption Systems can be installed under encroachment permit. The installation must be installed with a qualified signal contractor upon approval by SCDOT.
- If the signal installation or upgrade is within a project, the preemption system can be included with a financial participation agreement that details installation and maintenance responsibilities. Generally any cost added to the project for the installation of the preemption system is the responsibility of the local government.

Luminaires
Luminaires are not standard SCDOT equipment and are not necessary for signal operations. Some local governments desire luminairres to be installed on signal support poles or mast arm poles. SCDOT allows the installation, however there must be a separate power source and meter for the luminaire(s).
SCDOT does not have a material specification or construction specification for luminairres. Therefore, this information must be obtained from the local government.

Wireless Detection Arrays
Wireless detection is standard SCDOT equipment. However, some local governments desire to install an array of wireless dettection that operates as an origin destination detection system. If a local government desires wireless detection sensors exceeding the layouts shown in **Figures 4-39 through 4-42,** the local government should be financially responsible for the addional detection. Exceptions to this include if the District Traffic Engineer approves the detection layout as necessary or if the funding source allows the additional detection.

CHAPTER 5

EQUIPMENT

SCDOT

Traffic Signal Equipment Specifications

Equipment needed for each traffic signal or flashing beacon installation is detailed on the traffic signal or flasher plans.

SCDOT has Material Specifications and Traffic Signal Supplemental Technical Specifications-SC-M-675 (installation methodology) for each item needed as well as Standard Drawings detailing installation standards and requirements.

These Specifications and Standard Drawings are available on the SCDOT website.

Traffic Signal Equipment Qualified Products List (QPL)

SCDOT has established a process and listing for signal equipment meeting SCDOT Material Specifications at Qualified Products List (QPL).

SCDOT has an Evaluation Policy for Traffic Signal Equipment and an Evaluation Form.

Traffic Signal Pedestrian Equipment - Qualified Products Policy #90

Vehicle Loop Detection Equipment - Qualified Products Policy #91

Signal Heads, Modules, and Blankout Signs - Qualified Products Policy #92

Traffic Signal Controller, Cabinet, and Components - Qualified Products Policy #93

Traffic Signal Electrical Equipment and Support Cables - Qualified Products Policy #94

Traffic Signal Poles - Qualified Products Policy #95

Traffic Signal Network Devices - Qualified Products Policy #96

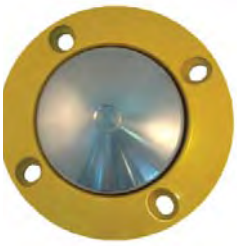
Flashers and Equipment - Qualified Products Policy #97

Pedestrian Group *Qualified Products Policy #90*

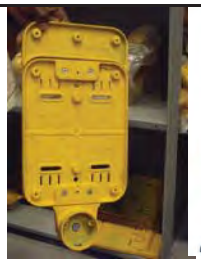
Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Pedestrian Push Button Station Assembly w/ Sign	M686.4	SC-M-686-4	144140 - PB Station Assembly 9" X 15", includes assembly, button and sign 144109 - PB Station Assembly 9" X 12", includes assembly, button and sign 136818 Pedestrian Push Button (Solid State)	4400018371 ***Expires April 2023***

Pedestrian Assembly with button and sign

Solid State Push Button with Tone only (no light required)



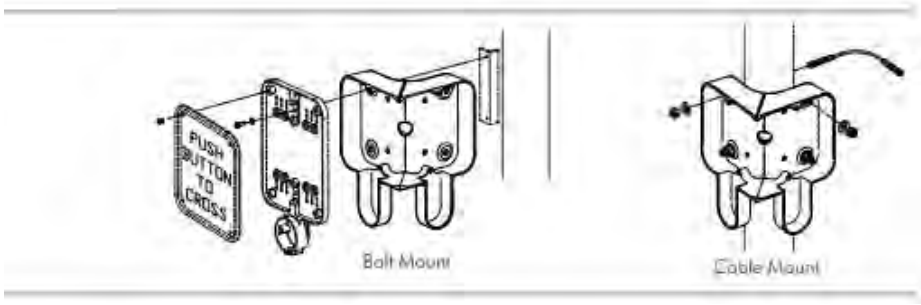
Microswitch (Mechanical) Push Button
(SCDOT has discontinued installing Microswitch Push Button)



Pedestrian Assembly without button and sign
Standard color - Yellow (Y),
but generally available in powder coated:
Textured Black (B), Green (G), Clear Coat Natural (N)

Signs for Push Button Assembly

Accesible Pedestrian Signal (APS)
Push Button Assembly



Pedestrian Pole Adapter
for 90 degree mounting on small diameter pole- *incidental item*

Pay Items:

6865793	F&I Pedestrian Push Button Microswitch Type Station Assembly (9"x12") & Sign (R10-3e or R10-3b)
6865794	F&I Pedestrian Push Button Microswitch Type Station Assembly (9"x15") & Sign (R10-3e or $10-4a)
6865795	F&I Pedestrian Push Button Microswitch Type
6865796	F&I Pedestrian Push Button Solid State w/ Tone Station Assembly (9"x12") & (R10-3e or R10-3b)
6865797	F&I Pedestrian Push Button Solid State w/ Tone Station Assembly (9"x15") & (R10-3e or R10-4a)
6865798	F&I Pedestrian Push Button Solid State w/ Tone
686578A	F&I Audible Pedestrian System (APS) inc. Pedestrian Head & Button Assembly with sign (R10-3e)

Pedestrian Group *Qualified Products Policy #90*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Pedestrian Pole and Base	M682.4	SC-M-682-4	Not stocked at Supply Depot	4400018371 ***Expires April 2023***

Standard color - natural brushed aluminum, but generally available in powder coated: Textured Black (B), Green (G), Brown (B)

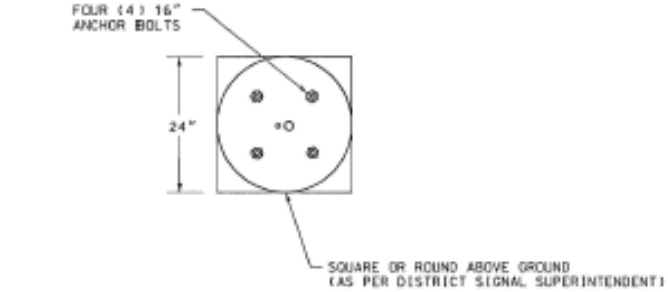
Pedestrian Pole Anchor

Pedestrian Pole Collar

Anchor Bolts

Pedestrian Pole
4.5" diameter aluminium

Pedestrian Pole Assembly



Pedestrian Pole foundation detail

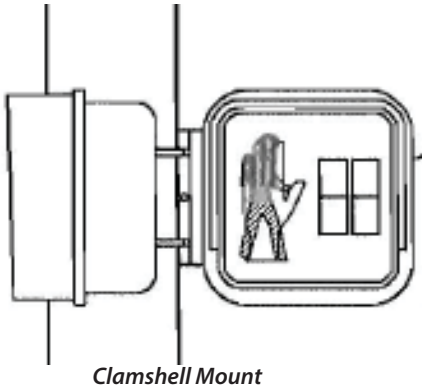
Pay Items:

6825480	F&I 4' Break-away Aluminum Pedestal Pole and Base
6825482	F&I 8' Break-away Aluminum Pedestal Pole and Base
6825484	F&I 10' Break-away Aluminum Pedestal Pole and Base
6888192	Powdercoating option for 4' Aluminum Pole
6888193	Powdercoating option for 8' Aluminum Pole
6888194	Powdercoating option for 10' Aluminum Pole
6825486	Install Concrete Foundation for Aluminum Pedestal Pole

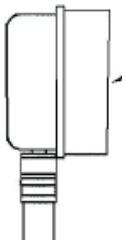
Pedestrian Group *Qualified Products Policy #90*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Pedestrian Signal Heads	M686.3	SC-M-686-3	136957 Hand/Man Countdown Ped Head, no mounting hardware 137036 Hand/Man Countdown Ped Head, clamshell left side mount 136956 Hand/Man Countdown Ped Head,clamshell right side mount 136812 Countdown, Hand/Man Pedestrian Module	4400018371 ***Expires April 2023***

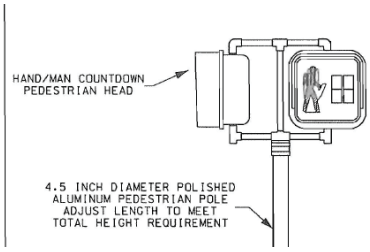
Options



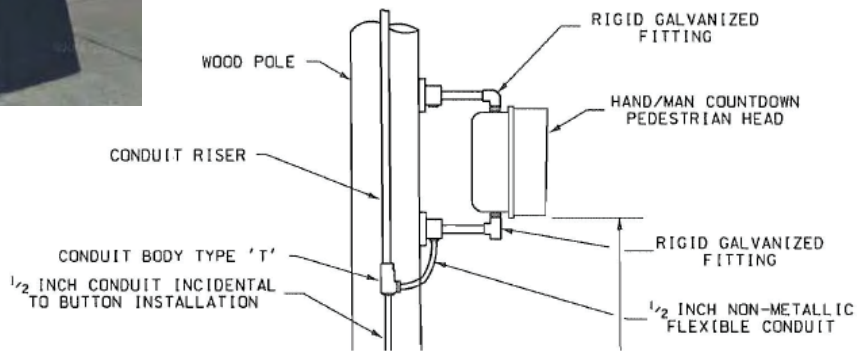
Clamshell Mount



Single Post top



Dual Post top



Side of Pole Mounting

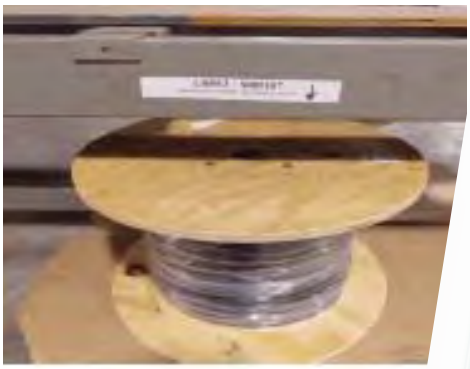
Pay Items:

6865782 F&I Pedestrian Signal Head - mounting is incidental
6865783 F&I Countdown Pedestrian Signal Head - mounting is incidental

Vehicle Loop Detection Equipment Group *Qualified Products Policy #91*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Loop Sealant	M678.1	SC-M-678-1	Not stocked at Supply Depot	N/A
Loop Wire	M678.1	SC-M-678-1	136953 - Traffic Signal 14 Gauge Loop Wire Single Conductor, Black, w/ footage Markings, 5,000 Ft. Reel	N/A
Loop Lead - In Cable ***QPL Group 94***	M678.1	SC-M-678-1	136821 4 Conductor Gray 136815 8 Conductor Gray 149401 16 (8 pair) Conductor Gray	4400015675 **expires March 2022**

Loop Sealant *- incidental item*



Loop Wire

Pay Items:

6770413	F&I No. 14 Copper Wire, 1-Conductor for Loop Wire - sealant is incidental
6770389	F&I No. 14 Copper Wire, 4 Conductor Gray
6770394	F&I No. 14 Copper Wire, 8 Conductor Gray

Signal Heads, Modules, and Blankout Signs Group *Qualified Products Policy #92*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Vehicle Signal Heads	M686.1	SC-M-686-1	137038 1 section, 12", Yellow ball Signal Head 137033 3-section, RYG Signal Head, 137032 4-section, RYGGA Signal Head 136956 5-section, RYGYAGA Signal Head	4400009067 4400009068 ***Expires August 2019***
Backplates	M898.1	SC-M-686-1	Not Stocked at Supply Depot	N/A
Vehicle Signal Modules	M686.1	SC-M-686-1	137046 LED, Red ball, 12", Signal Module 137047 LED, Yellow ball, 12", Signal Module 136940 LED, Green ball, 12", Signal Module 136961 LED, Red arrow, 12", Signal Module 136960 LED, Yellow arrow, 12", Signal Module 136939 LED, Green arrow, 12", Signal Module	4400009067 4400009068 ***Expires August 2019***

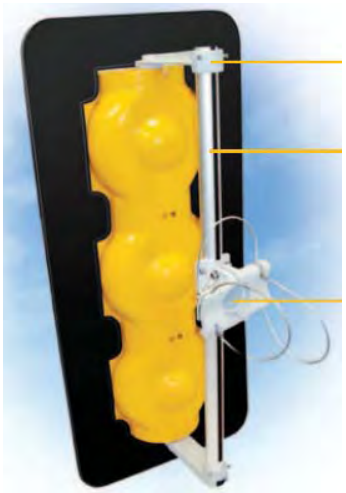
Signal heads are polycarbonate material, and are supplied with signal head housing, modules, tunnel visors, dual entrance weather head, span wire mounting

3-Section Signal Head

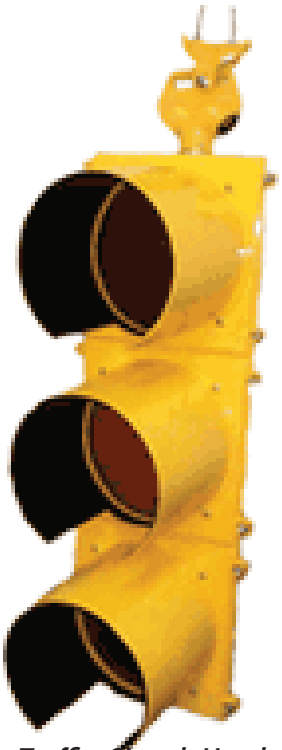
4-Section Signal Head
T Configuration, In-line Configuration

5-Section Signal Head

Backplate with Retroreflective Border



Vehicle Traffic Signal Head Mounting Assembly for Mast Arm



Vehicle Traffic Signal Head with mounting hardware

Pay Items:

6865710	F&I 12" - 5-Section Signal Head - span wire mounting is incidental
6865720	F&I 12" - 4-Section Signal Head - span wire mounting is incidental
6865723	F&I 12" - 3-Section Signal Head - span wire mounting is incidental
6865834	F&I Backplate with Retroreflective Borders for Traffic Signal
6865831	F&I Vehicle Traffic Signal Head Mounting Assembly for Mast Arm

Dual Entrance Weather head with Span Wire Hanger

Balance Adjuster

Span Wire Hanger

Visor With Attachment Screws

Signal Housing

Signal Head Modules

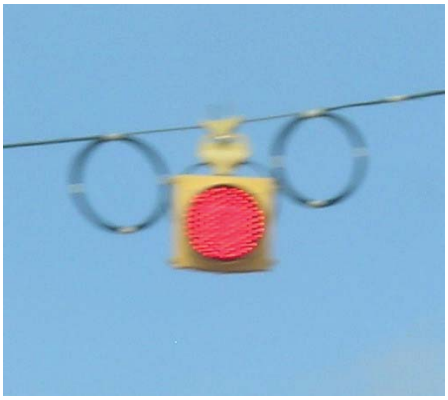
Signal Heads, Modules, and Blankout Signs Group *Qualified Products Policy #92*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Blankout Sign	M686.5	SC-M-686-5	Not Stocked at Supply Depot	4400019311 *Expires August 2019*

Blankout Sign, "Symbolic" LED No Right/Left Turn

Pay Items:

6865820 F&I No Right/Left Turn Symbolic LED Blankout Sign w/ Span Wire Mounting
6865821 F&I No Right/Left Turn Symbolic LED Module



1-Section Red Signal Head

1-Section Yellow Signal Head

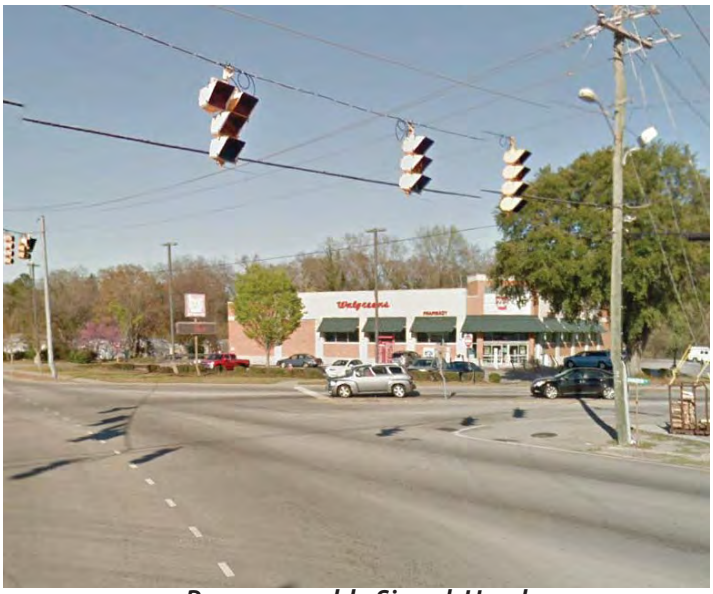
Pay Items:

6865736 F&I 12" - 1-Section Red Signal Head - span wire mounting is incidental
6865737 F&I 12" - 1-Section Yellow Signal Head - span wire mounting is incidental
6865820 F&I No Right/Left Turn Symbolic LED Blankout Sign w/ Span Wire Mounting
6865821 F&I No Right/Left Turn Symbolic LED Module

Non-QPL Traffic Signal Heads

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Optically Programmable Vehicle Signal Heads	N/A	**686.2 Optically Programmable Vehicle Signal Heads** (This is a stand-alone specification and is not inluded in Supplemental Technical Specification) *includes Material Specifications for Optically Programmable Vehicle Signal Head*	Not Stocked at Supply Depot	N/A
Extra long visors, Louevers	N/A	Special equipment to shield signal indications to address special issues such as acute approach angles, or closely spaced signals	Not Stocked at Supply Depot	N/A

Extra Long Visors



Programmable Signal Head

Louevers for Signal Heads

Pay Items:

6865750	F&I 12"Optically Programmable 5 Section Vehicle Traffic Signal Head(R.Y.YA.G.GA)
6865760	F&I -12" Optically Programmable 5 Section Vehicle Traffic Signal Head(R+R.YA.GA)
6865761	F&I - 12" Optically Programmable 5 Section Vehicle Traffic Signal Head(R.Y.G.GA)
6865770	F&I -12" Optically Programmable 5 Section Vehicle Traffic Signal Head(R.Y.G.)

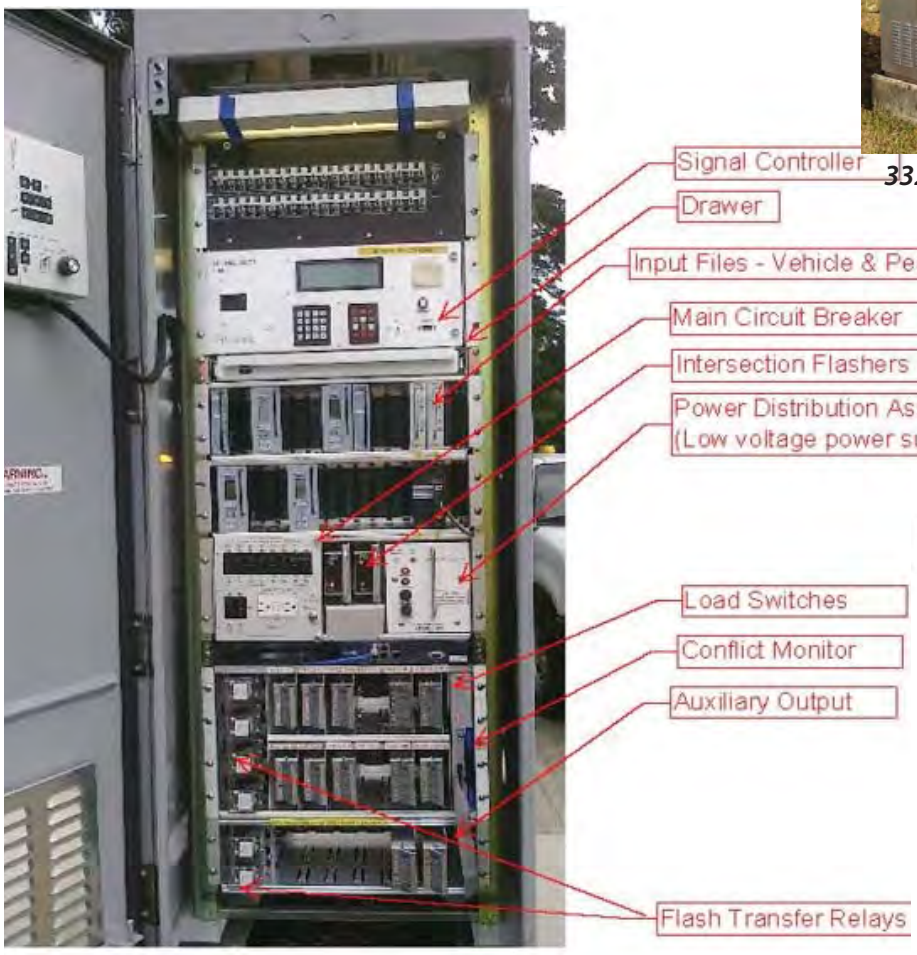
Controller, Cabinet, and Components Group *Qualified Products Policy #93*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
2070 Controller	M688.7	SC-M-688-7	136865 2070L Controller- 7A card, no software *2070 Controller includes:* Model 2070-4B Power Supply Module, 3 Amp, Model 2070-3B Front Panel Module, Model 2070 - 1B CPU Module, single board, Model 2070-2A Field I/O Module, Model 2070-7A Asynchronous Serial Com Module	4400015603 ***Expires August 2022***
332A Cabinet Assembly			136872 332A Cabinet Assembly	
336S Cabinet Assembly			Not Stocked at Supply Depot	
Conflict Monitor			Not Stocked at Supply Depot	

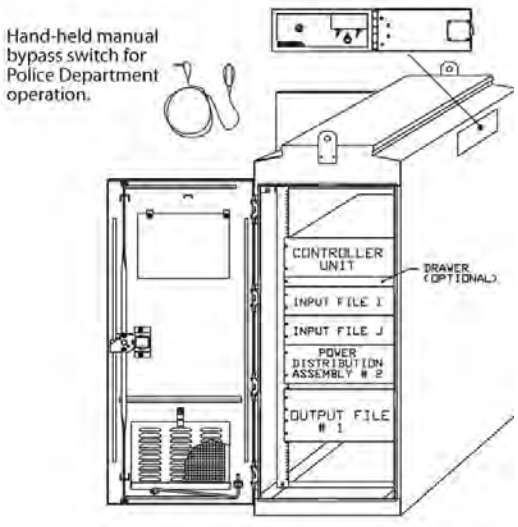
Cabinet Assembly includes:
1 conflict monitor, 12 Load Switches, 2 DC Isolators, 14 Flash Programming Sockets, 7 Flash Transfer Relays, 8 LCD Enhanced Loop Detectors

332A Signal Cabinet

336S Signal Cabinet



332A Cabinet Assembly



Pay Items:

6845510	F&I Controller & 336 Cabinet Assembly - Pole Mounted
6845511	F&I Controller & 332/336 Cabinet Assembly - Base Mounted- foundation included
6887951	F&I Concrete Cabinet Foundations

Controller

Conflict Monitor
2018 ECL-ip, 2010 ECL-ip

Cabinet Assembly Elements:

Load Switches

Flasher

DC Isolator, Model 242,
170 Type, 2 Channel

Pow-
ply Cabinet

er Sup-

Serial Communication Module,
Model 2070-7A

AC isolator,
Model 252,
170 Type 2 Channel

Loop Detector Amplifer, Model 222, 2 Channel

Flash Transfer Relay, Model 430

Loop Detector, LCD Enhanced/ Intelligent, 2 Channel

Non-QPL Traffic Signal Cabinets

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Flasher Cabinet Assembly	N/A	SC-M-688-8 includes Material Specifications for Flasher Cabinet Assembly consisting of 14" x 14" x 11" Aluminum Flasher Box with Mounting Brackets	Not Stocked at Supply Depot	N/A

Flasher Cabinet at School Zone

Flasher Cabinet

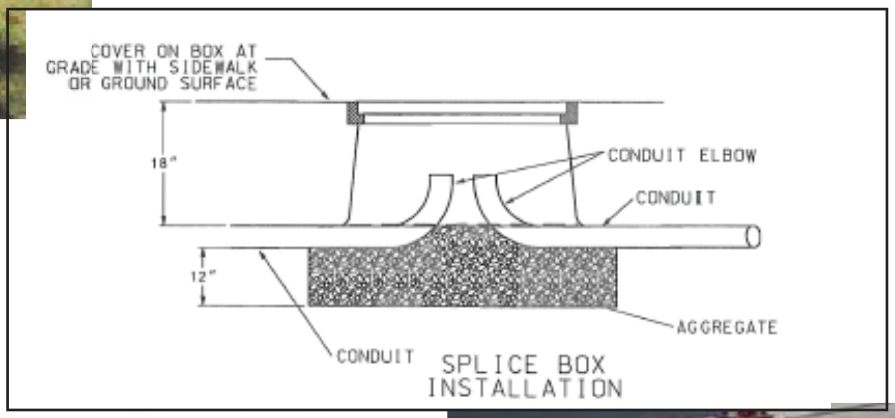
Pay Items:

6845655 F&I Flasher Cabinet Assembly

Traffic Signal Electrical Equipment and Support Cables Group Qualified Products Policy #94

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Splice Box / Junction Box	M680.2	SC-M-680-2	Not Stocked at Supply Depot	*N/A*

Mini Splice Box,
Electical Flush Enclosure



Splice Box, Electical Flush Enclosure
W/ Cover 13"X24"X18"

Hand Box, Electrical Flush Enclosure
W/ Cover, 17"X30"X24"

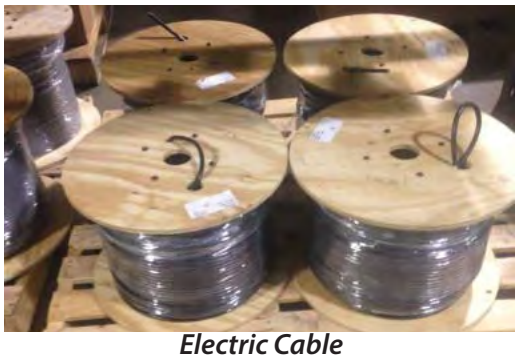
Pay Items:

6800518 F&I 13"x 24" x 18" Electrical Flash Underground Enclosure
680052C F&I 17"x 30" x 24" Electrical Flash Underground Enclosure
6800508 F&I 12" x 12" x 12" Electrical Flash Underground Enclosure

Traffic Signal Electrical Equipment and Support Cables Group *Qualified Products Policy #94*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Electrical Cable	M677.1	SC-M-677-1	136822 4 Conductor Black 136823 8 Conductor Black 149410 12 Conductor Black Electric Cable *Cable comes in 1,000' reels w/ footage markings*	4400015675 ***Expires March 2022***
Loop Lead - In Cable	M678.1	SC-M-678-1	136821 4 Conductor Gray 136815 8 Conductor Gray 149401 16 (8 pair) Conductor Gray	
Steel Cable	M682.3	SC-M-682-3	Not Stocked at Supply Depot	N/A

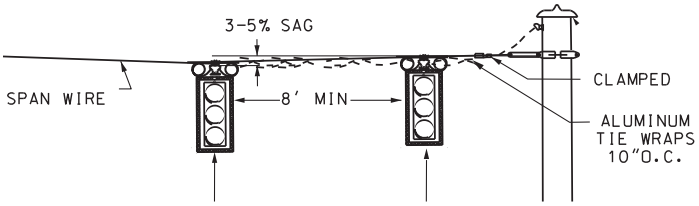
Electric Cable
4-C, 8-C, 12-C, Black



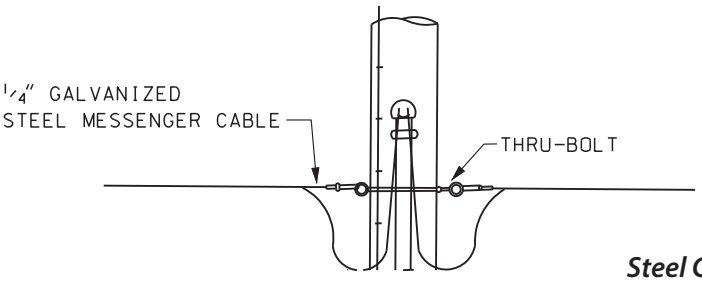
Electric Cable
4-C, 8-C, 8 pair, Grey

Pay Items:

6770389	F&I 4-C Grey (Loop/ Ped Detectors)
6770394	F&I 8-C Grey (Loop / Ped Detectors
6770388	F&I 4-C Black (Signal / Ped Heads)
6770393	F&I 8-C Black (Signal / Ped Heads)



Steel Cable
3/8" Steel Cable (Span Wire)



Steel Cable
1/4" Steel Cable (Messenger Wire)

Pay Items:

6825092	F&I 3/8" Galvanized Steel Cable (Span Wire)
6825090	F&I 1/4" Galvanized Steel Cable (Messenger Wire)

Non-QPL Traffic Electrical Equipment - Conduit

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Galvanized Rigid Conduit	N/A	SC-M-675 *includes Material Specifications for Conduit (all connections, fittings needed are incidental items)*	Not Stocked at Supply Depot	N/A
Schedule 80 PVC Conduit				
Flexible Galvanized Steel Conduit				
Schedule 80 HDPE Rolled Conduit				

Conduit in Trench

HDPE Rolled Conduit

SCH 80 PVC Conduit

Flexible Rigid Conduit

Pay Items:

For conduit either Trenched or Riser:

6750005	F&I 1" Galvanized Rigid Conduit
6750015	F&I 2" Galvanized Rigid Conduit
6750025	F&I 3" Galvanized Rigid Conduit
6750181	F&I 1" Aluminum Conduit
6750275	F&I 1" Schedule 80 PVC Conduit
6750278	F&I 2" Schedule 80 PVC Conduit
675027C	F&I 3" Schedule 80 PVC Conduit

Pay Items:

For high accuracy directional boring:

675027S	F&I 2" Schedule 80 PVC Conduit (Directional Bored)
675027V	F&I 3" Schedule 80 PVC Conduit (Directional Bored)
675027Y	F&I 4" Schedule 80 PVC Conduit (Directional Bored)
675027Z	F&I Additional Conduit within Directional Bore
6760050	F&I 1" Schedule 80 HDPE Conduit (Trenchless)
6760060	F&I 2" Schedule 80 HDPE Conduit (Trenchless)
6760070	F&I 3" Schedule 80 HDPE Conduit (Trenchless)
6760080	F&I 4" Schedule 80 HDPE Conduit (Trenchless)

Rigid Conduit

For flexibility:

6750175	F&I 1" Flexible Galvanized Steel Conduit - Weather Tight
6750179	F&I 2" Flexible Galvanized Steel Conduit - Weather Tight
675017D	F&I 3" Flexible Galvanized Steel Conduit - Weather Tight

Open Cut:

6750262	F&I Encased Conduit (2-2" PVC, Schedule 40)
6750263	F&I Encased Conduit (3-2" PVC, Schedule 40)

For bored and jacked:

6750078	F&I 1" Galvanized Rigid Conduit (Bored & Jacked)
6750085	F&I 2" Galvanized Rigid Conduit (Bored & Jacked)
6750090	F&I 3" Galvanized Rigid Conduit (Bored & Jacked)

Encased Conduit
(Duct Bank)

Non-QPL Traffic Electrical Equipment - Electric Service

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Electric Service	N/A	SC-M-680-1 *includes Material Specifications for Electric Service* *(Meter, Meter Box, Power Connection, 3-wire Cable, Disconnect Switch)*	Not Stocked at Supply Depot	N/A

680.1 Electric Service

2 Service Feed/Conduit

4 Meter Box/Meter

5 Disconnect Switch

Meter Mounting type

Electric Service Mounting Location

Pole

Pedestal Mounted

Pay Items:

6800499	F&I Electric Service for Traffic Signal
6800500	Modify Electric Service for Traffic Signal
6770318	F&I #6 Triplex Aluminum Service Wire

Upcoming QPL Traffic Electrical Equipment - Battery Back-up System

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Battery Back-up System cabinet, batteries, back-up system controller	M689.1	**689.1 Battery Back-up System** (This is a stand-alone specification and is not currently included in Supplemental Technical Specification)	Not Stocked at Supply Depot	N/A

Battery Back-up System (cabinet adjacent to signal cabinet)

Battery Back-up System (batteries)

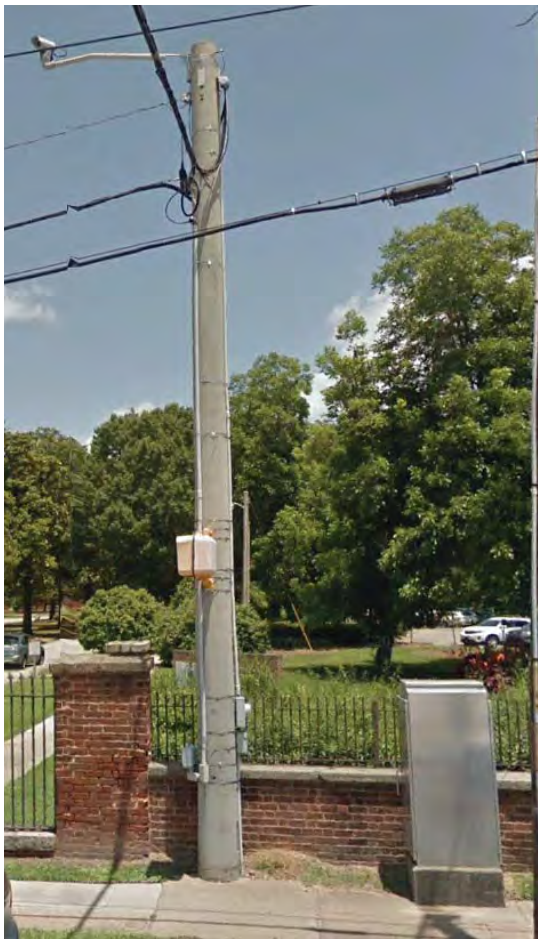
Pay Items:

6845518 F&I Battery Back-up System including Foundation

Traffic Signal Poles Group *Qualified Products Policy #95*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Steel Strain Poles	M688.5	SC-M-688-5	Not Stocked at Supply Depot **Steel pole includes:** *Design detail and shop drawings, hardware including anchor bolts (4), nuts, washers, pole cap, pole overs, pole plugs, span wire clamps (2) and associated hardware. Steel poles shall have base plate labled with manufacturer, lot #, length, diameter and ID #*	4400011625 ***Expires October 2020***
Concrete Strain Poles	M688.6	SC-M-688-6	Not Stocked at Supply Depot ***Concrete pole comes with:*** *Pole cap, hand hole covers, pull rope/wire, miscellaneous hardware* *Concrete pole shall be labeled with manufacturer, date, lot #, length, diameter, ground line capacity.*	

Powder-coated Steel Pole



Concrete Pole

Steel Pole

Pay Items:

682505A	F&I 26' Steel Strain Pole and Foundation
682505B	F&I 28' Steel Strain Pole and Foundation
682505D	F&I 32' Steel Strain Pole and Foundation
6825050	F&I 26' Steel Strain Pole (Powdercoated) and Foundation
6825051	F&I 28' Steel Strain Pole (Powdercoated) and Foundation
6825052	F&I 32' Steel Strain Pole (Powdercoated) and Foundation
6825056	F&I 26' Steel Strain Pole (Powdercoated over Galvanized) and Foundation
6825057	F&I 28' Steel Strain Pole (Powdercoated over Galvanized) and Foundation
6825058	F&I 32' Steel Strain Pole (Powdercoated over Galvanized) and Foundation

Pay Items:

6825061	F&I 35' Concrete Strain Pole
6825062	F&I 40' Concrete Strain Pole
6825064	F&I 45' Concrete Strain Pole

Non-QPL Traffic Signal Poles

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Wood Pole	N/A	SC-M-682-1 *includes Material Specifications for Wood Pole s*	Not Stocked at Supply Depot	N/A
Back-Guys	N/A	SC-M-682-1 *includes Material Specifications for Back-Guys*	Not Stocked at Supply Depot Back-Guy Assembly including, eye-type thru-bolt, guy-hook, strandvise (or 3 bolt clamp), jumper-bonding clamp, steel cable (3/8" guy-cable stranded), screw-type guy anchor	

Wood pole with Back guys

Wood pole with Sidewalk guys

Wood pole with Cabinet

Signal with wood poles

<u>Pay Items</u>:

6825020	F&I 35' Wood Pole - Class 2 - CCA Treated
6825021	F&I 40' Wood Pole - Class 2 - CCA Treated
6825023	F&I 50' Wood Pole - Class 2 - CCA Treated
6825025	F&I 60' Wood Pole - Class 2 - CCA Treated

<u>Pay Items</u>:

6825045	F&I 3/8" Back-guy for Wood Pole
6825046	F&I 3/8" Sidewalk Guy
6825047	F&I 3/8" Aerial Guy

Non-QPL Traffic Signal Poles

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Steel Pole with Mast Arm	N/A	SC-M-690-1 *includes Material Specifications for Mast Arms*	Not Stocked at Supply Depot	N/A
Luminaires	N/A	*N/A*	N/A - *Although Luminaires are installed in SCDOT construction projects, the local government typically provides the specification for the luminaire.*	N/A

Pay Items:

6888179	Design, Furnish & Install Steel Pole w/ Mast Arm including Foundation
6888172	Design, Furnish & Install Steel Pole w/ Mast Arm without Foundation
6888177	Design, Furnish & Install Steel Pole w/ Twin Mast Arm including Foundation
6888178	Design, Furnish & Install Steel Pole w/ Twin Mast Arm without Foundation
6888166	Powdercoating Per Mast Arm over Base
6888167	Powdercoating Per Mast Arm over Galvanized
6888168	Decorative Option per Mast Arm
6888174	Install Foundation for Mast Arm including Concrete and Rebar
6888169	Luminaire Option for Mast Arm- to account for taller pole
6865164	F&I Dual Luminaire including Luminaire Arms and all associatede hardware
6865831	F&I Single Luminaire including Luminaire Arms and all associatede hardware
6513020	F&I Mounting Assembly for Flat Sheet Sign erected onMast Arm
6865831	F&I Vehicle Traffic Signal Head Mounting Assembly for Mast Arm

COMMUNICATIONS GROUP (TRAFFIC SIGNAL NETWORK DEVICES)

- Video Detection System
- Wireless Detection System
- Short Range Radio Device Detection System
- Traffic Monitoring Cameras for Traffic Signals
- Wireless Broadband Radio Communications
- Ethernet Switches
- Fiber
- Factory Terminated Patch Panel
- Fiber Interconnect Center
- Fiber Modem
- Cell Modem

Traffic Signal Network Devices *Qualified Products Policy #96*

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Video Detection - Loop Emulation System	M688.3	SC-M-688-3	Not Stocked at Supply Depot	N/A

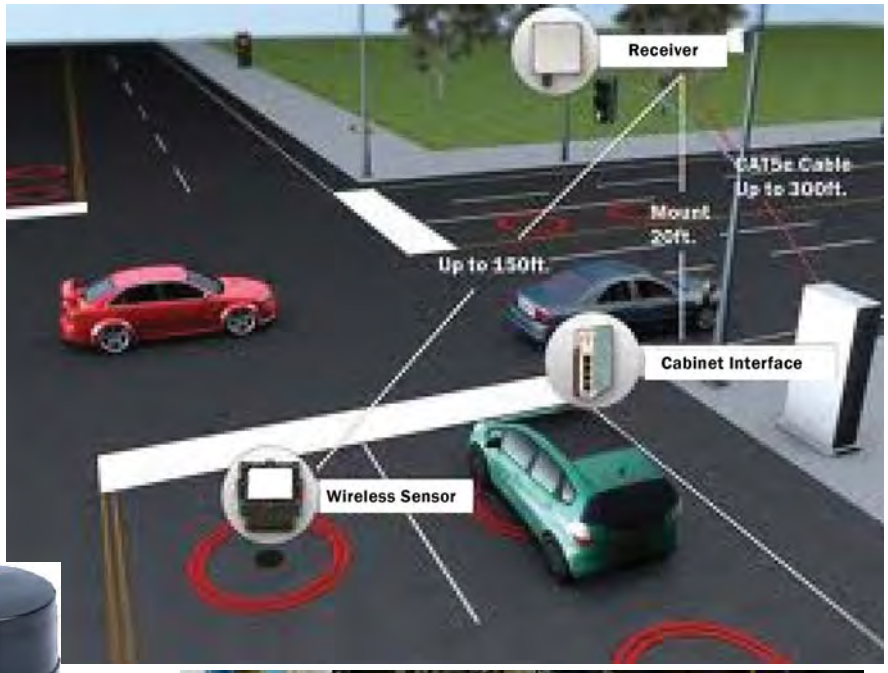
Pay Items:

6886042	F&I Video Detection Camera with Hardware and Lead-in
6886044	F&I Video Detection System Single Channel Processor Hardware - No Camera
6886045	F&I Video Detection System Dual Channel Processor Hardware - No Camera
68886042	F&I Video Detection Cable to Cross Roadway

Non-QPL Detection Equipment

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Wireless Vehicle Detection System	N/A	SC-M-678-2 includes Material Specifications for Wireless Detection System consisting of Sensors, Antennas, Repeaters, Cabinet Interface	Not Stocked at Supply Depot	N/A
Short-Range Radio Device Detector System	N/A	SC-M-699-1 includes Material Specifications for Short-Range Radio Device Detector System (Origin-Destination Device (Blue Toad)	Not Stocked at Supply Depot	N/A

Repeater



Antenna / Receiver

Sensors

Cabinet Interface

<u>Pay Items</u>:

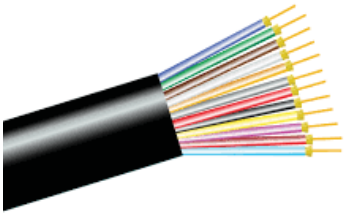
677049C	F&I Wireless Detection System w/o Sensors (Including Setback Detection Capability for 2 directions)
677049D	F&I Wireless Detection System w/o Sensors (Including Setback Detection Capability for 3 directions)
677049E	F&I Wireless Detection System w/o Sensors (Including Setback Detection Capability for 4 directions)
677049F	F&I Wireless Detection System w/o Sensors (without Setback Detection Capability)
6770494	F&I Flush Mounted Wireless Sensor

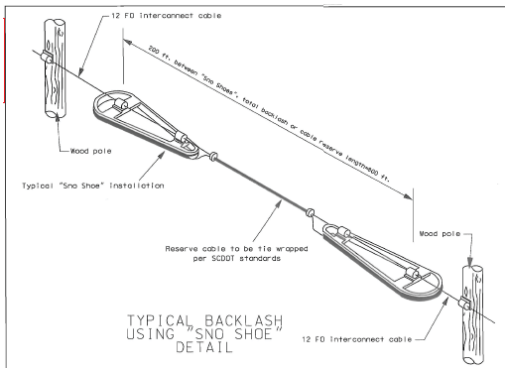
Non-QPL Network Devices for Traffic Signals - Procured by SCDOT with Public Interest Finding

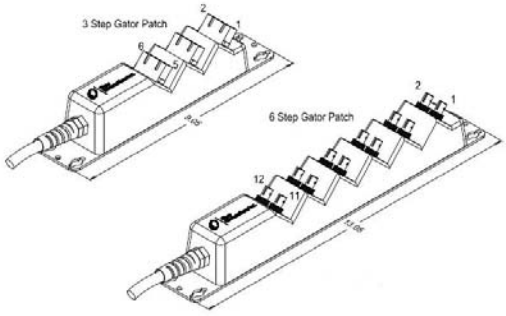
Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Traffic Monitoring Cameras for Traffic Signals	Make & Model for Cohu Camera(s)	SC-M-688-3 for installation method	Not Stocked at Supply Depot	
Wireless Broadband Radio (WBB)	N/A	SC-M-677-7 for installation method		
Ethernet Switch	N/A	N/A - Congigured and installed by SCDOT IT personnel or designee		
Cell Modem	N/A	N/A - Congigured and installed by SCDOT IT personnel or designee		

Non-QPL Communications Equipment

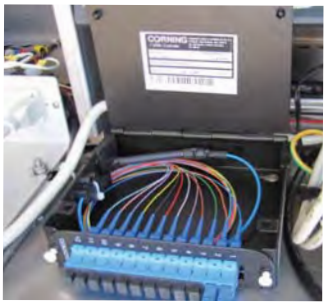
Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Fiber Optic Cable - 12 strand SMFO (Single mode Fiber Optic Cable)	N/A	SC-M-677-3 includes Material Specifications for Fiber Optic CableWood Pole s	Not Stocked at Supply Depot	4400019542 ***Expires September 2023***
Fiber Interconnect Centers	N/A	SC-M-677-3 includes Material Specifications for Fiber Interconnect Centers	Not Stocked at Supply Depot	
Factory Terminated Patch Panel (Gator Patch)	N/A	SC-M-677-6 includes Material Specifications for Fiber InFactory Terminated Patch Panel	Not Stocked at Supply Depot	







Patch Panel, Fiber Optic, Gator Patch, 200



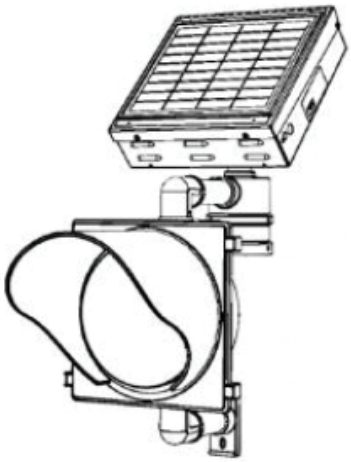
Interconnect Center Fiber Optic, Rack Mount, Sliding Module Cassette Shelf

Pay Items:

6770470	F&I 12 Strand Fiber Optic Cable - Single Mode
677046D	F&I Self Supporting 12 Strand Fiber Optic Cable - Single Mode
6770476	F&I Fiber Optic Interconnect Center
6888082	F&I Factory Terminated Patch Panel

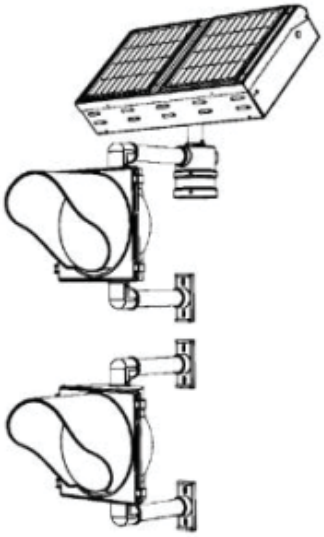
QPL Items for #97 Flashers and Equipment Qualified Products Policy #97

Item	Material Specification	Construction Specification	Supply Depot SCEIS #	Equipment Contract #
Solar Powered Flasher Assembly	M688.9	SC-M-688-9	Not Stocked at Supply Depot	4400017286 ***Expires October 2020***



The types of Solar Flasher Assembly is listed below:

- 24/7 Single Solar 24 Hour Flashing Beacon
- 24/7 Single Compact Solar 24 Hour Flashing Beacon
- Dual 24 Hour Solar Powered Flashing Beacon
- Dual Solar Powered School Flashing Beacon
- Dual Compact Solar School Zone Flasher



Pay Items:

6865700 F&I Solar Powered Flasher Assembly - Single Beacon
6865701 F&I Solar Powered Flasher Assembly - Dual Beacon
6865702 F&I Solar Powered Flasher Assembly

CHAPTER 6

SIGNAL SYSTEMS

SCDOT

Signal System:

A signal system consists of signals that operate to promote progression. The purpose of installing a signal system is to reduce delay, travel times and emissions. Signal systems do not add capacity to the roadway, but are important in managing capacity. The coordination of signals spaced no more than a quarter mile apart is desirable to promote a non-stopping flow of vehicles through the signalized area during peak traffic hours (a.m., noon, school dismissal, p.m.) during the weekday . This will improve the efficiency of traffic flow and minimize stops, delays and queueing.

Signal timing and coordination design is important because it directly affects the quality of our transportation system, which in turn affects virtually everything within our communities. Signal timing impacts the time we spend traveling, the quality of the air we breathe, the safety of roadway we travel, the costs of our trips, and many other aspects of our lives. Poorly timed and maintained signals can reduce the capacity of the roadway and result in unnecessary stops and delays.

There are different types of signal systems. Signal Operations duties are vital in maintaining the effectiveness of signal systems.

Signal Re-timings
Signal re-timings should be considered at least every 3 years.

Several changes to signalized intersections warrant the re-timing of traffic signals:

- When a new signal is added or a signal is updated
- When traffic or pedestrian volumes, or turning movements change significantly
- When access to a roadway changes
- When there is a change in the geometry of a roadway.

This information came from ITE, "Traffic Control System Operations: Installation, Management and Maintenance"

Signal Systems Operations
Traffic Signal System Operational (Re-timing) activities are classified as Type 1 Signal Activities. Operations experts monitor and verify communications between signals in a system. Fine tuning signal systems in the field by adjusting offsets and splits (as provided by the engineer) are also part of operating a signal system. Count data and Synchro are tools used as an aid in this endeavor.

Signal Operations duties include the following

- monitoring signal timings to ensure appropriate operation, including correct splits/offsets, entering coordination at appropriate times
- monitoring equipment operation to ensure malfunctions are repaired such as vehicle detection or pedestrian detection
- ensuring signal communications is operational include verifying integrity of fiber optic, wireless communication, Ethernet switches, cell modem
- fine tuning signal systems to address changing traffic volumes by adjusting offsets and splits (as provided by the engineer), using count data and Synchro as a tool in aid of this endeavor

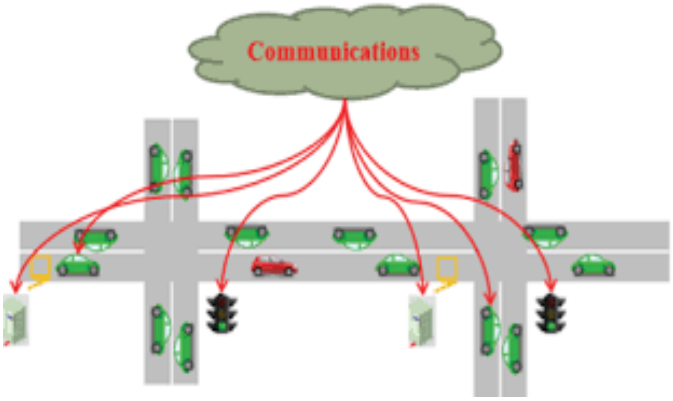
Signal Systems and Roadway Capacity

No form of signal timing can create additional capacity. Traffic Signal Systems only manage capacity. The effectiveness of any traffic signal system relies heavily on available roadway capacity, signal phasing, signal equipment in good repair, sufficient and working detection, operational communications, and personnel to operate/monitor operations of the system. Any signal system installed in SC and maintained by SCDOT should connect to SCDOT's network via an Ethernet connection.

Communications

With Ethernet communications, verification of communication is constantly monitored. If communications is not available, signal maintainers are notified via email or text.

For systems that do not have constant communications, but are Ethernet upgraded, communications should be verified multiple times daily.



Communications between the traffic signal controller and the central traffic signal software ensure signals are operating as designed. Needed signal timing adjustments can be made expeditiously and remotely with Ethernet communications.

Signal data resides on a server hosted on SCDOT network, Co-Location networks or on local government networks. Signals that do not have communications are operated/revised using software on laptops that connect to the signal controller via cable or blue tooth.

Signal System Operations Tools

As discussed in **Chapter 2** there are tools to optimize signal systems remotely. One of these tools is traffic monitoring cameras that can pan, tilt and zoom and provide remote visibility along the corridor. Another tool for systems operations is count information. Daily count data can be available if detection is installed to allow count data collection per lane. Consideration for future advanced traffic communication signal system technology should occur when determining detection placement.

Signal System Settings (Coordination Plans)

Coordination plans include multiple timing plans consisting of cycle lengths, splits and offsets) for specific times of the day and days of week, and special events (planned or manually selected. How these plans are implemented (or chosen) dictate the type of system in place:

- Time of day utilizes pre-set, scheduled plans, predicated by the time of day, day of the week and week of the year.
- Responsive selects the timing plan based on time of day but will change to a different cycle length with pre-set splits based traffic volumes exceeding or below a threshold. There are limitations on making drastic cycle length changes.
- Adaptive measures volumes per lane and stores historical data that predicts splits and cycle lengths. These predictions create a starting cycle length/split and offset based on historical data however are constantly adjusted based on current traffic volumes.

The following information is required to establish coordination plans:

- Average Annual Daily Traffic (AADT) – by approach – this is needed to determine how much green time is needed to serve changes in cycle length and directional distribution
- Turning Movement Counts for peak hours in 15 minute increments
- Crash History – to address identified safety issues
- Field reviews during peak hour
    - To record existing conditions (# lanes, usage, identify lane configuration, signal equipment, signing , pedestrian treatment, character of area)
    - To assess intersection performance (phasing, queuing, driveway operation, adjacent driveways influencing signals, intersections that add and subtract large volumes from mainline)
    - Travel along corridors to compare prevailing speeds with posted speeds, bottle necks, queuing
    - Determine size of signal system based on signal spacing and arrival patterns between signals
    - Ensure detection is in place and operational
    - Current timings are in place and operating as designed

Follow the iterative process below (manually or using Synchro software):

- Determine if current phasing or lane usage should be revised
    - Are additional phases needed to serve left turns;
    - Should left turn phasing type be revised (permissive, protected/permissive, protected only, service by time of day)
    - Should side street lane uses be revised to provide additional capacity (shared lanes, split phasing)
- Determine critical intersection based on phasing and volumes
- Establish prevailing cycle length needed to serve AM, PM, noon, off peak, weekend traffic volumes of critical intersection
- Determine if full cycle length is needed at remaining signals or if the signal can operate effectively utilizing half the prevailing cycle length
- Determine maximum split for each phase (either ensuring adequate time for pedestrian timings or allow pedestrian activation to suspend coordination temporarily to provide sufficient timing)
- Determine order of cycle length to maximize green band – putting greater weight on prevailing traffic direction
- Determine offsets based on the above

Perform these steps for each time frame – generally AM, PM,Mid-day, Off Peak, Weekend, Special (holiday, beach season, football, fair traffic). Establish multiple timing plans with varying cycle lengths and splits for each time frame for testing and evaluation.

Timing Plan - Week Days
Time of Day:

12:00 Mid-Night - 6:30 A.M.	Free
6:30 - 9:00 A.M.	#1 AM Peak
9:00 - 11:45 A.M.	#9 Off Peak
11:45 A.M. - 1:00 P.M	#2 Mid-day Peak
1:00 - 2:30 P.M.	#9 Off Peak
2:30 - 4:30 P.M.	#4 School Peak
4:30 - 6:30 P.M.	#9 PM Peak
6:30 - 10:00 P.M.	#9 Off Peak
10:00 -12:00 Mid-Night	Free

Timing Plan - Week Ends:
Time of Day:

12:00 Mid-Night - 6:30 A.M.	Free
6:30 - 11:45 A.M.	#9 Off Peak
11:45 A.M. - 6:30 P.M	#5 Shopping Peak
6:30 - 10:00 P.M.	#9 Off Peak

Timing Plan - Special Events
(Specify Day of Week and Week of Year) Example - Black Friday
Time of Day:

12:00 Mid-Night - 4:30 A.M.	Free
4:30 A.M. - 10: 00 PM	#8 Special Shopping Peak
10:00 - 12:00 Mid-Night	Free

Cycle splits: The cycle split is the percent (or actual seconds) of time each phase is served, in relation to the over all cycle length. This is calculated by summing the maximum green, yellow and red time for each phase.

Phase Sequence: The phase sequence is the predetermined order the phases occur under steady demand.

Offset: This is a relational value calculated based on the speed of travel, the distance between intersections and the green time on the mainline roadway, using a time space diagram. The reference point in the phase is typically the beginning of yellow for the side street phase.

Force Off: Used to terminate side street green and is equal to the non-coordinated maximum green time (determined from time/space diagram) + coordinated phase clearance (yellow +all red) + any non-coordinated phases between this phase and the coordinated phase and their clearance

Permissive Period: Allows controller to yield if a call is placed shortly after the yield point, and is calculated by taking the non-coordinated phase force off and subtracting the sum of that phases initial + passage (minimum green time) and subtracting out the main street clearance (yellow + all red).

By example, using **Figure 6-1** below, the force off would be calculated as follows:

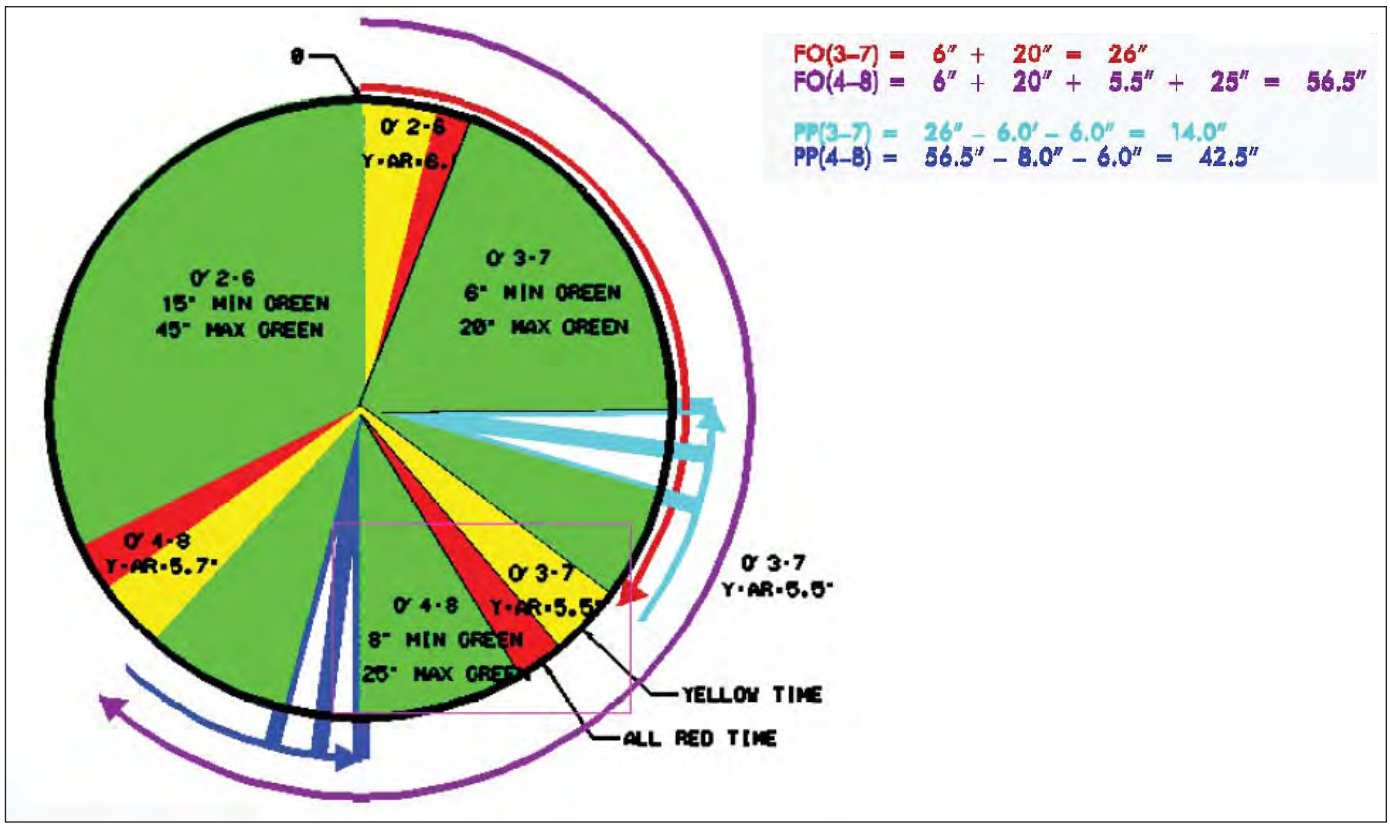


Figure 6-1
Force Off / Permissive Period Calculation

Recall - This setting can be set to "MIN" or "MAX" for the phases desired for the controller to serve, regardless of traffic demand. Typically, phases 2 and 6 are set to 'MIN' recall.

Red Revert - (0-25.5 sec..) applies to all phases that are programmed as red rest phases. This parameter insures that the phase will remain in red rest for the minimum period specified before the phase is re-serviced.

Float - Phases other than the coordinated phase(s) are active for their assigned split time only. This causes unused split time to revert to the coordinated phase.

Fixed - Phases are forced-off at fixed points in the cycle. This allows unused split time of a phase to revert to the phases served next in the sequence.

Timing Sheets

The SCDOT has timing sheets for 2070 controllers. Once Coordination is determined it is logged on these timing sheets and sent to the district signal shop for installation in the controllers. Once the signal timing has been programed for the intersection or system, there is typically a field review to determine if any timing changes need to be implemented. Below is a 2070 timing sheet with instructions:

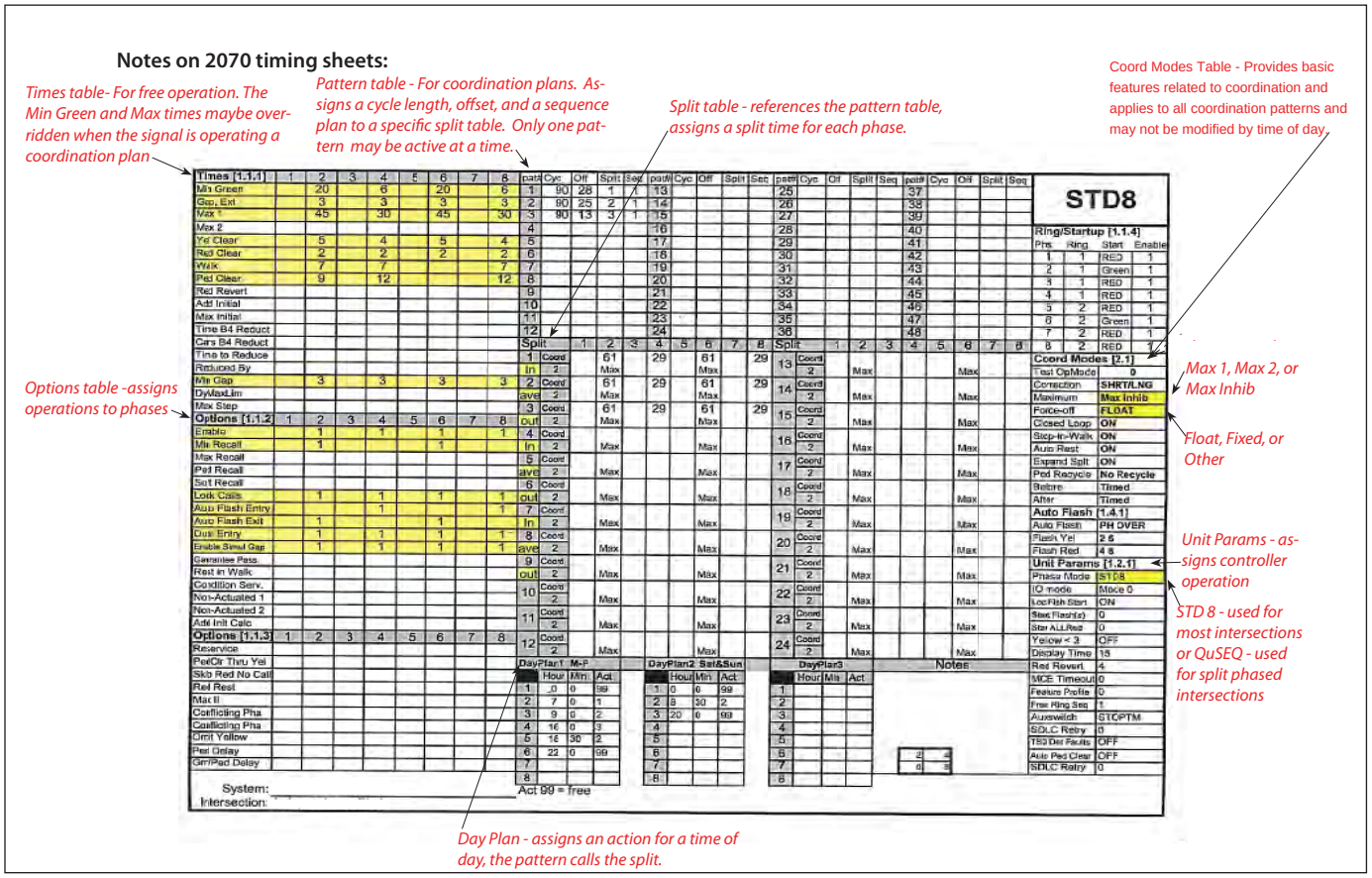


Figure 6-2
2070 Timing Sheet

Below is an example Time / Space Diagram from Synchro software.

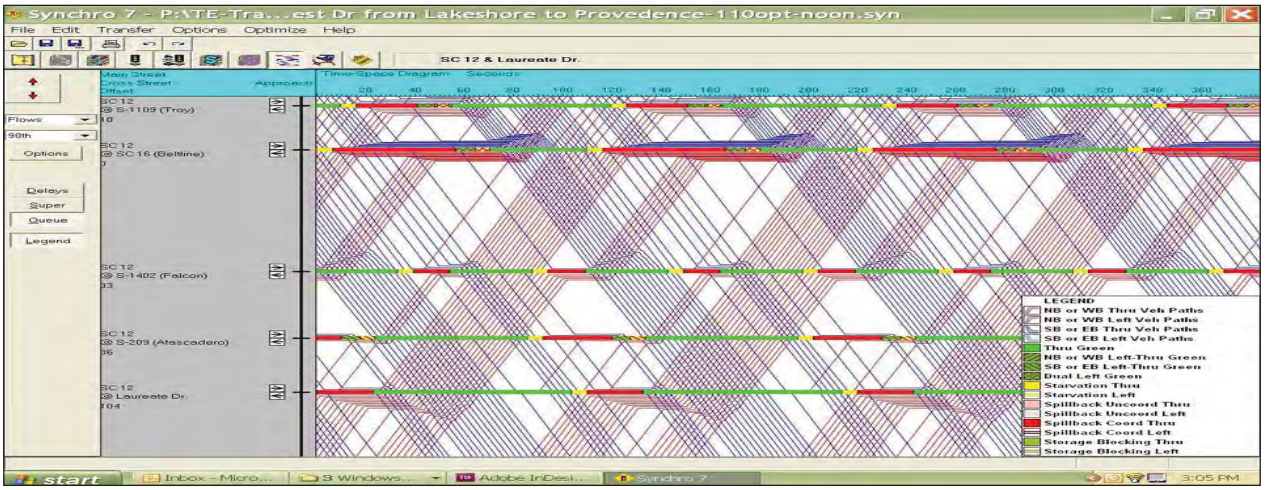


Figure 6-3
Time Space Diagram

Time Space Diagrams are a pictorial depiction of travel through a signal system where the distance between signals is represented on the vertical axis and time is the horizontal axis. The diagonal lines represent travel at a particular speed. The diagram shows where adjustments to offsets, splits and phasing can improve progression. Horizontal lines at signals indicate the backups and queuing that will occur. Synchro is a good tool to begin development of coordination timings, however field fine tuning is vital in signal system timing improvements.

NCHRP Report 812 Signal Timing Manual, 2nd Editon is a great resource for signal timing best practices.

Signal System Regional Planning

SCDOT's goal is to have a Signal System Regional Master Plan for each Metropolitan Planning Organization (MPO) area in the state. The Signal System Regional Master Plan will provide a planning document that details what type of signal system operation is appropriate. The Signal System Regional Master Plan should consist of the information listed below:

Corridor Evaluation
An evaluation of the corridor should be conducted to include documentation of traffic volumes and patterns. The study should note any factors that contribute to irregular or unpredictable traffic volumes along the corridor.

1. Time of Day Signal Timing will be considered the standard for predictable traffic volumes and splits occurring at predictable times of day and days of the week.

List of corridors	system type
Corridor Evaluation	needed improvements for equipment /communications
AADT	recommended traffic monitoring devices
# signals	general cost estimate
equipment type	possible funding sources
communications type	schedule
current signal	ranking

2. Traffic Responsive Signal Systems will be considered for corridors with predictable traffic volumes and splits that occur at unpredictable times of day and days of the week. (Corridors subject to event traffic, for example.)
3. Traffic Adaptive Signal Systems will be considered for corridors with unpredictable traffic volumes and splits or areas with sharp peaks where traffic responsive cannot adjust timing plans quickly enough to respond to the change in demand. Traffic Adaptive may also be implemented within construction projects, where patterns change due to construction phasing.

If the Corridor Evaluation indicates a need for an Advanced Traffic Signal System, either Responsive or Adaptive, the following measures should be implemented to improve traffic operations on the subject corridor to provide a basis for benefit/cost comparisons between the 3 types of signal systems.

1. The subject system must be currently operating as a coordinated signal system.
2. Operational improvements should be made at each intersection in the corridor to ensure the existing signal configurations are maximizing operation efficiency. These improvements should include:
    a. Ensure existing detection is operational and install additional if necessary
    b. Review gap times to ensure signal is operating efficiently
    c. Review phase allocation and green time served and make split adjustments for efficiency
    d. Implement Flashing Yellow Arrows for all protected/permitted left turn phases.
    e. Implement lagging left turn phases where possible.

3. Time of Day Signal Timing plans should be evaluated and field fine-tuned to ensure system operations are

optimized.

a. Adjust offsets or phase sequence to improve coordination
b. Adjust time entering or exiting coordination as necessary

Upon implementation of these measures, a determination may be made that the TOD Signal System is sufficient for operation of the corridor. If an Advanced Traffic Signal System is the better option, the following elements should be included in the implementation:

- Before /After study of delay, travel time, # stops
- Travel time devices should be installed for a minimum of 3 months prior and 3 months after to determine the effectiveness of the system. (It is recommended that these devices are installed up to a year in advance and remain at least a year after, to truly evaluate the effectiveness of the system.)
- Traffic monitoring cameras are recommended to be installed to be used to address citizen comments and concerns.

SIGNAL SYSTEM TYPE

Time of Day (TOD) Signal System

The most common type of system is the Time of Day (TOD) Signal System.

TOD Signal Systems operate specific cycle lengths, splits and offsets based on the time of the day and day of the week, based on traffic signal timing studies. TOD Signal Systems are very effective to address recurring traffic patterns for commuter or expected traffic volumes. For optimum operations, TOD signal systems should be re-evaluated on a 3 to 5 year basis, as there is not an automated way to adjust for volume changes over time. TOD signal systems also do not have a way to address unexpected traffic volumes due to incidents, weather or events.

Traffic Responsive Signal System :

A Traffic Responsive Signal System selects from a variety of pre-determined cycle lengths, splits and offsets based upon traffic volumes detected along the arterials. This allows the signal system to 'respond' to live traffic volumes and changing conditions. Traffic Responsive Signal Systems must 'transition' from one timing plan to an other and this 'transition' time generally occurs over 2 to 3 cycle lengths. This means that response time to address significant changes in traffic volumes can take 5 to 10 minutes.

This type of system minimizes stops on high speed arterial or in a grid of regularly spaced intersections by split control and cycle length selection. There are preset timing plans for specific times of day and days of week with option to go to different plans if traffic volumes reach preset thresholds.

Traffic Responsive Signal System coordination is based on a rapid reaction to sensed traffic conditions. It is an operator controlled system in that the operator can override the normal program by selecting a special timing plan from the District Office or Traffic Management Center.

Adaptive Signal Systems

An Adaptive Traffic Signal System also adjusts to changing traffic volumes and patterns. Over time, the Adaptive Traffic Signal System 'learns' from previous traffic patterns and tends to predict incoming volumes and transitions more rapidly than Responsive Traffic Signal Systems to changing conditions. Adaptive Traffic Signal Systems rely on detection to make these decisions. Adaptive systems attempt to minimize stop delay in an open network of roadways with similar characteristics by reducing cycle lengths and optimizing splits. Adaptive Timing has no specific timing plan – based on existing volumes and demands

Figures 6-4 and 6-5 give information in comparing Time of Day (TOD) Signal systems and Advanced Traffic Signal Systems (Responsive, Adaptive).

Pros	Cons
Continuously distributes green light time equitably for all traffic movements.	More detection is required
Prolongs the effectiveness of traffic signal timing.	More importance to keep detection operational
Improved response to changing traffic conditions	Advanced systems are more expensive to install
Improved response to side street traffic during majority of peak hours	SCDOT has limited experience with operating these types of systems
No requirement for re-timing study every 3-5 years	
Can improve level of service and reduce delays	

Figure 6-4
Pros and Cons of Time of Day vs Advanced Signal Systems

Type	Frequency	Monitoring Needs
Time of Day	3-5 years	(weekly monitoring)
Traffic Responsive	for 4-7 years	(daily monitoring)
Traffic Adaptive	No retiming cycle	(periodic monitoring/ more at beginning)

Figure 6-5
Frequency / Monitoring Needs for Time of Day and Advanced Signal Systems

Average Cost to Re-time Signals

- Time of day - $6,000/signal
- Traffic Responsive - $8,000/signal plus detection
- Traffic Adaptive - $15,000/signal plus detection
- Typical Benefit to Cost ratio is 40:1

Types of Adaptive Systems

Two adaptive systems have been used in SC:

In Synch adaptive (Rhythm Engineering) utilizes a processing unit that operates an adaptive system by monitoring detector inputs from the traffic controller. This adaptive system is compatible with any type of controller and software. Rhythm Engineering monitors these systems and provides 2 years' service and maintenance with the purchase of the system. There is a requirement for Ethernet communications as there are IP address- able cameras and processing unit. Adaptive systems that utilize separate processing units are the sole responsibility of the entity that maintains the signal system, or the entity that procured the funds for the adaptive signal processing units. All repairs or replacements, such as for lightning or other non-warrantied issues, will be the responsibility of the procuring entity. This expense is eligible as signal equipment under the Signal Maintenance Agreement.

Synchro Green adaptive (Trafficware) utilizes a central software that resides on the central signal server and local software that resides on each controller. SCDOT has this adaptive system on state contract. The benefits of this adaptive is the ability to run this adaptive system in the background, with live detector inputs, prior to installation in the field. This allows the engineer to 'test' the adaptive prior to field operation. Stop bar detection for each lane is required for appropriate operation of this adaptive system.

Benefits of Signal Re-timing

- Reduced travel time & fuel consumption
- Signal Re-timing costs are minimal compared to construction capacity costs, such as adding lanes
- Savings pays for total project cost within a short time frame
- Benefit to Cost ratio generally exceeds 2:1 and can be as high as 40:1

Factors that can negatively affect signal re-timing

- More than 2 signal phases reduces the amount of green time serving each phase
- Traffic signal spacing <800' can result in queueing between signals due to heavy side street volumes or > 1 mile platoons of traffic dissipate, resulting in intermittent vehicle arrivals
- Signals adjacent to free flow movements, like channelized right turns from interstates can result in queuing and merging issues
- Pedestrian recall settings, Exclusive pedestrian phases can create undue delay to side streets
- Unexpected fluctuations in traffic may overwhelm planned signal system timings
- Short auxiliary lanes often back up and block through lanes
- Defective detection results in serving maximum green times which can create undue delay

Impact of equipment and maintenance on signal timings

- Maintaining communications to signal systems is vital to signal operations and management
- Ensuring signal systems settings are appropriate for existing conditions is vital to appropriate operations
- Detection malfunctions result in phases serving maximum green times regardless of vehicle demand- this creates delay in serving phases where no cars or pedestrians are present.
- Traffic Monitoring tools such as cameras with pan/tilt/zoom capability is important for engineers to view issues remotely to assess mitigating congestion.
- Synchro Traffic Modeling software can assist engineers in applying appropriate signal system settings such as offsets, splits and phase sequencing

Synchro Traffic Modeling Software

SCDOT uses Synchro to assist in the determination of cycle lengths and splits for isolated intersections or for signal systems where coordination is needed. Synchro will yield reports concerning level of service, delay, and queuing to assist in obtaining a starting point for signal coordination. Simulation Traffic models the intersection or signal systems vehicle traffic and also has the ability to view data in 3D.

Consultants performing signal re-timing for SCDOT shall provide Synchro files detailing proposed signal timing plans.

SCDOT Synchro Defaults

The following settings are SCDOT defaults, unless directed otherwise:

Network Settings

- Peak Hour Factor – 0.90
- Yellow – 4 seconds
- Red – 2 seconds
- Offset style – Beginning of Yellow
- Minimum green time for through phases – 22 seconds
- Minimum green time for left turn phases – 15 seconds
- Simulation taper length – 100 feet
- Crosswalk width – 10 feet
- Consider Lead/Lag optimization only if no left turn trap situation
- If no system is in place set as Actuated uncoordinated; If system is in place set as Actuated Coordinated

Detector Templates

Left turn lane– Detector 1 - 0 feet from stop bar, length - 30 feet
Generally for side streets, use loops at stop bar (leading to 0)
Edit template phases – 2 Southbound, 4 Westbound or as shown on signal plan

Simtraffic

Intervals and volumes
Seed 10 min*, record 60 or record 4 15-minute intervals
* for large networks seeding should cover saturating network

All other default settings within Synchro should be used unless approved by SCDOT.

See **Figures 6-6, 6-7**, and **6-8** for example reports from Synchro. Also, see **Figure 6-9** to see a Comparison Report for Level of Service, Volume Capacity Ratio, and Delay.

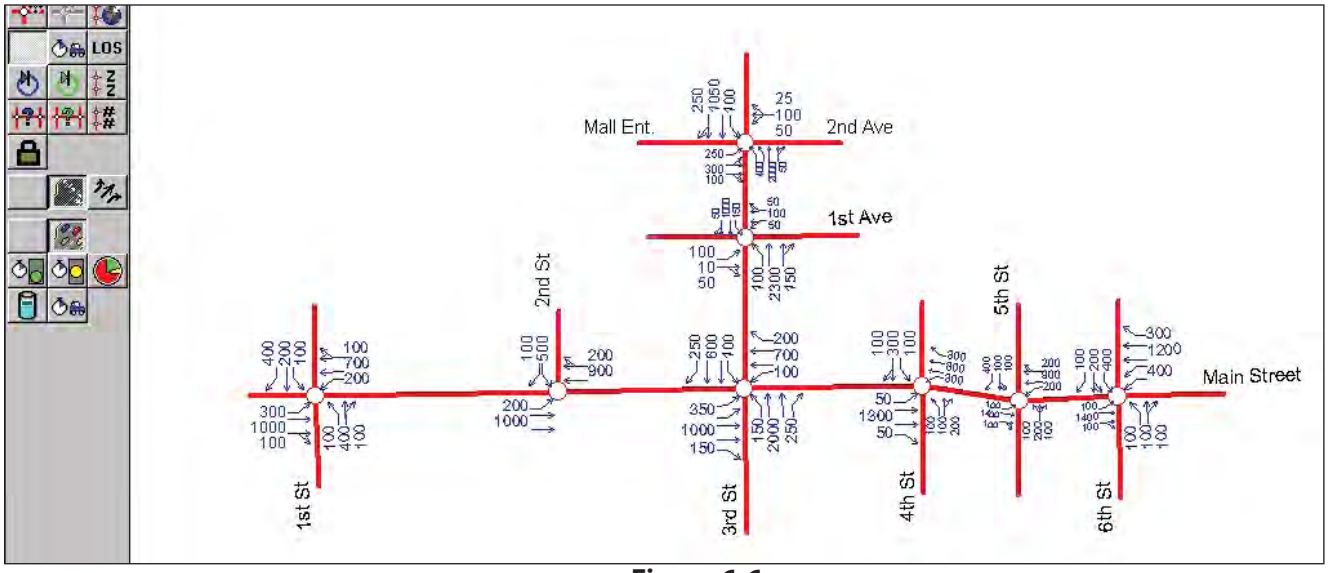


Figure 6-6
Synchro System Screen Shot

Plaza Blvd	II	40	48.2	11.0	59.2	0.52	31.5	B
Anderson Rd	II	40	17.2	36.0	53.2	0.15	10.1	F
Patriot Parkway	II	40	14.0	6.9	20.9	0.12	21.0	D
Riverview Road	II	40	20.8	8.7	29.5	0.18	22.0	C
Total	II		440.2	192.2	632.4	4.15	23.6	C

Arterial Level of Service: WB Cherry Rd

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS

Figure 6-7
Synchro Level of Service Report Screen Shot

Lanes, Volumes, Timings
38: Albright Road & Main Street

Rock Hill CMAQ System Timing
Albright - 2006 Midday

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	48	644	37	28	647	165	17	19	23	158	26	54
Satd. Flow (prot)	1770	3511	0	1778	3557	1591	0	1705	0	1698	1725	1599
Flt Permitted	0.386			0.364						0.950	0.965	
Satd. Flow (perm)	719	3511	0	681	3557	1591	0	1705	0	1698	1725	1599
Satd. Flow (RTOR)		8				165		23				54
Adj. Flow (vph)	48	644	37	28	647	165	17	19	23	158	26	54
Lane Group Flow (vph)	48	681	0	28	647	165	0	59	0	92	92	54
Turn Type	Perm			Perm		Perm	Split			Split		Perm
Protected Phases		6			2		3	3		4	4	
Permitted Phases	6			2		2						4
Detector Phase	6	6		2	2	2	3	3		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		15.0	15.0	15.0	8.0	8.0		8.0	8.0	8.0
Minimum Split (s)	21.0	21.0		22.0	22.0	22.0	13.5	13.5		14.3	14.3	14.3
Total Split (s)	40.0	40.0	0.0	40.0	40.0	40.0	25.0	25.0	0.0	25.0	25.0	25.0
Total Split (%)	44.4%	44.4%	0.0%	44.4%	44.4%	44.4%	27.8%	27.8%	0.0%	27.8%	27.8%	27.8%
Yellow Time (s)	3.6	3.6		3.6	3.6	3.6	3.3	3.3		3.8	3.8	3.8
All-Red Time (s)	2.4	2.4		3.4	3.4	3.4	2.2	2.2		2.5	2.5	2.5
Lost Time Adjust (s)	-2.3	-2.3	0.0	-2.3	-2.3	0.0	-2.3	-2.3	0.0	-2.3	-2.3	0.0
Total Lost Time (s)	3.7	3.7	4.0	4.7	4.7	7.0	3.2	3.2	4.0	4.0	4.0	6.3
Lead/Lag							Lead	Lead		Lag	Lag	Lag
Lead-Lag Optimize?												
Recall Mode	C-Max	C-Max		C-Max	C-Max	C-Max	None	None		None	None	None
Act Effct Green (s)	61.6	61.6		60.8	60.8	59.0		11.0		12.8	12.8	10.5
Actuated g/C Ratio	0.68	0.68		0.68	0.68	0.66		0.12		0.14	0.14	0.12
v/c Ratio	0.10	0.28		0.06	0.27	0.15		0.26		0.38	0.37	0.23
Control Delay	7.0	6.2		6.9	6.2	1.0		27.3		38.9	38.7	12.5
Queue Delay	0.0	0.0		0.0	0.0	0.0		0.0		0.0	0.0	0.0
Total Delay	7.0	6.2		6.9	6.2	1.0		27.3		38.9	38.7	12.5
LOS	A	A		A	A	A		C		D	D	B
Approach Delay		6.2			5.2			27.3			32.9	
Approach LOS		A			A			C			C	

Intersection Summary
Cycle Length: 90
Actuated Cycle Length: 90
Offset: 0 (0%), Referenced to phase 2:WBTL and 6:EBTL, Start of Yellow, Master Intersection
Natural Cycle: 50
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.38
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 53.8% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 38: Albright Road & Main Street

Figure 6-8
Synchro Lanes, Volumes, Timings Report Screen Shot

Lexington (32) - Bush River Rd

AM

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3
Bush River Road @	90	90	100	110	90	90	100	110	90	90	100	110
Outlet Point Blvd	C	C	C	B	0.74	0.86	0.78	0.78	25.7	22.9	21.3	19.7
Berryhill Rd	D	B	B	B	1.15	1.15	1.32	1.38	36.7	13.7	14.1	15.3
I-20 WB Ramp	B	C	C	C	1.15	1.15	1.32	1.38	19.7	30.1	26.3	21.8
I-20 EB Ramp	C	B	B	B	1.06	0.86	0.83	0.82	29.3	14.8	15.8	17.7
Independence Blvd	C	A	A	A	0.67	0.71	0.67	0.65	21.3	7.6	6.7	6.6

Average

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3
Bush River Road @	90	90	100	110	90	90	100	110	90	90	100	110
Outlet Point Blvd	B	B	B	B	0.61	0.61	0.59	0.57	19.1	14.6	14.6	13.6
Berryhill Rd	B	B	A	B	0.98	0.70	0.59	0.56	19.5	10.3	9.8	11.1
I-20 WB Ramp	B	B	B	B	0.98	0.70	0.59	0.56	18.6	13.6	13.5	13.6
I-20 EB Ramp	A	A	A	A	0.46	0.42	0.57	0.54	8.3	6.6	5.4	5.6
Independence Blvd	B	A	B	B	0.49	0.43	0.72	0.62	11.7	8.1	17.0	14.9

PM

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3
Bush River Road @	90	80	90	100	90	80	90	100	90	80	90	100
Outlet Point Blvd	B	B	B	B	0.58	0.59	0.58	0.56	13.2	14.2	13.8	16.2
Berryhill Rd	D	B	B	B	1.06	0.94	0.94	0.91	46.7	11.8	13.3	14.9
I-20 WB Ramp	C	C	C	D	1.06	0.94	0.94	0.91	27.5	28.4	33.0	42.2
I-20 EB Ramp	C	A	B	B	0.84	0.76	0.76	0.75	22.9	9.6	10.7	11.5
Independence Blvd	B	B	B	A	0.72	0.63	0.61	0.57	15.7	11.8	10.1	8.0

Other

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3	Original	Cycle1	Cycle2	Cycle3
Bush River Road @	90	80	90	100	90	80	90	100	90	80	90	100
Outlet Point Blvd	B	B	B	B	0.52	0.53	0.51	0.50	13.2	14.1	12.9	13.9
Berryhill Rd	C	A	A	A	0.75	0.63	0.62	0.64	22.1	6.3	6.8	6.0
I-20 WB Ramp	C	B	B	B	0.75	0.63	0.62	0.64	22.6	11.6	11.5	13.5
I-20 EB Ramp	A	A	A	A	0.45	0.42	0.42	0.56	9.7	7.7	8.7	5.3
Independence Blvd	B	A	A	B	0.44	0.40	0.37	0.62	11.1	9.6	9.3	13.9

File: lependence
Designed By:
Date Submitted: 39626

Figure 6-9
Synchro Level of Service, Volume to Capacity Ratio, Delay Comparison Report

Task 3 Signal Timing - 1-5 Intersection (per Intersection)		
Task 4 Signal Timing - 6-10 Intersection (per Intersection)		
Task 5 Signal Timing - 11+Intersection (per Intersection)		
The purpose of this Task is to provide optimized traffic signal timings for intersections as directed by the Department. Although task order is per intersection, cost per intersection shall be categorized by systems with (0-5) (6-10) and (11 plus) intersections		
#	**Project Tasks**	**Task Description**
1	Project Management	The ***CONSULTANT*** will manage the project to conform to the **SCDOT** requirements for monitoring and controlling the engineering budget, project schedule and invoicing procedures. The ***CONSULTANT*** shall provide project management for all of the tasks detailed below including the submission of monthly invoices and progress reports to the **SCDOT**. The ***CONSULTANT*** will assign a Project Manager to serve as the primary contact for communications with the **SCDOT** Add identify and review with SCDOT staff, project issues, expectations, goals, and objectives for each task orders. Up to 3 meetings may be required, including kick-off meeting.
2	Traffic Counts	***CONSULTANT*** will provide to SCDOT a Memo containing the following proposed information: 1. Proposed Count Locations for 24 hour directional counts, up to 4 per signal system. 2. Proposed Count Locations and schedule for 8 hour turning movement counts, up to 2 per signal. Counts will be ordered after approval of proposed locations and time frames has been received from SCDOT.
	Methodology report	The Consultant will develop a traffic signal Methodology Report containing the following data: 1. Field Data Collection Methodology. 2. Traffic Flow observations made in the field. 3. Specific local conditions or preferences for timing development. 3. Methodology for calculating pedestrian and vehicular clearance intervals if desired. 4. Signal Analysis software to be used. 5. Methodology for conducting and routing preferences of the Before and After Studies.
3	Inventory & data collection report	The ***CONSULTANT*** will create a Data collection report consisting of the following data (can be submitted electronically): 1. Directional count data in graphical and tabular format. 2. Intersection sketches. 3. Current District/Municipality timing preferences. 4. Existing Count data.* 5. Existing timing data.* (databases and/or Synchro files) * When available, existing timings and/or count data will be provided to the ***CONSULTANT*** to aid in timing effort.
4	Timing Plan Development	**Preliminary Assessment:** Prior to beginning the development of the signal timing plans, the ***CONSULTANT*** will evaluate the operations of all project intersections to determine any operational and/or geometric changes that would benefit the overall system operations. Additionally, the assessment will also include preliminary recommendations and cycle lengths. The preliminary assessment will be submitted in memo form and will consist of the following: 1. Intersection inventory diagrams
		2. Proposed number of timing plans up to 6. 2. Proposed cycle lengths. 3. Proposed Clearance Intervals. 4. Recommended time-of-day for each plan's time periods. 5. Recommended day-of-week for each plan's time periods. 6. Master Controller databases (if applicable) 7. Local Controller Timing Sheets. 8. Capacity Analysis. 9. Turning movement counts 10. Preliminary Assessment Include evaluation of existing equipment and plan testing process 11. Development of timing plans will begin after the approval of proposed clearance intervals has been received from SCDOT. 12. Consultant will make recommendations concerning what type signal system would be most effective-TOD, responsive or Adaptive. **Development of Base System Timing Plans:** The ***CONSULTANT*** will prepare timing plans for systems using SYNCHRO version 7 and develop up to six (6) separate time-of-day plans. The ***CONSULTANT*** will submit the Synchro output sheet's, the Synchro files, and the timing plan development methodology for **SCDOT** review and approval. Time space diagrams will be developed in Synchro and submitted with the timing plans for review. Based on the results of SCDOT's review, the ***CONSULTANT*** will finalize the Synchro timings. Once finalized, the ***CONSULTANT*** will export the files for importing into ATMS for SCDOT maintained signals.
5	Implementation and Fine Tuning of Signal Timing Plans	Proposed timing plans will be loaded and tested in the signal shop by the District signal shop or local government signal maintainer with the Consultant. After successful testing a time shall be established for field implementation; Consultant shall be present in the field during field implementation. The ***CONSULTANT*** will begin to fine tune each system for each time-of-day plan. During the fine tuning, the ***CONSULTANT*** will make recommendations for timing adjustments that will be made in the controllers by the District or local government signal staff.

Figure 6-10
Signal Re-timing Scope of Services

CHAPTER 7

CONSTRUCTION

SCDOT

Roadway Improvement Projects -

- **Construction Letting - Design-Bid-Build** - Signal construction can occur within roadway improvement projects. The ***Signal Letting Package*** includes signal plans, pay items and estimated quantities and Signal Specifications should be included in the plan set for Design, Bid, Build project.
- **Request for Proposal Selection/Award- Design-Build** - For Design-Build projects, Design-Build Signal Scope (See **Chapter 4**) should be included in Design-Build RFP that detail all requirements and standards addressing the signal design and construction. Design-Build Team consists of Construction and Engineering companies to provide a turn-key project.

Resurfacing Projects -

Signal construction, consisting mainly of detection replacement and temporary detection occurs in Resurfacing Projects. Signal specifications for Resurfacing Projects should be included to detail all requirements for maintaining signal operations and detection during the resurfacing project.

- Temporary detection will be required for signals operating an advanced signal system.
- For resurfacing projects on roadways with high volumes (see Traffic Signal Special Provisions - Resurfacing), the contractor shall have two weeks to replace detection or temporary detection will be required.
- For resurfacing projects, where milling operations result in damage to detection on low volume roadways the contractor shall coordinate with the District Traffic Engineer to determine the schedule for detection replacement.

Encroachment Permit Projects -

Signal construction can occur within encroachment permit projects, funded by locals or private entities. SCDOT staff shall review signal plans, quantities and specifications to ensure that signal construction documents meet all SCDOT standards.

Local governments and / or private developers may perform signal work under an approved encroachment permit. The encroachment permit should include the following language:

The below special provisions are included for all permits that require signal work:

1. Contractor shall notify SCDOT District Signal Shop 48 hours prior to the start of signal work; SCDOT shall review and have approval authority concerning the contractor schedule. No signal work shall commence without SCDOT signal inspectors present.
2. Contractor shall ensure vehicle detection is maintained operational during signal work. Any disruption of or damage to existing traffic signal loops shall be repaired immediately. Coordinate with SCDOT District Signal Shop for specific requirements.
3. Contractor shall return existing signal equipment that is removed/no longer necessary as a result of the proposed improvements to SCDOT District Signal Shop. Permittee is responsible for ensuring the equipment is returned to SCDOT.
4. Equipment and materials for traffic signal equipment shall be in accordance with SCDOT Traffic Signal Material Specifications, latest edition. Invoices for all equipment and materials shall be provided to SCDOT.
5. Installation procedures and requirements for traffic signals shall be in accordance with SCDOT Traffic Signal Supplemental Technical Specifications, latest edition.
6. Contractor shall coordinate with existing utilities with regards to pole and conduit locations. The Contractor shall be responsible for verifying the location of existing utilities both horizontal and vertical.
7. SCDOT shall review and approve all traffic signal equipment catalog cuts and shop drawings.
8. Contractor shall have staff with minimum IMSA Level II Technician on site at all times during construction.
9. All traffic signal costs for design, equipment and installation are the responsibility of the permittee. Application for electric service shall be in accordance with SCDOT Engineering Directive T2. SCDOT will generally take over ongoing operation and maintenance of the signal upon final inspection and acceptance.
10. Permittee shall provide electronic copies of both the Synchro traffic signal analysis and the CADD plan showing the final traffic signal design to the DTE office, as well as a sealed PDF.
11. Contractor shall maintain and repair any damage to signals, in accordance with General Provisions in SCDOT Traffic Signal Supplemental Technical Specifications, latest edition. Penalties will be applied if contractor does not comply with these requirements.
12. Integration of the controller and cabinet will generally be performed by SCDOT or local governmental

agency maintaining the signal. SCDOT reserves the right to require the permittee to perform integration in accordance with manufacturers standards.Permittee shall coordinate with District Signal Supervisor 2 weeks prior to cabinet installation to ensure scheduling is not an issue.

13. Traffic Control during signal installation shall be in accordance with SCDOT Traffic Signal Special Provisions – Traffic Control.
14. If signal work is within Railroad Right of Way, signal installation shall be in accordance with SCDOT Traffic Signals @ Railroads Special Provisions. All costs associated with Railroad permits, flagging, insurance or improvements/ construction is the responsibility of the Permittee.

Signal Improvement Projects -

- **Construction Letting - Design-Bid-Build -** These projects consist on only signal improvements and possibly sidewalk, curb ramp median or island improvements (to accomodate pedestrian treatments). Signal projects are awarded to a contractor based on competitively low bid process. Awarded work consists of a contractual relationship between SCDOT and licensed contractor in which contractor is responsible for the construction of new signals or improvements to signals, based on the contract documents.

  The ***Traffic Signal Letting Package*** includes signal plans, pay items, estimated quantities and Signal Specifications. See more information on the Traffic Signal Letting Package in **Chapter 4**.

- **Work Order Assignment -** SCDOT has a fixed price services contract in place for signal construction/maintenance activities. The contacts can be found online at ***Procurement Services*** using SCEIS search engine with reference 'traffic signal'. Over 250 pay items are available to provide adequate resources for signal work. Over 10 signal contractors are available to perform signal work. Work should be assigned and managed in accordance with TG 35 Business Rules for District Traffic Signal Shop Operations

- ***I*n house Signal Construction -** Some district and local government signal maintainers perform signal construction activities rather than using a service contract. The benefit of staff performing construction is that they stay current on installation and construction methods and in many cases, available funding can accomplish more work. The cons are that existing staffing limits the amount of crews available to perform maintenance, inspection and construction. If a signal emergency occurs, the signal crew must leave the construction activity and attend to the emergency. In addition, all traffic control is the responsibility of SCDOT.

Construction Letting Award

Bid Reviews

Bids are reviewed by SCDOT Construction office and the Traffic Signal Project Manager for consistency with SCDOT cost estimates. If bid prices are reasonable, a recommendation is made to award the project to the lowest responsible bidder. .

Award

The Construction staff notifies the constractor of the award. The contracts are managed out of the District Construction Office with an assigned construction manager. The awarded contractor is responsible for contacting the District construnction office to set up the Pre-Construction Conference. Until this conference is held, a Notice to Proceed (NTP) cannot be given. The Length of the Contract begins upon award, so it is vital that the contractor coordinates with the SCDOT construction manager as soon as possible to avoid running out of time on the project.

Pre-Construction Conference

The Pre-Construction Conference includes the following individuals:

- Contractor,
- SCDOT district personnel (construction, traffic, utility, maintenance),
- SCDOT HQ Signal Project Manager,
- Affected utilty company representatives

The agenda for these meeting include discussion of the following:

- Schedule
- Traffic Control Plan
- Sub-Contractor paperwork for approval
- Material / Equipment Submittals/ Concrete Mix Design
  Any signal equipment provided by the contractor must be listed on the QPL. If the signal equipment is not on the QPL, submittals must meet SCDOT specifications.

EEO Policy and Employee wage interviews / Certified Payroll

- Contact information for emergency signal maintenance
- Damage Claims
- Appropriate licensing for contractor and for working within certain municipalities
- Notice to Proceed (NTP) date

Other items that may be discussed:

- General description of work
- Utility Coordination
- Point of contacts for Inspection
- Testing Requirements
  - Concrete
  - Fiber OTDR
- Invoicing / Quantities

Qualified Signal Contractors

The qualifications for signal contractors is listed in 675.0 General Provisions. Links to standard licensing entities are below:

- NEMA / NEC / NESC / IES/ ANSI
- IMSA
- SC Contractors Licensing

In addtion, all SCDOT contractors are required to complete an advanced work zone traffic control training, in accordance with Work Zone Traffic Control Training Guidelines for Contractors.

Currently, SCDOT requires IMSA (International Municipal Signal Association) Level 2 Signal Certification for all signal maintainers and signal contractors. SCDOT has plans to provide a training course for Signal Construction and Signal Construction Inspection, specific to SCDOT specifications and construction methods. This training course will be administered by an outside entity. This training will be available for SCDOT employees, local government signal maintainers, consultants and contractors.

Typical Construction Process

SCDOT cannot direct the signal contractor concerning means and methods, however, below is the typical order of signal construction:

- Order equipment, materials
- Mark utilities, right of way, get power turn-on scheduled/determine location for disconnect
- Install curb ramps if applicable
- Install pole foundations, cabinet foundations
- Install steel poles
- Install detection
- Install conduit, junction boxes (ensure sufficient for fiber, ped poles, loops)
- Install meter and cabinet
- Run Wire for detection
  - Underground - In conduit
  - Overhead - On messenger
- Install span wire, signal heads (bagged), overhead sign brackets
- Install pedestrian poles, heads, buttons
- Run wire for signal heads, install signs, ped heads, ped buttons
- Install pavement markings

For new signal installations

- Place the signal in flashing mode and flash for at least 3 and not more than 7 days prior to full signal operation. In the event where signalized intersections are replaced with new equipment, there is no mandatory flash period required.
- For new signals erect "Signal Ahead" signs (MUTCD W3-3) on all approaches with a "NEW" plaque above the signs on the day the signal is to be placed in stop and go operation,. Supplement the "Signal Ahead" signs with orange flags to draw attention to the signs. Remove the "Stop" signs from the side street and "Stop Ahead" signs if applicable, when the signal is placed into operation.
- Place the signal into operation on a normal workday, after the morning peak hour and prior to the afternoon peak hour.
- Remove the flags or flashers and the "NEW" plaques approximately two months after the signal is placed in operation.

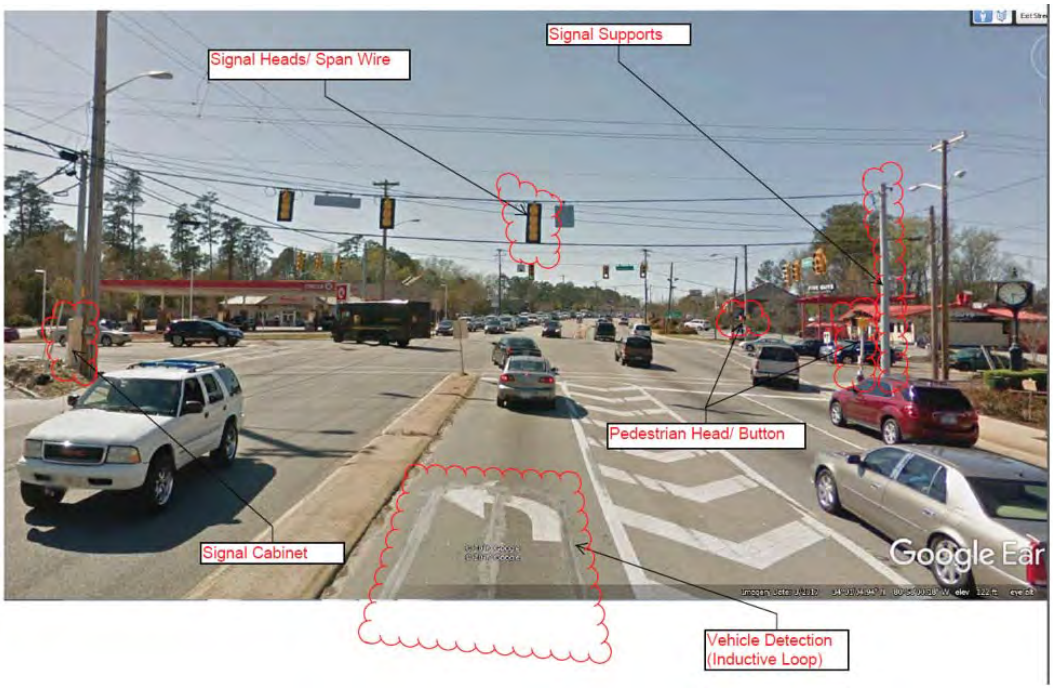
Maintaining Signal Operation during Construction

Detection

In accordance with the General Provisions in the Traffic Signal Supplemental Technical Specifications, detection should be maintained as incidental for construction projects involving traffic signals. Any damage to detection shall be repaired or temporary detection should be installed. Lane shifts, closures that impact detection should be planned for by revising signal timings and installing temporary detection.

Communications

Signal communications damaged during construction shall be repaired immediately in accordance with the Traffic Signal Supplemental Technical Specifications, General Provisions.



Signal Inspection

SCDOT Construction staff performs construction management and inspection services for all let projects. A Construction Engineering Services consultant may be obtained to perform this service. Construction staff coordinates with SCDOT Signal Maintenance staff to obtain their special inspection services for all signal construction. Local Governments maintaining signals for SCDOT may also perform signal inspection services.

SCDOT Signal Maintenance staff or Local Government Signal Maintenance staff is responsible for inspecting signal construction utilizing the Fixed Price On Call Signal Services contracts and Encroachment Permit projects.

An example Punch List is shown in **Figure 7-1**.

Common Construction Mistakes

- Splicing in conduit – not allowed
- SCDOT requires continuous electrical cable runs between
  - Signal heads and cabinet
  - Pedestrian heads and cabinet
  - Splice box @ loop and cabinet
    - Splice 1 conductor loop wires to 4/8 conductor electric cable in splice box
  - Pedestrian Buttons and cabinet
- Grounding
  - Signal poles, cabinet, electric service, pedestrian poles are not bonded for one grounding system
  - Ground rod is missing (not installed)
  - Grounds are not bonded properly
- Signal Heads
  - Proper Aiming
  - Tightening of signal supports
- Signal Pole
  - Missing handhole covers
- Conduit
  - Not enough provided

Contractor Review Rating

Signal inspectors should report signal contractor performance based on the following criteria:
(Form for Projects with SWKC Date ON or AFTER (1/01/08)

1. Project Closeout Activities
2. Public Relations
3. Rework
4. EEO, Davis Bacon Act and DBE compliance
5. Coordination and Cooperation with other Contractor(s) Utilities, and Railroads

Signal Flashing Operations during Construction Activities

Standard:

The MUTCD (Section 6F.07 Regulatory Sign Applications) requires that traffic signals be placed in flashing operation when construction personnel are flagging the intersection as part of construction activities. The South Carolina Code of Laws (Section 56-5-90) stipulates that only law enforcement can supersede signal control of traffic.

Policy:

When construction personnel are controlling traffic flow through signalized intersections With flagging operations, the Resident Construction Office overseeing the work shall be responsible for ensuring the intersection traffic signal is placed in flash and returned to normal operation at the conclusion of flagging operations. At no time is the signal to be left unattended in flash mode. The person responsible for placing the signal in flash must remain in the activity area until the signal has been returned to normal operation.

Procedure:

The Resident Construction Office overseeing the construction activities shall be responsible for ensuring the intersection traffic signal is placed in flash and returned to normal operations at the conclusion of flagging operations through the intersection. See Standard Drawings Section 610. One of following procedures shall be used by the District Office to comply with the standard and policy:

Option 1: Contractor Pay Item

Projects with activities that will impact signal operation and loop detection during the construction operation will have a pay item of (6885993 - Temporary Adjustment of Traffic Signal Equipment - EACH) included. Under this pay item, the signal contractor or subcontractor will place the signal in flash according to requirements and under the oversight of the Resident or SCDOT Signal Technician. The contractor will return the intersection to normal operation at the conclusion of flagging operations through the intersection.

Option 2: SCDOT Signal Staff

The SCDOT signal shop will be notified of the project work and a SCDOT Signal Technician will oversee and conduct the flashing operations in coordination with the Contractor.

Option 3: Resident Construction Office

The Resident Construction Office overseeing the project will used trained SCDOT construction staff to place the intersection in flash and return the intersection to normal operation at the conclusion of flagging operations through the intersection. The training requirements are detailed below:

SCDOT Construction Staff Training Requirements:

Designated inspectors will be trained by the District Traffic Signal Shop. Training will include the proper means to place a signal in flash and return to normal operation as well as procedures to follow in the event a problem is encountered. Training will last no more than two hours.

The appropriate Resident Construction Office will maintain the keys to the traffic signal police panels. Only those personnel who have been trained to operate the traffic signal will be permitted to check out the traffic signal keys and perform this operation.

Documentation required for all options:

The Resident Construction Office will notify the District Traffic Signal Shop in advance of plans to place intersections in flash and provide the District Traffic Signal Shop with contact information for the responsible party. The Resident Construction Office will be required to keep a log of intersections placed in flash for construction activities to include the time placed in flash, time returned to normal operation and responsible party. This log shall be e-mailed to the Traffic Signal Shop Supervisor at the end of each day during which signals have been placed in flash during construction activities.

SIGNAL PROJECT:_____
INTERSECTION:_____
_____
INSPECTION DATE:_____

South Carolina Department of Transportation

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TRAFFIC SIGNAL PUNCH LIST

Inspection Performed by _____

	CABINET	NO	YES	N/A
1	CABINET TESTING COMPLETED. THREE DAY ☐ SEVEN DAY ☐	☐	☐	☐
2	SIGNAL CABLE SLACK PROVIDED, NEATLY COILED AND BOUND WITH NYLON TIE	☐	☐	☐
3	LOOP LEADIN INSTALLED PROPERLY WITH SLACK AND LABELED IN BACK OF CONTROLLER	☐	☐	☐
4	CABLES LABELED WITH NYLON CABLE MARKERS IN INK AT CABLE END	☐	☐	☐
5	COMMUNICATION WIRE SHIELDING GROUNDED AT EACH CABINET	☐	☐	☐
6	GROUNDING BUSHINGS CORRECT AND INSTALLED PROPERLY ON RIGID CONDUIT	☐	☐	☐
7	CONDUIT ENDS 'DUCT-SEALED' IN ALL POLES, CONTROLLERS, AND BUILDINGS	☐	☐	☐
8	LOOP DETECTOR AMPLIFIERS INSTALLED, LABELED AND TUNED CORRECTLY	☐	☐	☐
9	CABINET GROUNDED PROPERLY AND EXOTHERMICALLY WELDED	☐	☐	☐
10	BASE MOUNT CABINETS INSTALLED CORRECTLY, PLACED ON BEAD OF CAULK AND BOLTED DOWN	☐	☐	☐
11	POLE MOUNT CABINET ATTACHED PROPERLY TO POLE	☐	☐	☐
12	SERVICE WIRES ATTACHED PROPERLY AND LUGS TIGHT	☐	☐	☐
	POLES			
13	WOOD POLES INSTALLED PROPERLY	☐	☐	☐
14	BACK GUYS INSTALLED PROPERLY	☐	☐	☐
15	GUY GUARDS INSTALLED	☐	☐	☐
16	STEEL POLES INSTALLED PROPERLY WITH ALL ATTACHED HARDWARE IN PLACE (POLE CAP,PLUGS,HANDHOLE COVERS)	☐	☐	☐
17	STEEL POLE FOUNDATIONS TO SPEC.	☐	☐	☐
18	CONCRETE POLES INSTALLED PROPERLY WITH ALL ATTACHED HARDWARE IN PLACE (PLUGS,HANDHOLE COVERS)	☐	☐	☐
19	RISERS ATTACHED TO POLES CORRECTLY WITH STRAPS OR CLAMPS AT 3' O.C. WITH ALL FITTINGS COMPLETE	☐	☐	☐
20	POLE GROUNDS BONDED TO GROUND SYSTEM	☐	☐	☐
	ELECTIRCAL SERVICE			
21	ELECTRIC SERVICE INSTALLED PROPERLY AND EXOTHERMICALLY WELDED	☐	☐	☐
22	EARTH GROUND SYSTEM MEASURED AND RESULTS PROVIDED TO SCDOT	☐	☐	☐
23	PROPERLY BONDED	☐	☐	☐
	PEDESTRIAN HEADS, BUTTONS, SIGNS AND POLES			
24	PEDESTRIAN PUSH BUTTON AND SIGNS INSTALLED TO PROPER HEIGHT AND DIRECTION (36" to 42" to button)	☐	☐	☐
25	PEDESTRIAN SIGNAL HEADS INSTALLED TO PROPER HEIGHT AND AIMED CORRECTLY (9' to 10' to bottom of ped head)	☐	☐	☐
26	PED POLES WITH HEADS SHALL BE BONDED PER SPECIFICATION	☐	☐	☐
27	PED POLE FOUNDATION INSTALLED CORRECTLY WITH BASE ATTACHED AND BONDED	☐	☐	☐
	ELECTRICAL AND STEEL CABLE			
28	CABLE ENDS ATTACHED TO POLES PER SPECS. AND PROPERLY BONDED	☐	☐	☐
29	ALUMINUM TIE WRAP AT 10" O.C. SPACING	☐	☐	☐
30	PROPER SAG AND CABLE SEPARATION TO SPEC. AND ELECTRICAL CODES	☐	☐	☐
31	SIGNAL CABLE RUNS SPLICE FREE	☐	☐	☐
	SIGNAL HEADS			
32	VEHICLE SIGNAL HEAD WITH ALL HARDWARE INSTALLED AND AIMED PROPERLY	☐	☐	☐
33	PROPER VERTICAL HEAD CLEARANCE PROVIDED	☐	☐	☐
34	SYMBOLIC LED BLANK OUT MESSAGE SIGN INSTALLED PROPERLY	☐	☐	☐
35	8" DRIP LOOPS AT ALL OVERHEAD ENTRANCE POINTS	☐	☐	☐
	COMMUNICATIONS			
36	COMMUNICATION MESSENGER INSTALLED PROPERLY AND BONDED	☐	☐	☐
37	FIBER OPTIC CABLE AND FUSION SPLICES TESTED AND WRITTEN OTDR REPORTS PROVIDED TO SCDOT PER SPECIFICATION	☐	☐	☐
38	FIBER OPTIC INSTALLED CORRECTLY WITH OPTIMAL STORAGE FOR ACCESSING SPLICE ENCLOSURES	☐	☐	☐
39	RADIO COMMUNICATIONS INSTALLED PROPERLY	☐	☐	☐

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	CONDUIT AND JUNCTION BOXES	PAGE 2		
40	CONDUIT SCHEDULE 80 OR APPROVED EQUAL	☐	☐	☐
41	PULLING LINE CORRECT AND INSTALLED IN ALL UNDERGROUND CONDUIT	☐	☐	☐
42	WARNING TAPE CORRECT AND INSTALLED IN CONDUIT TRENCHES	☐	☐	☐
43	TRENCHING AT PROPER DEPTH AND SURFACE RESTORED	☐	☐	☐
44	TRENCHING WITH SAWCUT TO SPEC.	☐	☐	☐
45	BORE AND JACK CORRECT	☐	☐	☐
46	CONDUITS MARKED WITH A 'X' UNDER CURB, SIDEWALK AND IN FOUNDATION (SPARES)	☐	☐	☐
47	CONDUIT JUNCTION BOXES BURIED AT 18"	☐	☐	☐
48	PULL/SPLICE BOXES INSTALLED CORRECTLY ON TOP OF 12" OF AGRIGATE	☐	☐	☐
	LOOPS INSTALLED PROPERLY			
49	LOOPS INSTALLED PROPERLY (SAWCUTS NO CLOSER THAN 12" AND DEPTH PER SPECIFICATION)	☐	☐	☐
50	SPLICES MEET SPECS.	☐	☐	☐
51	MEGGER AND INDUCTANCE TEST PERFORMED AND RESULTS PROVIDED TO SCDOT	☐	☐	☐
52	CABLE RUNS SPLICE FREE	☐	☐	☐

Figure 7-1
SCDOT Example Punch List Form

Construction Project Completion / Closure

The District Construction Project Manager initiates the closure of the construction project upon substantial completion and acceptance of the project.

Fixed price On Call Signal Services Contract

The Fixed Price On Call Signal Services Contract is a SCDOT procurement contract with over 250 pay items. For work estimated at less than $50,000, District signal staff selects a contractor on a rotation basis from a list of contractors who have signed on to work in that District. For work estimated to be over $50,000, District signal staff contacts 3 contractors to provide their best 'bid' on the work. Selection of the contractor is based on availabiltiy and cost.

Mobilization and Traffic Control is a percent of the total cost of the work order. Pay items for Directional boring, fiber optic cable installation, concrete and asphalt work as well as marking and lighting work are included. Typically these pay items are provided by sub-contractors to the signal contractor.

The Fixed Price On Call Signal Services Contract is not only useful for planned signal improvements, but is also vital in performing emergency repairs and maintenance work on traffic signals.

State On-Call Traffic Signal Cost Estimate Sheet

12/6/2018

Contractor:
Contract #:
Vendor #:
Project Location & Work Order #:
Expected Completion Date:

SCDOT Fixed Price On-Call Contract, effective 7/7/2014- 7/6/2018, change order #3 effective 1/2018 Click here to see contract.

LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
675.1 ELECTRICAL CONDUIT								
7	6750181		LF	$10.00	$0.00			FURNISH & INSTALL 1" ALUMINUM CONDUIT
8	6750182*		LF	$12.00	$0.00			FURNISH & INSTALL 2" ALUMINUM CONDUIT
9	6750005		LF	$12.52	$0.00			FURNISH & INSTALL 1.0" GALVANIZED RIGID CONDUIT
10	6750015		LF	$15.02	$0.00			FURNISH & INSTALL 2.0" GALVANIZED RIGID CONDUIT
11	6750025		LF	$18.79	$0.00			FURNISH & INSTALL 3.0" GALVANIZED RIGID CONDUIT
12	6750085		LF	$20.81	$0.00			FURNISH & INSTALL 2.0" GALV. RIGID CONDUIT (BORED AND JACKED)
13	6750090		LF	$20.00	$0.00			FURNISH & INSTALL 3.0" GALV. RIGID CONDUIT (BORED AND JACKED)
14	6750175		LF	$8.00	$0.00			FURNISH & INSTALL 1.0" FLEX.GALV.STEEL CONDUIT (WEATHER TIGHT)
15	6750179		LF	$10.00	$0.00			FURNISH & INSTALL 2.0" FLEX.GALV.STEEL CONDUIT (WEATHER TIGHT)
16	6750262		LF	$25.68	$0.00			FURNISH & INSTALL ENCASED CONDUIT (2-2" PVC, SCHEDULE 40)
17	6750263		LF	$31.10	$0.00			FURNISH & INSTALL ENCASED CONDUIT (3-2" PVC, SCHEDULE 40)
18	6750275		LF	$7.25	$0.00			FURNISH & INSTALL 1.0" SCHEDULE 80 PVC CONDUIT
19	6750278		LF	$8.25	$0.00			FURNISH & INSTALL 2.0" SCHEDULE 80 PVC CONDUIT
20	6750279		LF	$13.16	$0.00			FURNISH & INSTALL 3.0" SCHEDULE 80 PVC CONDUIT
21	6750275		LF	$15.00	$0.00			FURNISH & INSTALL 2.0" SCHEDULE 80 PVC CONDUIT (DIRECTION.BORED)
22	6750279		LF	$19.50	$0.00			FURNISH & INSTALL 3.0" SCHEDULE 80 PVC CONDUIT(DIRECTION.BORED)
23	6750272		LF	$4.50	$0.00			FURNISH ADDITIONAL 2" CONDUIT WITHIN DIRECTIONAL BORE
23a			LF	$6.05	$0.00			FURNISH ADDITIONAL 3" CONDUIT WITHIN DIRECTIONAL BORE
255			LF	$9.00	$0.00			ADDED FOR DIRECTIONAL BORE IN ROCKY GROUND
677.1 ELECTRICAL CABLE								
24	6770388		LF	$2.00	$0.00			FURNISH & INSTALL NO. 14 COPPER WIRE, 4 CONDUCTOR (BLACK)
25	6770389		LF	$2.05	$0.00			FURNISH & INSTALL NO. 14 COPPER WIRE, 4 CONDUCTOR (GRAY)
26	6770393		LF	$2.19	$0.00			FURNISH & INSTALL NO. 14 COPPER WIRE, 8 CONDUCTOR (BLACK)
27	6770394		LF	$2.26	$0.00			FURNISH & INSTALL NO. 14 COPPER WIRE, 8 CONDUCTOR (GRAY)
677.2 COMMUNICATIONS CABLE								
28	6770453		LF	$1.65	$0.00			FURNISH AND INSTALL ELECTRICAL COMMUNICATIONS CABLE - OVERHEAD - 12 PAIR
29	6770463		LF	$1.26	$0.00			FURNISH AND INSTALL ELECTRICAL COMMUNICATIONS CABLE - UNDERGROUND - 12 PAIR
677.3.4.5.6 FIBER OPTIC ITEMS - IF WORK IS PERFORMED BY PRIME SIGNAL CONTRACTOR- USE SEPARATE WORKSHEET IF FIBER WORK IS COMPLETED BY SUB CONTRACTOR								
30	6770470		LF	$2.82	$0.00			FURNISH AND INSTALL FIBER OPTIC CABLE-SINGLE MODE
31	677046D		LF	$4.00	$0.00			FURNISH & INSTALL SELF SUPPORTING FIBER OPTIC CABLE - SINGLE MODE
32	6770476		EA	$1,630.00	$0.00			FURNISH AND INSTALL FIBER OPTIC INTERCONNECT CENTER
33	6770482		EA	$1,500.00	$0.00			FURNISH AND INSTALL FIBER OPTIC MODEM
34	6888080		LF	$1.25	$0.00			INSTALL FIBER OPTIC CABLE (SINGLE MODE)
35	6888091		EA	$104.33	$0.00			INSTALL FIBER OPTIC MODEM
36	6888092		EA	$750.00	$0.00			INSTALL FIBER OPTIC INTERCONNECT CENTER
37	6888082		EA	$1,550.00	$0.00			FURNISH AND INSTALL FACTORY TERMINATED PATCH PANEL
38	6888093		EA	$900.00	$0.00			INSTALL FACTORY TERMINATED PATCH PANEL
39	6770486		EA	$1,200.00	$0.00			FIBER OPTIC REPAIR SPLICE OH/UG
39a			EA	$1,000.00	$0.00			FIBER OPTICE TRAINING - 1 day
40	6886030a		EA	$1,000.00	$0.00			TRAINING BEING FIBER OPTIC - 1 day
41			EA	$25.00	$0.00			FIBER OPTIC FUSION SPLICING < 24 SPLICES
42			EA	$18.00	$0.00			FIBER OPTIC FUSION SPLICING > 24 SPLICES
43			EA	$12.00	$0.00			FURNISH & INSTALL FIBER OPTIC JUMPER - SINGLE MODE, ST TO ST, 2 METER
44			EA	$12.00	$0.00			FURNISH & INSTALL FIBER OPTIC JUMPER - SINGLE MODE, ST TO LC, 2 METER
45			EA	$10.00	$0.00			LIGHT SOURCE POWER METER TESTING
46			EA	$5.50	$0.00			OPTICAL TIME DOMAIN REFLECTOMETER TESTING < 24 FIBERS
677.7 SPREAD SPECTRUM RADIO ASSEMBLY								
256	677048B		EA	$484.00	$0.00			INSTALL WIRELESS NETWORK COMMUNICATIONS LINK BETWEEN TWO SIGNALS (2 RADIOS)
257			EA	$242.00	$0.00			INSTALL WIRELESS NETWORK COMMUNICATIONS RADIO AT SIGNAL CABINET (1 RADIO)
258			LF	$2.50	$0.00			ADDITIONAL CABLE INSTALLATION TO CROSS ROADWAY

Figure 7-2a
On Call Pricing (page 1)

SCDOT Fixed Price On-Call Contract, effective 7/1/2014- 7/6/2018, change order #3 effective 11/2018 Click here to see contract.

LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
678.1 DETECTOR LOOP								
48	6770413		LF	$0.42	$0.00			FURNISH AND INSTALL NO. 14 COPPER WIRE, 1-CONDUCTOR FOR LOOP WIRE
49	6780495		LF	$6.10	$0.00			SAWCUT FOR LOOP DETECTOR
50a	677049C		EA	$8,182.00	$0.00			FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (INC SETBACK DETECTION CAPABILITY FOR 2 DIRECTIONS
50b	677049D		EA	$9,744.50	$0.00			FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (INC SETBACK DETECTION CAPABILITY FOR 3 DIRECTIONS
50c	677049E		EA	$10,887.00	$0.00			FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (INC SETBACK DETECTION CAPABILITY FOR 4 DIRECTIONS
50d	677049F		EA	$5,477.00	$0.00			FURNISH WIRELESS DETECTION SYSTEM W/O SENSORS (w/o SETBACK DETECTION CAPABILITY)
50e	677049G		HR	$150.00	$0.00			FURNISH MANUFACTURER TECHNICIAN ASSISTANCE
50	6770494		EA	$595.00	$0.00			FURNISH & INSTALL FLUSH MOUNTED WIRELESS SENSOR INC EPOXY
51	6887961		EA	$250.00	$0.00			INSTALL FLUSH MOUNTED WIRELESS SENSOR
52	6887962		EA	$75.00	$0.00			REMOVE FLUSH MOUNTED WIRELESS SENSOR
54	6887963		EA	$750.00	$0.00			INSTALL SET BACK LOOP EQUIPMENT
56	6887964		EA	$450.00	$0.00			INSTALL CABINET EQUIPMENT
680.1 ELECTRIC SERVICE								
70	6800499		EA	$725.00	$0.00			FURNISH AND INSTALL ELECTRICAL SERVICE FOR TRAFFIC SIGNAL *(COMPLETE WITH RISER, METER, AND DISCONNECT SWITCH)*
259			EA	$750.00	$0.00			FURNISH AND INSTALL PEDESTAL MOUNTING FOR ELECTRIC SERVICE
71	6770318		LF	$1.88	$0.00			FURNISH AND INSTALL # 6 TRIPLEX ALUMINUM SERVICE WIRE
680.2 SPLICE BOX/JUNCTION BOX								
72	6800508		EA	$220.00	$0.00			FURNISH AND INSTALL 12"W x 12"L x 12"D ELECTRICAL FLUSH UNDERGROUND ENCLOSURE - MinSB« - (STR.POLY.CONC) HD
73	6800518		EA	$385.00	$0.00			FURNISH AND INSTALL 13"X24"X18"D.ELEC.FLUSH UNDGRD.ENCLOSURE-(STR.POLY.CONC.)HD
74	680052C		EA	$425.00	$0.00			FURNISH AND INSTALL 17"X30"X26"D.ELEC.FLUSH UNDGRD.ENCLOSURE-(STR.POLY.CONC.)HD
682.1.2 WOOD POLE, BACK GUYS								
75	6825020		EA	$535.00	$0.00			FURNISH AND INSTALL 35' WOOD POLE-CLASS II-CCA TREATED(0.60)
76	6825021		EA	$675.00	$0.00			FURNISH AND INSTALL 40' WOOD POLE-CLASS II-CCA TREATED(0.60)
77	6825045		EA	$240.00	$0.00			FURNISH AND INSTALL 3/8" BACKGUY FOR WOOD POLE
78	6825046		EA	$275.00	$0.00			FURNISH AND INSTALL 3/8" SIDEWALK GUY
79	6825047		EA	$160.00	$0.00			FURNISH AND INSTALL 3/8" AERIAL GUY
80			EA	$425.00	$0.00			FURNISH AND INSTALL 35' WOOD POLE- CLASS III- CCA TREATED
81			EA	$565.00	$0.00			FURNISH AND INSTALL 40' WOOD POLE- CLASS III- CCA TREATED
682.3 STEEL CABLE								
82	6825090		LF	$2.83	$0.00			FURNISH AND INSTALL 1/4" GALVANIZED STEEL CABLE
83	6825092		LF	$5.25	$0.00			FURNISH AND INSTALL 3/8" GALVANIZED STEEL CABLE
682.4 PEDESTRIAN POLE AND BASE								
84	6825480		EA	$500.00	$0.00			FURNISH & INSTALL 4' BREAK-AWAY ALUMINUM PEDESTAL POLE AND BASE
85	6825484		EA	$820.00	$0.00			FURNISH AND INSTALL 10' BREAK-AWAY ALUMINUM PEDESTAL POLE AND BASE
86	6888190		EA	$250.00	$0.00			INSTALL 10' PEDESTRIAN PEDESTAL POLE AND BASE
87	6825486		EA	$200.00	$0.00			FURNISH & INSTALL ALUMINUM PEDESTAL POLE CONCRETE FOUNDATION
88	6888192		EA	$160.00	$0.00			POWDERCOATING OPTION FOR 4' ALUMINUM PEDESTAL POLE
89	6888194		EA	$185.00	$0.00			POWDERCOATING OPTION FOR 10' ALUMINUM PEDESTAL POLE

SCDOT Fixed Price On-Call Contract, effective 7/1/2014- 7/6/2018, change order #3 effective 11/2018 Click here to see contract.

LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
686.1 LED MODULES AND/OR POLYCARBONATE VEHICLE SIGNAL HEAD								
90	6865710		EA	$900.00	$0.00			FURNISH AND INSTALL 12" 1-WAY-5 SECTION(R.Y.YA.G.GA)VEHICLE TRAFFIC SIGNAL
91	6865720		EA	$740.00	$0.00			FURNISH AND INSTALL 12" 1-WAY-4 SECTION(RA+RA/YA.GA)VEHICHLE TRAFFIC SIGNAL
92	6865721		EA	$720.00	$0.00			FURNISH AND INSTALL 12" 1-WAY-4 SECTION(R.Y.G.GA)VEHICLE TRAFFIC SIGNAL
93	6865731		EA	$568.93	$0.00			FURNISH AND INSTALL 12" 1-WAY-3 SECTION(R.Y.G.)VEHICLE TRAFFIC SIGNAL
94	6865733		EA	$580.00	$0.00			FURNISH AND INSTALL 12" 1-WAY-3 SECTION(RA.YA.GA.)VEHICLE TRAFFIC SIGNAL
95	6865734		EA	$568.93	$0.00			FURNISH AND INSTALL 1 WAY -3 SECTION (R(12").Y(12").Y(8"))VEHICLE TRAFFIC SIGNAL
96	6865735		EA	$679.95	$0.00			FURNISH AND INSTALL 12" 4-WAY-1 SECT.(R.Y.R.Y.)CLUST. MOUNT CAUTION HEAD
97	6865736		EA	$285.00	$0.00			FURNISH AND INSTALL 12" 1-WAY-1 SECTION(RED)VEHICLE TRAFFIC SIGNAL
98	6865737		EA	$285.00	$0.00			FURNISH AND INSTALL 12" 1-WAY-1 SECTION(YELLOW)VEHICLE TRAFFIC SIGNAL
99	6887900		EA	$180.00	$0.00			INSTALL 12" 1-WAY-5 SECTION(R.Y.YA.G.GA)VEHICLE TRAFFIC SIGNAL
100	6887901		EA	$180.00	$0.00			INSTALL 1 WAY-4 SECTION (RA+RA.YA.GA) VEHICLE TRAFFIC SIGNAL
101	6887902		EA	$180.00	$0.00			INSTALL 1 WAY-4 SECTION (R.Y.G.GA) VEHICLE TRAFFIC SIGNAL
102	6887903		EA	$180.00	$0.00			INSTALL 1 WAY-3 SECTION (RA.YA.GA) VEHICLE TRAFFIC SIGNAL
103	6887904		EA	$180.00	$0.00			INSTALL 1 WAY-3 SECTION (R.Y.G) VEHICLE TRAFFIC SIGNAL
104	6887905		EA	$180.00	$0.00			INSTALL 1 WAY-1 SECTION (RA) VEHICLE TRAFFIC SIGNAL – (PER APPROACH)
105	6887906		EA	$180.00	$0.00			INSTALL 12" 1-WAY-1 SECTION (YA) VEHICLE TRAFFIC SIGNAL – (PER APPROACH)
106	6887907		EA	$180.00	$0.00			INSTALL 12" 1-WAY-1 SECTION (GA) VEHICLE TRAFFIC SIGNAL – (PER APPROACH)
107	6887908		EA	$180.00	$0.00			INSTALL 12" 1-WAY-1 SECTION (RED) VEHICLE TRAFFIC SIGNAL – (PER APPROACH)
108	6887909		EA	$180.00	$0.00			INSTALL 12" 1-WAY-1 SECTION (YELLOW) VEHICLE TRAFFIC SIGNAL – (PER APPROACH)
109	6887910		EA	$180.00	$0.00			INSTALL 1 WAY-1 SECTION (GREEN) VEHICLE TRAFFIC SIGNAL – (PER APPROACH)
110	6887911		EA	$250.51	$0.00			INSTALL 4 WAY-1 SECTION (R.Y.R.Y) CLUSTER MOUNT CAUTION HEAD
111	6887912		EA	$180.00	$0.00			INSTALL 1 WAY-3 SECT (R(12").Y(12").Y(8")) VEHICLE TRAFFIC SIGNAL
112	6887920		EA	$40.57	$0.00			INSTALL LED MODULE
113	6887930		EA	$45.00	$0.00			INSTALL BACKPLATE W/ RETROREFL.BORDER FOR TRAFF. SIG.
114A	6865834		EA	$146.00	$0.00			FURNISH AND INSTALL BACKPLATE W/ RETROREFL.BORDERS FOR 3 SECTION TRAFF. SIG.
114B			EA	$190.00	$0.00			FURNISH AND INSTALL BACKPLATE W/ RETROREFL.BORDERS FOR 4 SECT IN LINE TRAFF. SIG.
114C			EA	$190.00	$0.00			FURNISH AND INSTALL BACKPLATE W/ RETROREFL.BORDERS FOR 4 SECTION 'T' TRAFF. SIG.
114D			EA	$190.00	$0.00			FURNISH AND INSTALL BACKPLATE W/ RETROREFL.BORDERS FOR 5 SECTION TRAFF. SIG.
115	6865722		EA	$684.49	$0.00			F&I - 12" 1-WAY-4 SECTION(RA.YA.YAF.GA)VEH TRAFFIC SIGNAL
116	6887899		EA	$180.00	$0.00			INSTALL 12" 1-WAY-4 SECTION(RA.YA.YAF.GA)VEHICLE TRAFF SIG
117	6865723		EA	$568.93	$0.00			F&I - 12" 1-WAY-3 SECTION(RA.YA.YAF)VEH TRAFFIC SIGNAL
118	6887898		EA	$180.00	$0.00			INSTALL 12" 1-WAY-3 SECTION(RA.YA.YAF)VEH TRAFFIC SIGNAL
686.3 PEDESTRIAN SIGNAL HEAD								
119	6865783		EA	$545.00	$0.00			FURNISH AND INSTALL 1-WAY-1SECT.(COUNTDOWN HAND/MAN EMBLEM)PED.SIG.HEAD
120	6865788		EA	$210.00	$0.00			FURNISH AND INSTALL PEDESTRIAN LED MODULE
121	6865787		EA	$110.00	$0.00			FURNISH & INSTALL VISOR WITH ATTACHMENT SCREWS
122	6887926		EA	$30.00	$0.00			INSTALL VISOR WITH ATTACHMENT SCREWS
123	6887925		EA	$30.00	$0.00			INSTALL PEDESTRIAN LED MODULE – EACH
124	6888320		EA	$115.50	$0.00			INSTALL PEDESTRIAN SIGNAL HEAD
125	6865840		EA	$125.00	$0.00			FURNISH & INSTALL PEDESTRIAN TRAF. SIGNAL HEAD MOUNTING ASSEMBLY FOR POST TOP
126	6865841		EA	$105.00	$0.00			FURNISH & INSTALL PEDESTRIAN TRAF. SIGNAL HEAD MOUNTING ASSEMBLY FOR SIDE POLE
127	6865842		EA	$155.00	$0.00			FURNISH & INSTALL PED. TRAF. SIGNAL HEAD MOUNT. ASSEMBLY FOR DUAL POST TOP
128	6865782		EA	$515.00	$0.00			FURNISH & INSTALL 1-WAY-1SECT. PEDESTRIAN SIGNAL HEAD W/ HAND/MAN LED MODULE AND CLAMSHELL MOUNT FOR SIDE POLE
130	6865784		EA	$590.00	$0.00			FURNISH & INSTALL 1-WAY-1SECT. PEDESTRIAN SIGNAL HEAD W/ HAND/MAN COUNTDOWN LED MODULE AND CLAMSHELL MOUNT FOR SIDE POLE (LEFT)
131	6865785		EA	$590.00	$0.00			FURNISH & INSTALL 1-WAY-1SECT. PEDESTRIAN SIGNAL HEAD W/ HAND/MAN COUNTDOWN LED MODULE AND CLAMSHELL MOUNT FOR SIDE POLE(RIGHT)

Figure 7-2b
On Call Pricing (page 2)

SCDOT Fixed Price On-Call Contract, effective 7/1/2014- 7/1/2018, change order #3 effective 1/2018 Click here to see contract.

LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
686.4 PEDESTRIAN PUSH BUTTON STATION ASSEMBLY W/ SIGN								
132	6865791		EA	$250.00	$0.00			FURNISH AND INSTALL PEDESTRIAN PUSH BUTTON STATION ASSEMBLY AND SIGN (R-10-3E)
133	6888325		EA	$70.00	$0.00			INSTALL PEDESTRIAN PUSH BUTTON STATION ASSEMBLY AND SIGN
136	6865795		EA	$115.00	$0.00			FURNISH & INSTALL PEDESTRIAN PUSH BUTTON MICROSWITCH TYPE
137	6865796		EA	$175.00	$0.00			FURNISH & INSTALL PEDESTRIAN PUSH BUTTON SOLID STATE WITH LIGHT AND TONE STATION ASSEMBLY (9"x12") AND SIGN (R-10-3E)
138	6865797		EA	$185.00	$0.00			FURNISH & INSTALL PEDESTRIAN PUSH BUTTON SOLID STATE WITH LIGHT AND TONE STATION ASSEMBLY (9"x15") AND SIGN (R-10-3E)
139	6865798		EA	$130.00	$0.00			FURNISH & INSTALL PEDESTRIAN PUSH BUTTON SOLID STATE WITH LIGHT AND TONE
686.5 SYMBOLIC LED BLANKOUT SIGN								
140	6865820		EA	$2,500.00	$0.00			FURNISH & INSTALL NO RIGHT/LEFT TURN SYMBOLIC LED BLANKOUT SIGN W/ SPAN WIRE MOUNTING
141	6887928		EA	$235.00	$0.00			INSTALL NO RIGHT/LEFT TURN SYMBOLIC LED BLANKOUT SIGN W/ SPAN WIRE MOUNTING
142	6865821		EA	$775.00	$0.00			FURNISH & INSTALL NO RIGHT/LEFT TURN SYMBOLIC LED MODULE EA
143	6887927		EA	$50.00	$0.00			INSTALL NO RIGHT/LEFT TURN SYMBOLIC LED MODULE
688.1 REMOVAL SALVAGE AND DISPOSAL OF EQUIPMENT AND MATERIALS								
144	6885982		EA	$750.00	$0.00			REMOVE FOUNDATION FOR STEEL STRAIN POLE – 18" BELOW GRADE
145	6885990		EA	$750.00	$0.00			REMOVAL, SALVAGE AND DISPOSAL OF EXISTING TRAFFIC SIGNAL EQUIP
260			EA	$750.00	$0.00			REMOVE CONCRETE POLE - 18" BELOW GRADE
261			EA	$1,500.00	$0.00			COMPLETELY REMOVE AND DISPOSE CONCRETE SIGNAL POLE
688.2 TEMPORARY ADJUSTMENT OF TRAFFIC SIGNAL EQUIPMENT AND TIMINGS								
146	6885992		EA	$500.00	$0.00			TEMPORARY ADJUSTMENT OF TRAFFIC SIGNAL EQUIPMENT
147	6885993		EA	$325.00	$0.00			TEMPORARY TIMING ADJUSTMENT PER SITE VISIT
148	6887933		EA	$70.00	$0.00			INSTALL COMMUNICATION SERVICE FOR TRAFFIC SIGNAL
688.3 VIDEO DETECTION - LOOP EMULATION SYSTEM								
150	6886041		EA	$575.00	$0.00			INSTALL VIDEO DETECTION SYSTEM INCLUDING LEAD-IN
262	6886042		EA	$2,500.00	$0.00			FURNISH & INSTALL VIDEO DETECTION CAMERA W/ HARDWARE & LEAD-IN
263	6886043		LF	$2.00	$0.00			FURNISH & INSTALL VIDEO DETECTION CABLE TO CROSS ROADWAY
264	6886044		EA	$2,245.00	$0.00			FURNISH & INSTALL VIDEO DETECTION SYSTEM SINGLE CHANNEL PROCESSOR HARDWARE - NO CAMERA
265	6886045		EA	$3,695.00	$0.00			FURNISH & INSTALL VIDEO DETECTION SYSTEM DUAL CHANNEL PROCESSOR HARDWARE - NO CAMERA
688.4 RADAR DETECTION SYSTEM								
266			EA	$4,500.00	$0.00			FURNISH & INSTALL RADAR FOR STOP BAR DETECTION, INC 150' CABLE & MOUNTING HARDWARE
267			EA	$3,000.00	$0.00			FURNISH & INSTALL CABINET INTERFACE COMPONENTS FOR STOP BAR DETECTION
268			EA	$4,800.00	$0.00			FURNISH & INSTALL RADAR FOR SETBACK DETECTION, INC 150' CABLE & MOUNTING HARDWARE
269			EA	$3,000.00	$0.00			FURNISH & INSTALL CABINET INTERFACE COMPONENTS FOR SETBACK DETECTION
270			EA	$5,500.00	$0.00			FURNISH & INSALL RADAR FOR SPEED /VOLUME DETECTION INC 150' CABLE & MOUNTING HARDWARE
271			EA	$1,200.00	$0.00			FURNISH & INSTALL CABINET INTERFACE COMPONENTS FOR SPEED /VOLUME DETECTION
272			LF	$2.00	$0.00			FURNISH & INSTALL RADAR DETECTION CABLE TO CROSS ROADWAY

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688.5 STEEL STRAIN POLE AND FOUNDATION								
151	6887940		EA	$2,098.01	$0.00			INSTALL FOUNDATION FOR STEEL STRAIN POLE
152	6888155		EA	$550.00	$0.00			INSTALL STEEL STRAIN POLE ON EXISTING FOUNDATION
153	682505A		EA	$5,000.00	$0.00			FURNISH AND INSTALL 26' STEEL STRAIN POLE, POLE BANDS AND HARDWARE AND FOUNDATION
154	682505B		EA	$5,200.00	$0.00			FURNISH AND INSTALL 28' STEEL STRAIN POLE, POLE BANDS AND HARDWARE AND FOUNDATION
155	682505D		EA	$5,500.00	$0.00			FURNISH AND INSTALL 32' STEEL STRAIN POLE, POLE BANDS AND HARDWARE AND FOUNDATION
156	6825050		EA	$5,500.00	$0.00			FURNISH & INSTALL 13" X 26' STEEL STRAIN POLE (POWDER COATED) AND FOUNDATION
157	6825056		EA	$5,800.00	$0.00			FURNISH & INSTALL 13" X 26' STEEL STRAIN POLE (POWDER COATED OVER GALVANIZED) AND FOUNDATION
158	6825051		EA	$5,700.00	$0.00			FURNISH & INSTALL 13" X 28' STEEL STRAIN POLE (POWDER COATED) AND FOUNDATION
159	6825057		EA	$6,000.00	$0.00			FURNISH & INSTALL 13" X 28' STEEL STRAIN POLE (POWDER COATED OVER GALVANIZED) AND FOUNDATION
160	6825052		EA	$6,000.00	$0.00			FURNISH & INSTALL 13" X 32' STEEL STRAIN POLE (POWDER COATED) AND FOUNDATION
161	6825058		EA	$6,300.00	$0.00			FURNISH & INSTALL 13" X 32' STEEL STRAIN POLE (POWDER COATED OVER GALVANIZED) AND FOUNDATION
161a			EA	$2,902.00	$0.00			FURNISH AND INSTALL 26' STEEL STRAIN POLE, POLE BANDS AND HARDWARE ON EXIST. FOUNDATION
161b			EA	$3,102.00	$0.00			FURNISH AND INSTALL 28' STEEL STRAIN POLE, POLE BANDS AND HARDWARE ON EXIST. FOUNDATION
161c			EA	$3,402.00	$0.00			FURNISH AND INSTALL 32' STEEL STRAIN POLE, POLE BANDS AND HARDWARE ON EXIST. FOUNDATION
273			EA	$4,500.00	$0.00			FURNISH & INSTALL 50' STEEL CAMERA POLE INC SCREW ANCHOR FOUNDATION
688.6 CONCRETE STRAIN POLE								
162	6825061		EA	$3,811.05	$0.00			FURNISH AND INSTALL 35' CONCRETE STRAIN POLE
163	6825062		EA	$4,189.70	$0.00			FURNISH AND INSTALL 40' CONCRETE STRAIN POLE
164	6825064		EA	$4,471.10	$0.00			FURNISH AND INSTALL 45' CONCRETE STRAIN POLE
165	6887945		EA	$1,500.00	$0.00			INSTALL CONCRETE STRAIN POLE
274			EA	$7,500.00	$0.00			FURNISH & INSTALL 60' CONCRETE CAMERA POLE INC BACKFILL FOUNDATION
688.7 CONTROLLER AND 332/336 CABINET								
166	6845510		EA	$8,500.00	$0.00			FURNISH & INSTALL CONTROLLER AND 336 CABINET ASSEMBLY - POLE MOUNTED
167	6845511		EA	$11,387.00	$0.00			FURNISH & INSTALL CONTROLLER AND 332/336 CABINET ASSEMBLY - BASE MOUNTED INC FDN
275			EA	$1,900.00	$0.00			FURNISH & INSTALL CABINET INC FOUNDATION FOR NETWORK DEVICES INCLUDING CAMERAS, RADIO, RADAR EQUIPMENT
276			EA	$1,500.00	$0.00			FURNISH & INSTALL POLE MOUNTED CABINET FOR NETWORK DEVICES INCLUDING CAMERAS, RADIO, RADAR EQUIPMENT
168	6845614		EA	$475.00	$0.00			INSTALL 2070L CONTROLLER UNIT &/OR CONFLICT MONITOR IN EXISTING CABINET
169	6888226		EA	$235.00	$0.00			INSTALL CONTROLLER-BASE MOUNTED CABINET ON EXISTING FOUNDATION
170	6845520		EA	$2,000.00	$0.00			FURNISH AND INSTALL 2070L LOCAL CONTROLLER* WITHOUT SOFTWARE
171	6887950		EA	$175.00	$0.00			INSTALL PRE-FABRICATED CONCRETE CABINET FOUNDATION
172	6887951		EA	$850.00	$0.00			FURNISH AND INSTALL CONCRETE CABINET FOUNDATION
173	6887952		EA	$125.25	$0.00			INSTALL PREFORMED CABINET FOUNDATION
174	6888220		EA	$344.44	$0.00			INSTALL SCDOT SUPPLIED POLE MOUNTED CABINET ASSEMBLY** AND CONTROLLER
175	6888225		EA	$220.00	$0.00			INSTALL SCDOT SUPPLIED BASE MOUNTED CABINET ASSEMBLY** AND CONTROLLER
176	9610201		$	1.08	$0.00			RAILROAD LIABILITY INSURANCE (ENTER EXPECTED COST & FEES; 8% ADDED FOR CONTRACTOR ADMIN TIME)
177			HR	$187.50	$0.00			RAILROAD FLAGGING
178	6845518		EA	$5,700.00	$0.00			FURNISH AND INSTALL BATTERY BACK-UP INCLUDING FOUNDATION
179	6888243		EA	$500.00	$0.00			INSTALL BATTERY BACK-UP INCLUDING FOUNDATION
688.8 REMOTE SPLICE/FLASHER CABINET								
180	6888245		EA	$313.13	$0.00			INSTALL SPLICE/FLASH CABINET
181	6845655		EA	$410.00	$0.00			FURNISH & INSTALL SPLICE-CABINET/FLASHER CABINET
688.9 SOLAR POWERED FLASHER ASSEMBLY								
182	6865700		EA	$3,800.00	$0.00			FURNISH & INSTALL SOLAR POWERED FLASHER ASSEMBLY - SINGLE BEACON
183	6865701		EA	$4,200.00	$0.00			FURNISH & INSTALL SOLAR POWERED FLASHER ASSEMBLY - DUAL BEACON
184	6865702		EA	$3,800.00	$0.00			FURNISH & INSTALL SOLAR POWERED FLASHER ASSEMBLY
185	6887960		EA	$450.00	$0.00			INSTALL SOLAR POWERED FLASHER ASSEMBLY

Figure 7-2c
On Call Pricing (page 3)

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LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
689.1 WORKING CREW WITH EQUIPMENT								
186	6887990		HR	$250.00	$0.00			WORKING CREW WITH EQUIPMENT (BUCKET TRUCK, LINE TRUCK/POLE TRAILER, FOREMAN VEHICLE). MAY SUBSTITUTE LINE TRUCK FOR BUCKET TRUCK, IF NECESSARY. MATERIALS SUPPLIED BY SCDOT. SIGNAL SHOP SUPERVISOR SHALL DESIGNATE ALL EMERGENCIES, PAY RATE TO BE 1 1/2 X DAY.
186a			HR	$54.00	$0.00			SIGNAL TECHNICIAN 1
186b			HR	$70.00	$0.00			SIGNAL TECHNICIAN 2
186c			HR	$85.00	$0.00			SIGNAL TECHNICIAN 3
689.3 TRAFFIC SIGNAL SYSTEM TRAINING								
187	6886020		HR	$187.50	$0.00			TRAINING BEING SIGNAL RELATED SYSTEM TRAINING
690.1 STEEL POLE WITH MAST ARM								
188	6865831		EA	$300.00	$0.00			FURNISH & INSTALL VEHICLE TRAFFIC SIGNAL HEAD MOUNTING ASSEMBLY FOR MAST ARM
189	6888110		EA	$450.00	$0.00			INSTALL STREET LIGHT LUMINAIRE, INCLUDING MOUNTING HARDWARE
190	6825110A		EA	$5,300.00	$0.00			FURNISH 21' STEEL POLE WITH 26' MAST ARM (INC MOUNTING HARDWARE, GALVANIZED, NON-DECORATIVE) ADAPTER PLATE SEPARATE ITEM
191	6825130A		EA	$7,000.00	$0.00			FURNISH 21' STEEL POLE WITH DUAL MASTS (BOTH 26' IN LENGTH), INCLUDING MOUNTING HARDWARE, GALVANIZED, NON-DECORATIVE) ADAPTER PLATE SEPARATED ITEM
192			EA	$200.00	$0.00			ADDED COST FOR EACH 2' INCREMENT UP TO 20'
193			EA	$300.00	$0.00			ADDED COST FOR EACH 2' INCREMENT > 20'
194	6825120A		EA	$6,700.00	$0.00			FURNISH 27' STEEL POLE WITH 26' MAST ARM (MOUNTING HARDWARE, GALVANIZED, NON-DECORATIVE) ADAPTER PLATE SEPARATE ITEM
195	6825310A		EA	$9,000.00	$0.00			FURNISH 27' STEEL POLE WITH DUAL MASTS (BOTH 26' IN LENGTH), INCLUDING MOUNTING HARDWARE, GALVANIZED, NON-DECORATIVE) ADAPTER PLATE SEPARATE ITEM
196	6888163		EA	$1,200.00	$0.00			DESIGN MAST ARM FOUNDATION (DOES NOT INCLUDE SOIL BORING OR UTILITY CHECK)
197	6888164		EA	$1,078.00	$0.00			FURNISH & INSTALL DUAL LUMINAIRE INCLUDING LUMINAIRE ARMS AND ALL ASSOCIATED HARDWARE
198	6888165		EA	$550.00	$0.00			FURNISH & INSTALL SINGLE LUMINAIRE INCLUDING LUMINAIRE ARMS AND ALL ASSOCIATED HARDWARE
199	6888166		EA	$500.00	$0.00			POWDERCOATING PER MAST ARM OVER BASE
200	6888167		EA	$800.00	$0.00			POWDERCOATING PER MAST ARM OVER GALVANIZED
201	6888168		EA	$1,000.00	$0.00			DECORATIVE OPTION PER MAST ARM
201a			1/0	0.15	$0.00			ADDED FOR 130 MPH WIND SPEED ZONE (15% ADDED AFTER CALC OF ARM BASED ON LENGTH AND PRIOR TO ADDING DECORATIVE, POWDERCOATING OR SKIRT)
201b			1/0	0.12	$0.00			ADDED FOR 110 MPH WIND SPEED ZONE (12% ADDED AFTER CALC OF ARM BASED ON LENGTH AND PRIOR TO ADDING DECORATIVE, POWDERCOATING OR SKIRT)
201c			1/0	0.1	$0.00			ADDED FOR 100 MPH WIND SPEED ZONE (10% ADDED AFTER CALC OF ARM BASED ON LENGTH AND PRIOR TO ADDING DECORATIVE, POWDERCOATING OR SKIRT)
201d			1/0	0.07	$0.00			ADDED FOR 90 MPH WIND SPEED ZONE (7% ADDED AFTER CALC OF ARM BASED ON LENGTH AND PRIOR TO ADDING DECORATIVE, POWDERCOATING OR SKIRT)
202	6888171		EA	$1,800.00	$0.00			INSTALL STEEL POLE WITH MAST ARM WITHOUT FOUNDATION
203	6888181		EA	$2,000.00	$0.00			INSTALL STEEL POLE WITH TWIN MAST ARMS WITHOUT FOUNDATION
204	6888173		EA	$1,800.00	$0.00			SOIL BORING - UTILITY REVIEW FOR MAST ARM DESIGN PER SIGNAL QUADRANT (INCLUDES 1 SOIL BORING TEST/REPORT AND RED LINED PLAN INDICATING UTILITY LOCATIONS)
205	6888174		CY	$575.00	$0.00			INSTALL FOUNDATION FOR MAST ARM INCLUDING CONCRETE AND REBAR
205a			EA	$900.00	$0.00			ADDED PER FOUNDATION IF SLEEVE REQUIRED
206			EA	$850.00	$0.00			GALVANIZED FINISH PER MAST ARM
207			EA	$1,800.00	$0.00			ADAPTER PLATE PER MAST ARM
208			EA	$2,178.00	$0.00			MAST ARM SKIRT & BREAKAWAY COUPLINGS PER MAST ARM

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LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
699.1 SHORT RANGE RADIO DEVICE DETECTOR SYSTEM								
277	6990010		EA	$5,800.00	$0.00			SHORT-RANGE RADIO DEVICE DETECTOR SYSTEM TYPE A- W/ LICENSE [SYSTEM WITH POWER OVER ETHERNET W/75' OF CAT5 CABLE AND POE INJECTOR
278	6990011		EA	$6,300.00	$0.00			SHORT-RANGE RADIO DEVICE DETECTOR SYSTEM TYPE B- W/ LICENSE [SYSTEM WITH POWER OVER ETHERNET AND CELLULAR MODEM W/75' OF CAT5 CABLE AND POE INJECTOR
279	6990012		EA	$6,900.00	$0.00			SHORT-RANGE RADIO DEVICE DETECTOR SYSTEM TYPE C- W/ LICENSE [SYSTEM WITH CELLULAR MODEM FOR COMM AND BATTERY AND SOLAR PANEL FOR POWER
Concrete curbs, sidewalks, and ramps -- Standard Drawing #720-901-02 (Pedestrian Ramps: General Notes & Definitions):								
210	7204100		SY	$50.00	$0.00			CONCRETE SIDEWALK 4" UNIFORM
211	7203210		LF	$21.19	$0.00			C&G - CONC.CURB & GUTTER(2'-0")VERT.
212	7209000		SY	$100.00	$0.00			Pedestrian Ramp Construction (includes Detectable Warning Surface and ramp partitions; curb and gutter separate)
213	7206000		SY	$75.00	$0.00			Concrete Median (for at-grade pass-through of raised medians)
214	7209100		SF	$40.00	$0.00			Surface Applied Detectable Warning (placed on existing ramp or on asphalt, not used in new ramp construction)
Pavement								
215	2023000		SY	$30.00	$0.00			Removal and Disposal of Existing Pavement (equal to area of new ramp, includes sidewalk, curb & gutter, etc)
216	9614006		SY	$75.16	$0.00			FULL DEPTH ASPHALT PAVING / PATCHING 6" UNIFORM
217	2031000		CY	$25.00	$0.00			UNCLASSIFIED EXCAVATION
Signing								
218	6888130		SF	$9.00	$0.00			INSTALL FLAT SHEET, TYPE III, FIXED SIZE & MESSAGE SIGN (SHOULDER MOUNTED)
219	6888131		SF	$11.00	$0.00			INSTALL FLAT SHEET, TYPE VIII OR IX, SIZE DETERMINED BY MESSAGE (OVERHEAD)
220	6888132		SF	$11.00	$0.00			INST.FL.SH.FIXMSG.SGN-MAST.MNT
221	6513015		EA	$150.00	$0.00			MOUNTING ASSEMBLY FOR F.S. SIGN ERCTD ON SPAN WIRE
222	6513016		EA	$180.00	$0.00			RELOCATION OF MOUNT.ASSEMBLY FOR FS.SIGN ON SPAN WIRE
223	6513017		EA	$150.00	$0.00			REMOVAL OF MOUNTING ASSEMBLY FOR FS.SIGN ON SPAN WIRE
224	6513021		EA	$250.00	$0.00			RELOCATION OF MOUNT.ASSEMBLY FOR FS.SIGN ON MAST ARM
225	6513022		EA	$200.00	$0.00			REMOVAL OF MOUNTING ASSEMBLY FOR FS.SIGN ON MAST ARM
226	6510105		SF	$22.00	$0.00			FURNISH AND INSTALL FLAT SHEET, TYPE III, FIXED SIZE & MESSAGE SIGN (SHOULDER MOUNTED)
227	6510108		SF	$27.50	$0.00			FURNISH AND INSTALL FLAT SHEET, TYPE VIII OR IX, SIZE DETERMINED BY MESSAGE (OVERHEAD)
228	6513020		EA	$250.00	$0.00			FURNISH & INSTALL MOUNTING ASSEMBLY FOR FLAT SHEET SIGN ERCTD ON MAST ARM
Markings								
229	6250015		LF	$0.87	$0.00			8"WHITE SOLID LINES(CROSSWALK&CHANNELIZATION)FAST DRY PAINT
230	6250010		LF	$0.18	$0.00			4" WHITE SOLID LINES (PVT. EDGE LINES)-FAST DRY PAINT
231	6250110		LF	$0.13	$0.00			4" YELLOW SOLID LINE(PVT.EDGE&NO PASSING ZONE)-FAST DRY PAINT
232	6250025		LF	$2.36	$0.00			24" WHITE SOLID LINES (STOP/DIAGONAL LINES)-FAST DRY PAINT
233	6250030		EA	$45.00	$0.00			WHITE SINGLE ARROW (LEFT, STRAIGHT, RIGHT)-FAST DRY PAINT
234	6250035		EA	$60.00	$0.00			WHITE WORD MESSAGE "ONLY"-FAST DRY PAINT
235	6250040		EA	$60.00	$0.00			WHITE COMBINATION ARROW (STR.& RT.OR STR.& LT.)FAST DRY PAINT
236	6271015		LF	$2.76	$0.00			8" WHITE SOLID LINES THERMOPLASTIC - 125 MIL.
237	6271010		LF	$0.58	$0.00			4" WHITE SOLID LINES (PVT. EDGE LINES) THERMO.- 90 MIL.
280			LF	$0.64	$0.00			4" WHITE BROKEN LINES (PVT. CENTER LINES) THERMO. - 90 MIL
238	6271074		LF	$0.51	$0.00			4" YELLOW SOLID LINES (PVT.EDGE LINES) THERMO-90 MIL.
239	6271025		LF	$10.08	$0.00			24" WHITE SOLID LINES (STOP/DIAG LINES)-THERMO.-125 MIL
240	6271030		EA	$81.72	$0.00			WHITE SINGLE ARROWS (LT, STRGHT, RT) THERMO.-125 MIL.
241	6271035		EA	$160.00	$0.00			WHITE WORD MESSAGE "ONLY" -THERMOPLASTIC - 125 MIL.
242	6271040		EA	$140.00	$0.00			WHITE COMBINATION ARROWS(STR&RT.OR STR&LT)THERMO-125MIL
243			LF	$2.00	$0.00			REMOVAL OF STOP BAR MARKING
244	6319505		LF	$1.60	$0.00			REMOVAL OF PAVEMENT MARKINGS

Figure 7-2d
On Call Pricing (page 4)

*SCDOT Fixed Price On-Call Contract, effective 7/1/2014- 7/1/2018, change order #3 effective 1/2018 Click here to see contract.

LINE	PAY ITEM	ESTIMATED QUANTITY	UNIT	CONTRACT UNIT COST	CONTRACT LINE ITEM TOTAL	OPTIONAL BID UNIT COST	OPTIONAL BID LINE ITEM TOTAL	DESCRIPTION, SPECIFICATION REFERENCE
Lighting								
245	6651145		EA	$3,500.00	$0.00			FURNISH & INSTALL SINGLE ALUMINUM LIGHT STANDARD – 35'- BREAKAWAY- W/O FDN (SGL.LIGHT STD.35'HT.,AL.POLE-INCL TOP TENON MT.)
246			EA	$850.00	$0.00			INSTALL 35' SPUN BRUSHED ALUMINUM POLE W/ LUMINAIRE ON EXISTING FDN
247			EA	$1,500.00	$0.00			FURNISH & INSTALL NEMA 4X STAINLESS STEEL ENCLOSURE FOR LIGHTING SYSTEM (W/O FDN)
248			HR	$50.00	$0.00			TROUBLESHOOT/REPAIR LIGHTING SYSTEM
249			EA	$200.00	$0.00			FURNISH & INSTALL PHOTOCELL
250			EA	$150.00	$0.00			INSTALL PHOTOCELL
251			LF	$100.00	$0.00			FURNISH & INSTALL GROUND ROD, INC COPPER WIRE & CLAMP

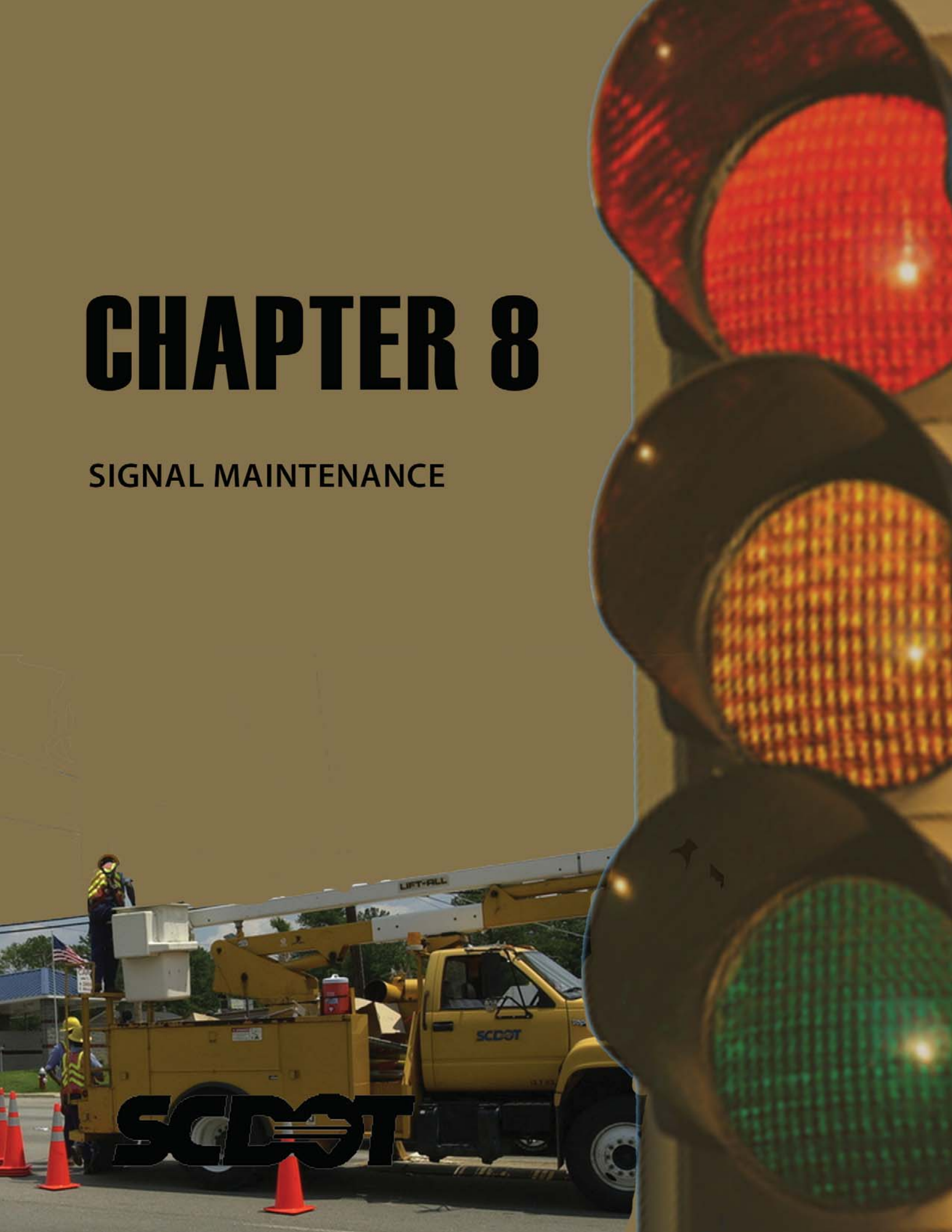
	Contract	Bid
Pay Item Total:	$0.00	$0.00

103.1 MOBILIZATION, 103.2 MOBILIZATION OF MATERIAL								
1	1031010		1/0	4%	$0.00			MOBILIZATION (4% of the total cost of work order or minimum of $400, whichever is greater)
		INSERT "1" above to calculate 4% of Pay Item Total above or $400 (whichever is greater)						
2	9610021		EA	$173.89	$0.00			MOBILIZATION OF MATERIAL PER WORK ORDER OR TRIP, 1-100 MILES BETWEEN LOCATION OF MATERIAL AND WORKSITE
3	9610022		EA	$289.82	$0.00			MOBILIZATION OF MATERIAL PER WORK ORDER OR TRIP, 101-250 MILES BETWEEN LOCATION OF MATERIAL AND WORKSITE
4	9610023		EA	$405.75	$0.00			MOBILIZATION OF MATERIAL PER WORK ORDER OR TRIP, 251+ MILES BETWEEN LOCATION OF MATERIAL AND WORKSITE
TRAFFIC CONTROL								
5	1071100		1/0	10.00%	$0.00			TRAFFIC CONTROL PRIMARY ROAD / WORK ORDER (10% of total cost of work order or minimum of $275, whichever is greater)
		INSERT "1" above if day work; this will calculate 10% of Pay Item Total above or $275 (whichever is greater)						Use either item 253 or 254
		OR						
6			1/0	14.00%	$0.00			TRAFFIC CONTROL PRIMARY ROAD / WORK ORDER (NIGHT WORK) (14% of total cost of work order or minimum of $350, whichever is greater)
		INSERT "1" above if night work; this will calculate 14% of Pay Item Total above or $350 (whichever is greater)						
6a			HR	$175.00	$0.00			TRAFFIC CONTROL PROVIDED FOR SCDOT WORK INCLUDING FLAGMAN, TEMP SIGNS SET UP AND CONE SET UP
6b			HR	$250.00	$0.00			TRAFFIC CONTROL PROVIDED FOR SCDOT WORK INCLUDING FLAGMAN, CONE SET UP, TEMPORARY SIGNS , ARROW BOARD
6c			HR	$400.00	$0.00			TRAFFIC CONTROL PROVIDED FOR SCDOT WORK INCLUDING FLAGMAN, CONE SET UP, TEMPORARY SIGNS , ARROW BOARD, TRUCK W/ CRASH CUSHION

Figure 7-2e
On Call Pricing (page 5)

CHAPTER 8

SIGNAL MAINTENANCE



Traffic Signal Maintenance

Traffic signals can severely limit roadway capacity if they are not properly maintained. Malfunctioning signal equipment typically fail in a manner that provides pre-timed signal phasing designed for congested traffic conditions meaning longer times on both the main street and side street. These fail safe measures result in unnecessary delays and limited roadway capacity. Proper attention to signal maintenance is vital in ensuring our roadways operate as designed.

There are seven (7) SCDOT Signal Maintenance Shops, one in each SCDOT District. Contact information for the signals shops is below:

District 1 Signal Shop 803-737-6660 1408 Shop Rd Columbia, SC 29201 Reports to District Traffic Engineer	**District 5 Signal Shop** (843) 661-4710 3018 East Palmetto St Florence, SC 29506 Reports to District Traffic Engineer
District 2 Signal Shop (864) 227-6971 510 W. Alexander Avenue Greenwood, SC29646 Reports to District Traffic Engineer	**District 6 Signal Shop** (843) 740-1668 6355 Fain Blvd, Bldg E N. Charleston, SC 29406 Reports to District Traffic Engineer
District 3 Signal Shop (864) 241-1010 13 Saluda Dam Rd Greenville, SC 29611 Reports to District Traffic Engineer	**District 7 Signal Shop** (803) 531-6850 1724 Charleston Hwy Orangeburg, SC 29115 Reports to District Mechanical Engineer
District 4 Signal Shop (803) 377-4155 1143 SCDOT Rd Chester, SC 29706 Reports to District Traffic Engineer	

Figure 8-1
SCDOT Signal Shop Contact Information

In addition, SCDOT contracts out signal maintenance to local governments under Signal Maintenance Agreements. This program is described later in this chapter, however contact information for the local government signal shops is below:

City of Anderson Public Works (864) 231-2246 1100 Southwood Street Anderson, SC 29624	**Town of Mount Pleasant** Transportation Department (843) 856-3080 100 Ann Edwards Lane Mount Pleasant, SC 29464
City of Beaufort Public Works (843) 524-2777 1911 Boundary Street Beaufort, SC 29902	**City of Myrtle Beach** Public Works – Traffic Engineering (843) 918-2000 3210 Mr Joe White Avenue Myrtle Beach, SC 29577
Beaufort County Engineering and Infrastructure (843) 255-2940 113 Industrial Village Road Beaufort, SC 29906	**Town of North Augusta** Engineering and Public Works (803) 441-4223 100 Georgia Avenue North Augusta, SC 29841
City of Charleston Traffic and Transportation (843) 724-7368 180 Lockwood Drive, Ste C Charleston, SC 29403	**City of North Charleston** Public Works – Traffic Signal & Signs (843) 745-1026 5800 Casper Padgett Way North Charleston, SC 29406
City of Columbia Public Works -Traffic Engineering (803) 545-3850 2910 Colonial Drive Columbia, SC 29203	**City of Rock Hill** Utilities Department (803) 329-5500 757 S Anderson Road Rock Hill, SC 29730
City of Greenville Public Works – Traffic Engineering (864) 467-4360 26 Woods Lake Road Greenville, SC 29607	**City of Spartanburg** Public Services – Traffic Services (864) 596-3740 189 John B White Sr. Boulevard Spartanburg, SC 29306
Town of Hilton Head Island Engineering (843) 341-4600 1 Town Center Court Hilton Head Island, SC 29928	

Figure 8-2
Local Government Signal Shop Contact Information

Signal Maintenance activities are classified as Type 4 Signal Activities. Signal maintenance should be performed in accordance with:

- TG 35 – Business Rules for Signal Shops
- SCDOT Maintenance Manual Chapter 38
- Engineering Directive 2 Fiscal and Maintenance Responsibilities for Traffic Signal Installations on the State Highway system

Types of Maintenance

1. **General Maintenance** - Traffic signal maintenance generally includes performing emergency maintenance (trouble calls), addressing signals that are in emergency flash, replacing LED modules, checking and repairing loop by either repairing or re-cutting, maintaining the signal cabinet, and verifying that the wiring is in good operating shape. Trouble calls are documented in a trouble log in the cabinet. Repairing detection is vital to maintain efficient traffic flow.
2. **Extraordinary maintenance** - Extraordinary maintenance is defined as repairs needed beyond ordinary maintenance. Some examples would be a signal knockdown from a tree falling or a vehicle collision or over-height vehicle. When emergency repairs are needed beyond typical maintenance, public safety is the number one goal, and it becomes vital to reinstate signal operation as soon as possible.
3. **Preventive Maintenance** - Preventive maintenance checks are performed at each signal annually. This preventive maintenance form is completed and stored electronically within the signal management tool, TEAMS. The purpose of the check is to clean around and inside the cabinet, to replace the conflict monitor, to ensure the cabinet equipment is working properly and is appropriately inventories; other items reviewed are the operation of pedestrian treatments, appropriate clearance for signal head, and ensuring the loops are all working properly. Any items that cannot be addressed immediately are noted in TEAMS and are added to a work order list for scheduled repair, or replacements.

   Conflict monitors are removed and replaced with certified tested conflict monitors. SCDOT performs conflict monitor testing to ensure equipment removed is in working order and can be re-used at another location. Typical SCDOT Conflict Monitoring Testing Procedures are available to authorized signal maintainers in the SCDOT Sharepoint/Traffic Signals webpage.

Signal Maintainers also perform the following duties:

- Signal maintenance staff performs inspection activities for signal construction projects.
- Signal maintenance staff manages field inventory and shop inventory of signal equipment.
- Signal mainenance staff performs maintenance for specialized lighting, such as lighting on roundabouts, bridges, and overhead signing lighting.
- Signal maintenance staff is sometimes tasked with electrical repair duties on SCDOT buildings/grounds.

Standards Committee

The District Signal Superintendants participate in a Standards Committee, meeting quarterly with Traffic Signal and Systems staff from Traffic Engineering at headquarters SCDOT. The purpose of this committee is to develop maintenance, construction and equipment standards and specifications, for statewide compliance. This allow signal maintainers to assist with signal repairs statewide,

Standard Operating Procedure

The Standard Operation Procedure for for signal shops is detailed in Traffic Engineering Guideline # 35 - Business Rules for Signal Shops. SCDOT Signal Maintenance should be performed in accordance with **TG 35 – Business Rules for Signal Shops,** dated 6/30/2017 (original memo from Chief Engineer for Field Operations to DEA's 3/3/2015). These business rules address General Responsibilities, Staff and Training, Procurement, On Call Services Contracts, Maintenance and Work Order Items, Signal Projects, and Signal Shop Inventory Control.

Communications Maintenance and Implementation

Signal maintainers coordinate with both SCDOT Network Services and SCDOT Traffic Engineering (ITS and Traffic Signals and Systems) to expand the Traffic Signal Communications Network. Funding for implementaion and repairs of these Type 3 Signal Activities (See Chapter 3 Communications) is generally from the Statewide Traffic Signal Improvement funding source. These projects are managed by the Traffic Signal and Systems staff, however the field work is managed by the District Traffic Engineers and Signal maintainers. Signal maintainers are also responsible for maintaing communications to the traffic signals.

Fiscal Responsibility for Signal Maintenance

SCDOT is responsible for maintenance costs for all traffic signals and flashing beacons on the state's highway system unless noted otherwise in an agreement (encroachment permit) with a local government or other entity, or as noted below.

School Limit Sign Flashing Beacons

- SCDOT will maintain approved flashing beacons installed on SCDOT right of way. It is permissible for school facilities to pay electrical costs for power. Otherwise SCDOT will pay electrical charges
- Equipment for school speed limit sign beacons, including signs, will be paid for by the requesting entity and installed under encroachment permit. Maintenance of equipment on SCDOT right-of-way will be provided by the Department unless within the limits of a local government participating in the signal maintenance agreement program.
- Solar flashers are typically preferred for school speed limit beacons, however, if the flashers are powered from the school facility, the school will pay electric charges

Emergency Traffic Signals and Flashing Beacons at Fire Stations.

a. All costs relating to emergency traffic signals and flashing beacons for fire stations will be the responsibility of the fire department or governmental agency that funds the fire department
b. SCDOT or local government SMA partner will maintain these signals.
c. If preemption is needed for a signal at an intersection in close proximity to the fire station, the fire station or jurisdictional body is responsible for costs to install the interconnect from the fire station to the traffic signal and costs to install and maintain the switching mechanism in the fire station.

Active Railroad Warning Devices – Railroad companies are responsible for all maintenance activities and costs for maintaining railroad devices.

Signal Maintenance Agreements

SCDOT HQ Traffic Signal and Systems unit administers a Signal Maintenance Agreement program in which qualified local governments are paid by SCDOT to maintain traffic signals and flashing beacons including school flashers within and sometimes adjacent to their jurisdictions. Agreements are developed in which the local governments certify they are able to perform the necessary work to maintain traffic signals to Department standards. The signal maintenance agreements are for day-to-day maintenance of SCDOT signals. SCDOT pays a set rate for routine maintenance per signal per year, based on the device type. Additional payments are established based on the local governments performing engineering and/or operations functions. Emergency repairs are part of routine maintenance however any large equipment purchases due to emergency repairs should be reimbursed by SCDOT in addition to the set routine maintenance payment. Reimbursements for equipment and loop repair are provided based on a set percentage per base reimbursement rate. If equipment replacements exceed this amount, the local government should obtain direction and guidance from the District Traffic Engineer to ensure signals are operational.

Work requiring SCDOT review and approval

Local governments that participate in the signal maintenance agreement program must obtain approval from the District Traffic Engineer prior to installing traffic signals and flashing beacons including school flashing beacons.

If the local government is reimbursed for engineering, the local government must submit the appropriate engineering study to the District Traffic Engineer that supports the request for new signals/flashers or revisions to signals.

If approved, there are several methods to install or revise the signal or flasher:

The local government can install the new signal or flasher and SCDOT will reimburse the local government for the installation of equipment on SCDOT right-of-way, upon receipt of an invoice of materials/equipment. The invoice should be submitted to the District Traffic Engineer for reimbursement. SCDOT will not reimburse beyond the cost of labor and/or equipment on state contract. In addition, SCDOT is not obligated to reimburse the local government for any equipment that does not meet SCDOT specifications or for any non-standard signal equipment (see **Chapter 5 Equipment**).

- The local government may request SCDOT to install the new signal or flasher. This work will be performed by SCDOT forces or contract labor based on SCDOT's schedule and budget capabilities.

The new signal or flasher will be added to the list of signals in the Signal Maintenance Agreement. Maintenance and electric current costs will be paid in accordance with the agreement. If signals or flasher electrical costs are paid by others, SCDOT will not reimburse for said electrical costs.

Signal Upgrades/Replacements
Local governments should submit a prioritized list of signals to be included in the annual Signal Upgrade letting for that district.

Detection and Equipment Funding
Any malfunctioning detection should be repaired as soon as possible. These repairs can be performed by the local government or the local government may request SCDOT to perform the work. SCDOT will reimburse for the cost of these repairs using the Signal Maintenance Agreement funding, up to the allotted amount.

SCDOT will furnish or reimburse the local government for spare equipment as defined in the agreement as budgets permit. If the local government wishes to procure equipment other than what is offered on the

Department's state contract, reimbursement can be obtained up to the standard equipment rate if procured in accordance with SCDOT approved procurement methods.

SCDOT reserves the right to provide standard equipment to the local government in lieu of reimbursement for non-standard equipment. SCDOT is not obligated to reimburse the local government for purchases of non-standard equipment if prior approval has not been obtained. If the non-standard equipment violates any SCDOT policy, the SCDOT reserves the right to instruct that the equipment be removed and/or replaced at the expense of the local government. SCDOT also reserves the right to replace signal cabinets, controllers, and/or software at SCDOT traffic signals if deemed in the best public interest by SCDOT..

Signal Operations
Local governments must obtain SCDOT approval to install new signal phases or to revise the phasing operation of the signal. Occasional modifications to signal timing operations is permissible to address varying traffic conditions, however major signal system revisions should be reviewed by the local government's Traffic Engineer or SCDOT prior to implementation.

Flashing Operation
Traffic signals should remain in normal stop and go operation. Exceptions to this may occus if law enforcement personnel are directing traffic for special or emergency conditions. The signal may also be placed in flashing operation when construction/maintenance personnel are directing traffic due due to construction or signal maintenance activities. The signal may go into emergency flash due to malfunction, power surges or restarting after an electrical outage. Signal maintenance staff should place the signal back into normal operation as soon as feasible.
SCDOT does not recommend the use of Late Night Flash (LNF) operation as a method to reduce delay at signalized intersections during late night hours. The signal timings and/or equipment settings should be

adjusted in a manner that would reduce delay during periods of low volume.

- Implement a late night timing plan with a reasonably low cycle length
- Install pedestrian push buttons and reduce the minimum green values.
- Install or repair loop detection (for pre-timed or semi-actuated signals) and remove the delay value from the loop detectors at night.

The implementation of one or all of these options will allow the signal to operate on a much shorter cycle length and will reduce delay on the side streets.

If implementing these options is not feasible or is unsuccessful, either due to limitations on funding or controller capabilities, the use of LNF operation may be considered if an engineering study indicates the safety of the intersection is not compromised. At a minimum, this study should include the following information:

- Traffic volumes for each approach recorded at 15-minute intervals for a period of 24 hours. If there are protected left turn movements and/or if right turns are observed to carry most of the volume for the minor street, they may need to be counted separately from the thru volumes. Separate counts are needed for weekday and weekend studies. Weekday studies should be conducted between Monday PM and Thursday AM. Weekend studies should be conducted between Friday PM and Sunday AM.
- Observations of vehicle classifications for each movement including cars, trucks, public transit vehicles, pedestrians, and bicyclists.
- Posted speed limit or 85th percentile speed for each approach.
- Condition diagram showing intersection characteristics such as geometrics, channelization, grades, sight-distance restrictions, transit stops and routes, parking conditions, pavement markings, roadway lighting, driveways, railroad crossings, and adjacent land use (particularly businesses that are open late within a quarter-mile of the intersection and on the opposite side of the major street from a neighborhood).
- Collision diagram showing crash type, location, movement direction, severity, weather, time of day, date, and day of week for at least one year.
- Proposed hours of flashing operation.

LNF operation is not recommended if any of the following apply:

- Posted speed limit is higher than 35mph for any approach.
- More than two approach lanes exist on each leg of the major route.
- More than eight total approach lanes exist for all legs of the intersection (including left turn lanes).
- Large number of trucks exist on the minor street (or in protected left turn movements).
- The two-way traffic volume for the major street exceeds 500vph
- The highest volume approach for the minor street volume exceeds 150vph.
- Sight distance restrictions exist.

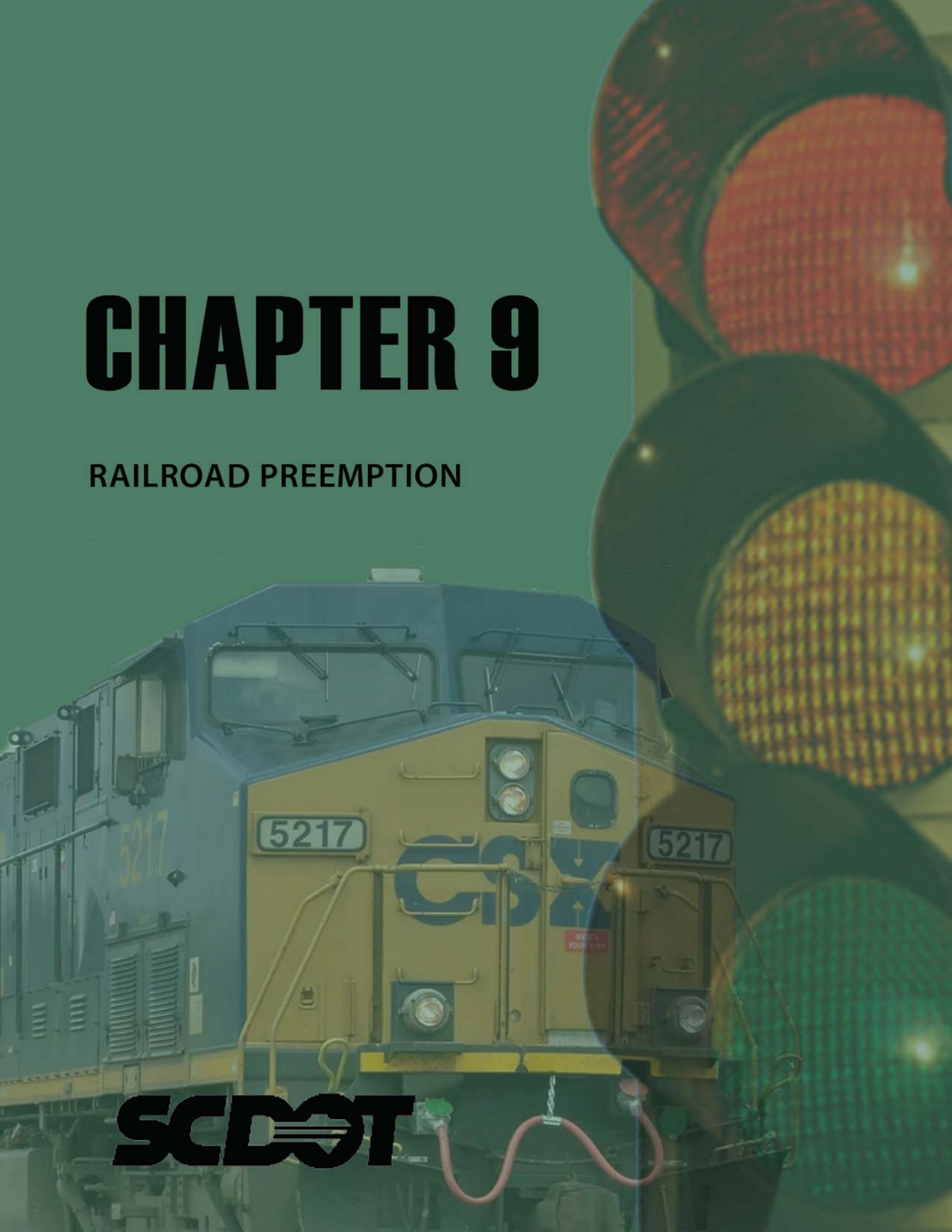
The study should include all of the aforementioned information and should meet all of the recommendations. Any exception to the recommendations included here should be noted in the study with justification for the exception. If approved, LNF should be used no less than two consecutive hours, preferably four. If bars or other late-night establishments are located nearby the LNF operation should not be used until at least one hour after closing time. LNF is not required to be used every night of the week and can be used on weekdays, weekends, or both. LNF operation should be monitored and revised if safety issues are noted.

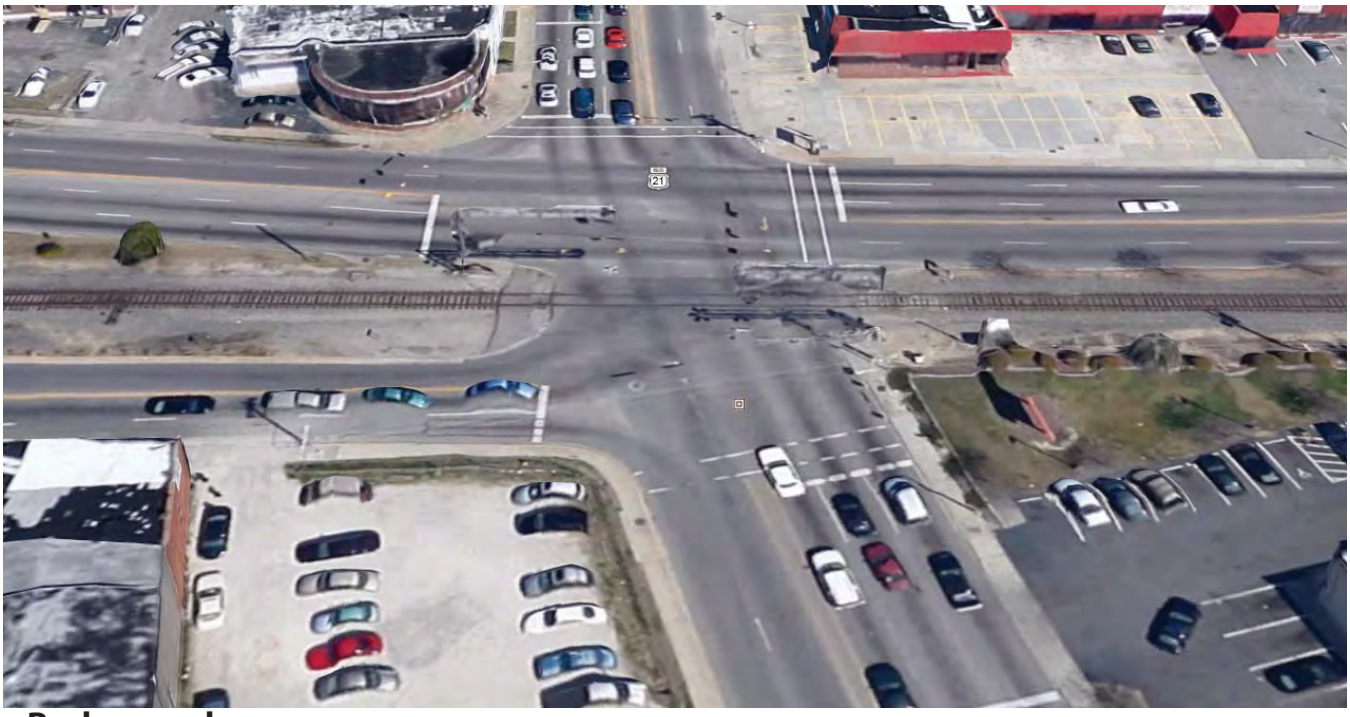
Electric Current Costs

Electric bills for signal electric costs for SCDOT maintained signals are generally sent to and paid out of the local SCDOT Maintenance office budget. SCDOT generally reimburses local governments participating in the signal maintenance agreement program for electric current costs. Some entities pay electrical costs based upon agreements (encroachment permits) with SCDOT, such as for signals or beacons at fire stations, schools, or private driveways.

CHAPTER 9

RAILROAD PREEMPTION





Background:

When at grade railroad crossings and traffic signals are in close proximity, it is imperative that they work together to discourage motorists from stopping on the tracks.Therefore, these design standards have been written to assist the engineer in developing and maintaining traffic signals preempted by active railroad warning devices. In addition, guidance is given to assist the engineer in making a decision concerning the need for interconnection, based on nationally accepted practice. Ultimately, engineering judgement should be used conderning design and implementation.

Preemption

Preemption 'interuppts' normal signal operation to clear the track area prior to train arrival at the intersection. During activation of the railroad warning devices, the signal enters into this special railroad preemption operation utilizing a direction wire connection between the railroad devices the signal cabinet. The traffic signal remains in railroad preemption operation until the train deactivates the railroad warning devices. The traffic signal exits railroad preemption operation and resumes normal operation.

Review:

When interconnection between active railroad warning devices and a traffic signal is required, a signal plan shall be submitted by the District Traffic Engineer or other qualified engineer to the Director of Traffic Engineering for review and approval. The Director of Traffic Engineering will review and approve the signal plan and coordinate with the railroad company to implement the needed changes. A preemption agreement may be developed to detail the needed work and the responsibilities of the parties involved, and provide a cost estimate for the work.

Funding:

Typically, Railroad Companies required SCDOT to pay for Railroad Warning Device installations and upgrades. Railroad Companies also invoice SCDOT for processing Preemption Agreements including engineering and installation fees. Funding for this work should be obtained from projects where these improvements are required as part of the scope.. Examples of these projects include Railroad Upgrades, roadway construction, encroachment permit, local option sales tax projects. If project funds are not available, other funding sources are signal maintenance funds or signal upgrade/installation funds.

Railroad Companies:

There are several railroad companies operating in South Carolina. Each railroad company has a different process for implementing and installing interconnection. Care should be taken to contact the appropriate railroad company to ensure that the proper procedures are met when requesting interconnection. In addition, each railroad company has different permitting requirements when working within the railroad right of way. Generally, Insurance, right of entry permits, and or flagging operations are required. The railroad may require plans, details and elevations to detail the proximity between the traffic signal equipment and railroad tracks and devices. Overhead spans are not usually permitted. At locations where the railroad track has an existing span over the track, the railroad company may not permit replacement of the span. Underground conduits are preferred and boring under the tracks is generally performed by the railroad company under agreement with SCDOT, where SCDOT pays the railroad for any work required and agreed upon by both parties.

References :

Below are other sources of information for at grade railroad crossings.

- **Manual on Uniform Traffic Control Devices** Chapters 4 and 8.
- **Preemption of Traffic Signals near Railroad Crossings** - ITE 2006
- FHWA Railroad - Highway Grade Crossing Handbook - latest edition

Conditions for Interconnection

Below are the items to consider when determining if interconnection is needed at new or existing traffic signals:

- Rail crossing is typically within 200' of signalized highway intersection (Not limited to 200', but rarely greater than 500')
- Queuing regularly[1] occurs within Track Clearance Distance
  Regularly is defined as the queuing that occurs within the TCD during normal peak traffic times. This can be determined by observation or see "Design Guidelines for Railroad Preemption at Signalized Intersections" ITE Journal, February 1997, for estimating queues.
- Active railroad warning devices are existing or planned
- Train speeds exceed 20 mph

Conduct Field Review

Obtaining geometric information concerning proximity of the railroad track with adjacent intersection, signing, marking and signals is vital in designing railroad preemption operation. Engineers should review location in field to obtain the following information:

- Existing signs and markings, utilities & signal components
- Roadway Geometry such as travel lanes and uses
- Existing/proposed active railroad warning devices (gates, flashers), cabana location, maximum train speed, train activity, activation distance
- Measure Clear Storage Distance (CSD) and Track Clearance Distance (TCD) as indicated below:

  The Track Clearance Distance (TCD) is measured from 6' downstream of the rail to 12' upstream from the center line of the rail. The national terminology indicates a couple of other areas that could be the measuring point, upstream of the rail, including the railroad stop bar on the track approach or the railroad-warning device. The Department typically uses the 6' and 12' measurement.

  If the track and the roadway are not perpendicular, care should be taken to measure the longest distance, using either the edge of pavement or the center line, depending on the skew. The longest TCD should be measured for the track clearance calculation.

  The Clear Storage Distance (CSD) is measured from the edge of the TCD (6' from the rail) to the stop bar or the normal stopping point of the adjacent signalized intersection.

If the track and the roadway are not perpendicular, care should be taken to measure the shortest distance, using either the edge of pavement or the center line, depending on the skew. The shortest CSD should bemeasured for the track clearance calculation.

Figure 9-1 is provided for assistance in determining the appropriate measurement of the TCD and the CSD.

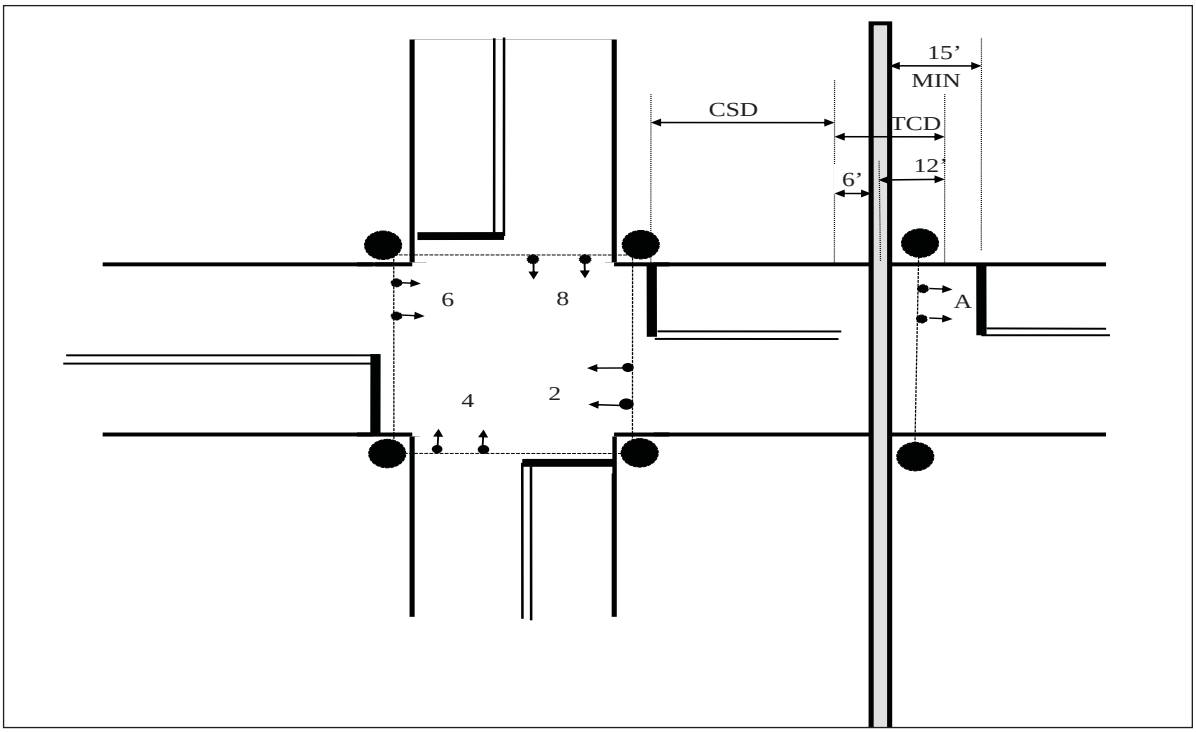


Figure 9-1
TCD, CSD Measurement Guide

Determine Storage Availability
Determine if adequate storage is available in the CSD for the vehicles. If not, provide stop bar in advance of track with detection device for those vehicles unable to store in CSD without overhanging into the TCD area. When CSD is severely limited, consider stopping all vehicles in advance of track, using "Stop Here on Red" signs.

Determine Need for Presignals
Pre-signals are signal heads used as supplemental signal displays that display red indications during preemption to prevent vehicles from entering the TCD . Below are criteria to determine if pre-signals are a good tool to use.

- If railroad gates are not present or planned, and the geometric design of the intersection allows vehicles to store between the intersection and the at-grade crossing (within the CSD), consider using a pre-signal
- If advanced preemption (not simultaneous preemption) is provided, consider using pre-signals to control traffic since railroad warning devices will not be activated until after the preemption clear sequence has begun.
- If timed overlap is used, pre signals would be needed even if gates are present.

If pre-signals are used:

- Presignals should display two red indications per traffic approach.
- A stop bar in advance of the grade crossing should be provided when using pre signals.

Typically, pre-signals are placed on the approach side of the crossing and care should be taken to prevent their placement from blocking the visibility of any overhead railroad flashers. Pre-signals are supplemental traffic control equipment, to reinforce the message the railroad's active warning devices are displaying. As such, they are targeted to motorists approaching the rail/grade crossing. It is desirable to place the pre-signals where they would be visible from the stop bar on the upstream side of the crossing. However in many cases, the appropriate stopping point for motorists waiting on a train to clear the track is too close to the crossing to be able to obtain 40' between pre-signals and stop bar. The engineer should attempt to obtain the maximum distance between the pre-signal and stop bar possible, not to exceed a reasonable stopping distance for motorists approaching the grade crossing.

RYG Pre-signal

One type of pre-signal is the "R, Y, G" signal, used to operate a timed overlap that "clears" the TCD during both normal and preempted signal operation. A timed overlap (see Figure 9-2) extends the green time on the same approach, at the downstream intersection signal heads, while the "pre-signal" (upstream in advance of the railroad crossing) heads clear to yellow and red. The green is typically extended 3 to 5 seconds, based on the TCD & CSD distance. During preemption, the green time may be extended for a greater period of time than during normal operation, if necessary.

These are often used when the CSD is inadequate to store vehicles, but where it is not practical to stop all vehicles in advance of the crossing. These are also used when a frontage road (parallel and adjacent to the track on the upstream side of the crossing) exists to prevent blocking of the frontage road.

These pre-signals may be used regardless of the type of active railroad warning device and should be designed to operate effectively during both normal operation and preempted operation.

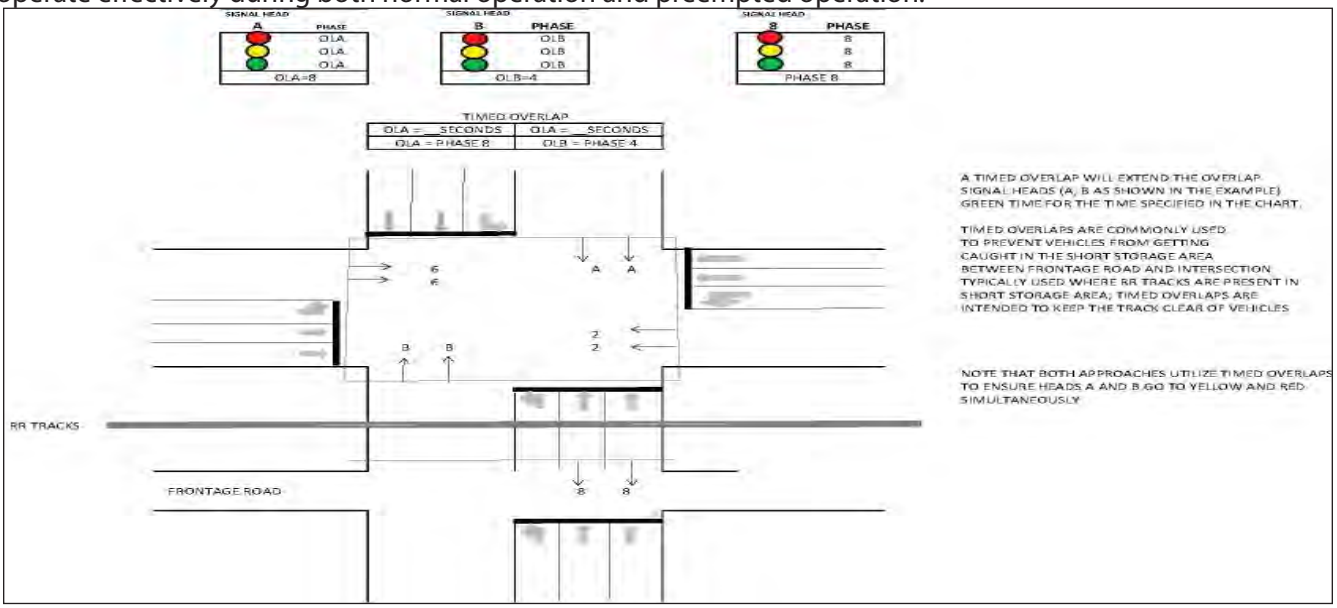


Figure 9-2
Timed Overlap Operation

RYY Pre-signal

Another type of pre-signal is the "R, Y, Y" signal, where the bottom section is an 8" section yellow, while the top and middle sections are 12" red and yellow sections, respectively. During normal operation, the bottom yellow section flashes yellow at all times. Upon preemption activation, the signal display changes from flashing yellow on the 8" head to a solid yellow on the middle head and then a solid red on the top head, and remains solid red until the preemption call is dropped. These pre-signals serve as a supplemental indication at those locations that serve a track clearance phase during preemption.

This type of pre-signals should be installed if railroad gates are not present and a track clearance phase is planned to operate within the preemption sequence.

RYG Pre-signal

RYY Pre-signal

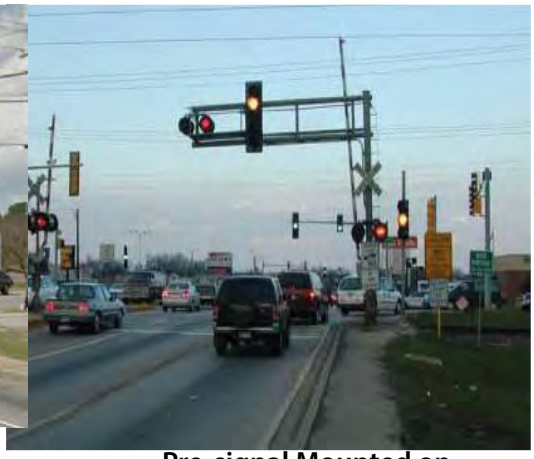
Pre-signal Placement

- Placing pre-signals on upstream side of rail/grade crossing, as close as possible to active warning devices. Place stop bar as far a feasible from the active warning device, between 15 and 40'.
- Placing the pre-signals on the railroad's cantilever structure (must obtain permission from the railroad)

If engineers determine that pre-signal heads are needed in advance of the railroad track(s), a physical connection (electric cable) is required between the pre-signal heads and the signal cabinet. Providing this physical connection will require either underground conduit bored under the track or an overhead connection on span over the track. Railroad companies do not typically allow overhead spans. Railroad companies may require their own contractors to perform boring under the tracks. Coordinating with the railroad to provide these services may be time consuming and delay the work.

- Placing the pre-signals on the downstream side of the rail/grade crossing either mounted separately or on the near side intersection signal span wire (When the train occupies the crossing, the visibility of these signal heads may become blocked by the train

Pre-signal Mounted Up Stream of Rail/Grade Crossing



Pre-signal Mounted on Railroad Cantilever

Maximum Signal Preemption Time (MSPT)
The Maximum Signal Preemption Time is the amount of time required to exit normal signal operation and enter Preemption Hold Interval. This time is limited as it begins when the train activates the railroad warning devices and should be well underway before the train arrives at the signal. This time is caculated by summing the Right of Way Transfer Time (RTT) and Queue Clearance Time (QCT).

Right of Way Transfer Time (RTT)
Is the maximum amount of time needed for the worst-case condition, prior to display of the clear track green interval or the preemption hold interval. This includes any pedestrian clearance, minimum green, yellow clearance, and red clearance interval for opposing traffic. Use maximum value of all phase combinations to determine MSPT.

Pedestrian Clearance - If pedestrian treatment is present or needed, certain measures must be implemented to ensure appropriate clearance is provided for both the pedestrian phase and the track clearance phase.

- If push buttons, only, are present, when preemption occurs, the controller may be programmed to immediately leave the current phase, serving only the yellow and red clearances.
- If pedestrian heads are existing or required, that cannot run simultaneous with the track clear approach, any pedestrian activation will have to be cleared prior to running the track clearance phase. The Walk phase may be immediately terminated, however a pedestrian clearance, a Flashing Don't Walk indication, must be served. This pedestrian clearance (flashing don't walk) time may be reduced upon preemption. To calculate this value divide the crossing distance by 5 feet/sec.. and subtract out the normal operation yellow and red clearances; If the Total Railroad Warning Time (TRWT) is severely limited the reduced clearance time may be shortened to run concurrently with the normal operation yellow and red time.

Minimum Green - Use only if engineering study indicates it is vital to safety of intersection and if adequate Railroad Warning Time is available.

Yellow Clearance - This is the normal operation yellow time for the phase that is operational when preemption occurs; do not reduce.

Red Clearance - This is the normal operation red time for the phase that is operational when preemption occurs; do not reduce.

Queue Clearance Time (QCT)
Queue Clearance Time is the "track clearance" time equal to the track approach green, yellow and red (optional), calculated by summing the Track Approach Green Time, the Yellow Clearance and the Red Clearance:

Track Approach Green Time **-** There are two ways of calculating the track approach green time:

- If Clear Storage Distance < Design Vehicle Length, the storage length to be cleared would be equal to Track Clear Distance + Clear Storage Distance. This will allow the design vehicle stopped within the TCD to clear the TCD area.
- If Clear Storage Distance > Design Vehicle Length, the storage length to be cleared would be equal to the Track Clearance Distance

Use Greenshields formula shown below &/or field observations to determine the track approach green time.

Track Approach + Green Time = 4 + 2N

N = Number Of Vehicles Queued In Area

4 = Startup Time

2 = Headway Factor

Field observations should include observing and measuring queue clearance times during peak traffic times and off peak times, noting operational characteristics of vehicles crossing and moving through the Clear Storage Distance & Track Clear Distance.

Yellow Clearance - This is the normal operation yellow time for the Queue Clearance phase; do not reduce.

Red Clearance - This is the normal operation red time for the Queue Clearance phase; do not reduce.

RIGHT OF WAY TRANSFER TIME (RTT) - SECONDS	PHASE 1/5	PHASE 2/5	PHASE 1/6	PHASE 2/6	PHASE 3/7	PHASE 3/8	PHASE 4/7	PHASE 4/8
Pedestrian Clearance if applicable								
Minimum Green*								
Yellow Change								
Red Clearance								
TOTAL								
USE WORSE CASE TO CALCULATE MSPT								

QUEUE CLEARANCE TIME (QCT) - SECONDS		PHASE		PHASE	
Track Approach Green Time					
Yellow Change	+		+		
Red Clearance					**TOTAL**
TOTAL	=		=		
TYPICALLY ONLY ONE PHASE TO CLEAR , BUT THE TRACK COULD CROSS 2 STREETS, REQUIRING 2 PHASES TO CLEAR					

MAXIMUM SIGNAL PREEMPTION TIME (MSPT)

RTT (RIGHT OF WAY TRANSFER TIME) USE LARGER VALUE CALCULATED FOR WORSE CASE SCENARIO)	+	
QCT (QUEUE CLEARANCE TIME) UIF MORE THAN ONE PHASE IS CLEARED, USE SUM OF THE PHASES		
TOTAL	=	

Figure 9-3
Calculation for Maximum Signal Preemption Time

Total Railroad Warning Time (TRWT)

Typically railroad companies provide a minimum of 20 seconds Railroad Warning Time (RWT) between activation of the railroad warning devices to the presence of the train in the crossing. Additional time may be available due to the type of warning device, width of crossing and speed of train. Unless the railroad company specifically indicates additional time is provided, SCDOT should plan on 20 seconds as the target time to have the track cleared. The Railroad Companies are required to provide a minimum of 20 seconds of warning time at locations where train speeds are 20 mph or higher. Railroad companies calculate TRWT in accordance with ***AREMA Signal Manual part 3.3.10.*** The Total Railroad Warning Time should be obtained from the railroad company.

Separation Time (ST)

The component of maximum preemption time during which the TCD is clear of vehicular traffic prior to the arrival of the train. This value can be calculated by subtracting the MSPT from the TRWT. A value of 2 seconds minimum is desirable but is not always possible.

SEPARATION TIME

TOTAL RAILROAD WARNING TIME (TRWT) *OBTAIN VALUE FROM RAILROAD COMPANY - ASSUME 20 SECONDS IF NO INFORMATION IS AVAILABLE*	-	
MSPT (MAXIMUM SIGNAL PREEMPT TIME)		
SEPARATION TIME = TRWT MINUS MSPT	=	

Figure 9-4
Calculation for Separation Time

Simultaneous vs. Advance Preemption

Simultaneous Preemption is the simultaneous notification of an approaching train to the highway traffic controller unit and railroad active devices.

Advance Preemption is prior notification of an approaching train to the highway traffic controller unit by railroad in advance of railroad active-warning device activation.

If Total Railroad Warning Time is greater than or equal to Maximum Signal Preemption Time:

- Use Simultaneous Preemption, meaning the notification of an approaching train is forwarded to the highway traffic controller unit and railroad active devices at the same time. If needed, re-review signal operation to ensure operation is as desired.

If Total Railroad Warning Time is less than Maximum Signal Preemption Time:

- Re-review signal operation and make adjustments to the "Maximum Signal Preemption Time" within engineering judgment.
- If MSPT cannot be reduced, conduct engineering study to determine how much additional time is needed and coordinate with railroad company to determine if advanced preemption is appropriate.

Preemption Hold Interval

Engineers should consider traffic volumes, number and types of travel lanes, signal phasing and sight distance when deciding the type of Preemption Hold Interval. The two types are Limited Service operation and Flashing operation.

Limited Service allows certain phases, that do not conflict or direct traffic to the at-grade crossing, to operate a normal green, yellow, red sequence. These are typically feasible with multiple lane approaches where the mainline traffic runs parallel to the railroad track. Limited service allows the operation of turn phases as well as through phases, as long as traffic is not directed to the track area.

Flashing best suits those areas that have one-lane approaches, where traffic volumes are either low on the side streets, or equal between mainline and side street. It is also used where the at-grade crossing crosses the mainline roadway. Flashing operation typically flashes red to the road perpendicular to the railroad track and yellow on the parallel roadway, however an all way red flash can also be used, as appropriate.

Exiting Preemption Hold Interval

(re-entering normal operation)

Exiting Limited Service - Upon exiting limited service operation, the signal shall resume normal operation by remaining in the current phase being served until the phase would normally time out and then serve the next phase shown in the phasing diagram on the traffic signal plan.

Exiting Flashing Operation - Exiting flashing operaton should comply with MUTCD Section 4D.31.

- Exiting Red-Red Flash - Is when the intersection functions as a All-Way Stop controlled intersection. When transitioning to steady mode, the intersection is first brought into a six second All-Way steady red configuration. After the six second steady red clearance interval has been provided, the first movements to be shown a green indication will be the through movements on the major street.
- Exiting Yellow-Red Flash - When transitioning to a steady mode, the signals facing the major-street traffic. Go directly from flashing yellow to steady green, and the signals facing the minor street traffic go directly from flashing red to steady red.

Consideration should be given to service the minor street at the earliest opportunity when the minor street crossed the track and there is significant queuing. The green time for the major street may be minimized to serve the minor street, as soon as possible upon resuming normal operation.

RAILROAD PRE-EMPTION SEQUENCE

SIGNAL HEAD NUMBER	CONDITION 1 INTERVAL							CONDITION 2 INTERVAL							F.CLEAR INTERVAL
	R/W	1	2	5	6	7	8	R/W	3	4	5	6	7	8	9
2	G	Y	R	R	R	R	Y^F	R	R	R	R	R	R	Y^F	G
4	R	R	R	G	Y	R	R^F	G	G	G	G	Y	R	R^F	R
6	G	Y	R	R	R	R	Y^F	R	R	R	R	R	R	Y^F	G
8	R	R	R	R	R	R	R^F	G	Y	R	R	R	R	R^F	R
SIGN"X"	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF
TIMINGS	*	5.0	2.3	12.0	3.9	2.3	**	*	3.9	2.3	12.0	3.9	2.3	**	A

* NORMAL R/W OPERATION GO IMMEDIATELY TO NEXT INTERVAL.

** INTERVAL TO CONTINUE UNTIL PRE-EMPTION TERMINATES, THEN ENTER NORMAL OPERATION IN INTERVAL 9.

A NORMAL OPERATION WILL RESUME IN Ø2-Ø6.

CONDITION 1 - PRE-EMPTION OCCURS DURING Ø2-Ø6 GREEN.

CONDITION 2 - PRE-EMPTION OCCURS DURING Ø4-Ø8 GREEN.

IF PRE-EMPTION OCCURS DURING ANY PHASE YELLOW OR ALL RED CLEARANCE, BEGIN CONDITION 1 SEQUENCE, STARTING WITH INTERVAL 5, ONCE YELLOW AND RED HAVE TIMED OUT.

TRACK CLEARANCE Ø4 = 12.0"

PREEMPTION HOLD INTERVAL = Y^F = Ø2, Ø6

R^F = Ø4, Ø8

Figure 9-5
Example Preemption Sequence Chart
Preemption Hold Interval - Yellow/Red Flash

RAILROAD PRE-EMPTION SEQUENCE

SIGNAL HEAD NUMBER	CONDITION 1 INTERVAL							CONDITION 2 INTERVAL							CONDITION 3 INTERVAL							F.CLEAR INTERVAL		
	R/W	1	2	7	8	9	10	R/W	3	4	7	8	9	10	R/W	5	6	7	8	9	10		11	N.O.
6	G	G	G	G	Y	R	R^F	G	G	G	G	Y	R	R^F	R	R	R	G	Y	R	R^F		R	G
4	R	R	R	R	R	R	R^F	R	R	R	R	R	R	R^F	G	Y	R	R	R	R	R^F		R	R
1,6	←G	←G	←G	←G	←Y	R	R^F	G	G	G	←G	←Y	R	R^F	R	R	R	←G	←Y	R	R^F		R	G
2	R	R	R	R	R	R	R^F	G	Y	R	R	R	R	R^F	R	R	R	R	R	R	R^F		R	G
8	R	R	R	R	R	R	R^F	R	R	R	R	R	R	R^F	G	Y	R	R	R	R	R^F		R	R
8,1	→R	→Y R	R	R	R	R	R^F	R	R	R	R	R	R	R^F	G	Y	R	R	R	R	R^F		R	R
SIGN"X"	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON		ON	OFF
SIGN"Y"	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON		ON	OFF
TIMINGS	*	4.0	2.0	14.0	4.0	2.0	**	*	4.0	2.0	14.0	4.0	2.0	**	*	3.5	2.5	14.0	4.0	2.0	**		3.0	A

* NORMAL R/W OPERATION GO IMMEDIATELY TO NEXT INTERVAL.

** INTERVAL TO CONTINUE UNTIL PRE-EMPTION TERMINATES, THEN BEGIN FINAL CLEAR IN INTERVAL 11.

A NORMAL OPERATION WILL RESUME IN 02-06.

CONDITION 1 - PRE-EMPTION OCCURS DURING 01-06 GREEN.

CONDITION 2 - PRE-EMPTION OCCURS DURING 02-06 GREEN.

CONDITION 3 - PRE-EMPTION OCCURS DURING 04-08 GREEN.

IF PRE-EMPTION OCCURS DURING ANY PHASE YELLOW OR ALL RED CLEARANCE, BEGIN CONDITION 1 SEQUENCE, STARTING WITH INTERVAL 7, ONCE YELLOW AND RED HAVE TIMED OUT.

RAILROAD PREEMPTION
TRACK CLEARANCE 01-6 EB = 14.0"
PREEMPTION HOLD INTERVAL: ALL WAY RED FLASH

Figure 9-6
Example Preemption Sequence Chart
Preemption Hold Interval - All Way Red Flash

RAILROAD PRE-EMPTION SEQUENCE

SIGNAL HEAD NUMBER	CONDITION 1 INTERVAL							CONDITION 2 INTERVAL							CONDITION 3 INTERVAL						
	R/W	1	2	11	12	13	LS	R/W	3	4	11	12	13	LS	R/W	5	6	11	12	13	LS
1	←	←Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
2	R	R	R	R	R	R	LS	G	Y	R	R	R	R	LS	R	R	R	R	R	R	LS
3	R	R	R	G	Y	R	R	R	R	R	G	Y	R	R	G	G	G	G	Y	R	R
4	R	R	R	R	R	R	R	R	R	R	R	R	R	R	↑	Y	R	R	R	R	R
5	←	←Y	R	R	R	R	LS	R	R	R	R	R	R	LS	R	R	R	R	R	R	LS
6	R	R	R	R	R	R	LS	G	Y	R	R	R	R	LS	R	R	R	R	R	R	LS
4,5	↗	Y↗	R	R	R	R	LS	R	R	R	R	R	R	LS	↗	Y↗	R	R	R	R	LS
8,1	R↗	R↗	R	G	Y	R	R	R	R	R	G	Y	R	R	G	G	G	G	Y	R	R
9	RR	RR	RR	←	←Y	RR	RR	RR	RR	RR	←	←Y	RR	RR	RR	RR	RR	←	←Y	RR	RR
SIGN"Y"	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON
TIMINGS	*	3.5	6.0	13.0	4.0	3.5	**	*	4.5	2.5	13.0	4.0	3.5	**	*	4.0	3.5	13.0	4.0	3.5	**

SIGNAL HEAD NUMBER	CONDITION 4 INTERVAL							CONDITION 5 INTERVAL							CONDITION 6 INTERVAL					L.S. CLEARANCE PHASE 2-5			PHASE 2-6			PHASE 3-
	R/W	7	8	11	12	13	LS	R/W	9	10	11	12	13	LS	R/W	11	12	13	LS	R/W	CLEAR		R/W	CLEAR		R / W
1	←	←Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
2	R	R	R	R	R	R	LS	G	Y	R	R	R	R	LS	R	R	R	R	LS	G	Y	R	G	Y	R	R
3	R	R	R	G	Y	R	R	R	R	R	G	Y	R	R	G	G	Y	R	R	R	R	R	R	R	R	G
4	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
5	R	R	R	R	R	R	LS	←	←Y	R	R	R	R	LS	R	R	R	R	LS	←	←Y	R	R	R	R	R
6	G	Y	R	R	R	R	LS	R	R	R	R	R	R	LS	R	R	R	R	LS	R	R	R	G	Y	R	R
4,5	R	R	R	R	R	R	LS	↗	Y↗	R	R	R	R	LS	R	R	R	R	LS	↗	Y↗	R	R	R	R	R
8,1	R↗	R↗	R	G	Y	R	R	R	R	R	G	Y	R	R	G	G	Y	R	R	R	R	R	R	R	R	G
9	RR	RR	RR	←	←Y	RR	RR	RR	RR	RR	←	←Y	RR	RR	←	←	←Y	RR	RR	RR	RR	RR	RR	RR	RR	←
SIGN"Y"	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON	ON	OFF	ON	ON	ON	ON	ON	OFF
TIMINGS	*	3.5	6.0	13.0	4.0	3.5	**	*	3.5	6.0	13.0	4.0	3.5	**	*	13.0	4.0	3.5	**	L.S.	3.5	6.0	L.S.	4.5	2.5	A

* NORMAL R/W OPERATION GO IMMEDIATELY TO NEXT INTERVAL.

INTERVAL TO CONTINUE UNTIL PRE-EMPTION TERMINATES, THEN BEGIN FINAL CLEAR IN INTERVAL 11.

** LIMITED SERVICE INTERVAL TO BEGIN, SERVING PHASE 02-05 & PHASE 02-06 UNTIL PRE-EMPTION TREMINATES. THEN BEGIN FINAL CLEAR AS SHOWN.

A NORMAL OPERATION WILL RESUME IN 03-08.

CONDITION 1 - PRE-EMPTION OCCURS DURING 01-05 GREEN.
CONDITION 2 - PRE-EMPTION OCCURS DURING 02-06 GREEN.
CONDITION 3 - PRE-EMPTION OCCURS DURING 04-08 GREEN.
CONDITION 4 - PRE-EMPTION OCCURS DURING 01-06 GREEN.
CONDITION 5 - PRE-EMPTION OCCURS DURING 02-05 GREEN.
CONDITION 6 - PRE-EMPTION OCCURS DURING 03-08 GREEN

IF PRE-EMPTION OCCURS DURING ANY PHASE YELLOW OR ALL RED CLEARANCE, BEGIN CONDITION 1 SEQUENCE, STARTING WITH INTERVAL 11, ONCE YELLOW AND RED HAVE TIMED OUT.

RAILROAD PREEMPTION
TRACK CLEARANCE PHASE 8 WB = 20.0"
PREEMPTION HOLD INTERVAL: LIMITED SERVICE PHASES 1,2,6

Figure 9-7
Example Preemption Sequence Chart
Preemption Hold Interval - Limited Service

Railroad Preemption Sequence Chart

The Railroad Preemption Sequence Chart is not required on the signal plan, however it is a good design tool to ensure the preemption operation is appropriate. It can also assist during reviews to check preemption in the field. The signal plan should have the following information:

RAILROAD PREEMPTION OPERATION:
TRACK CLEARANCE PHASE __ = __ SECONDS
PREEMPTION HOLD INTERVAL: _____
(Limited Service for Phases _____ or Yellow Flash Phase __ Red Flash Phase _ or All Way Red Flash)

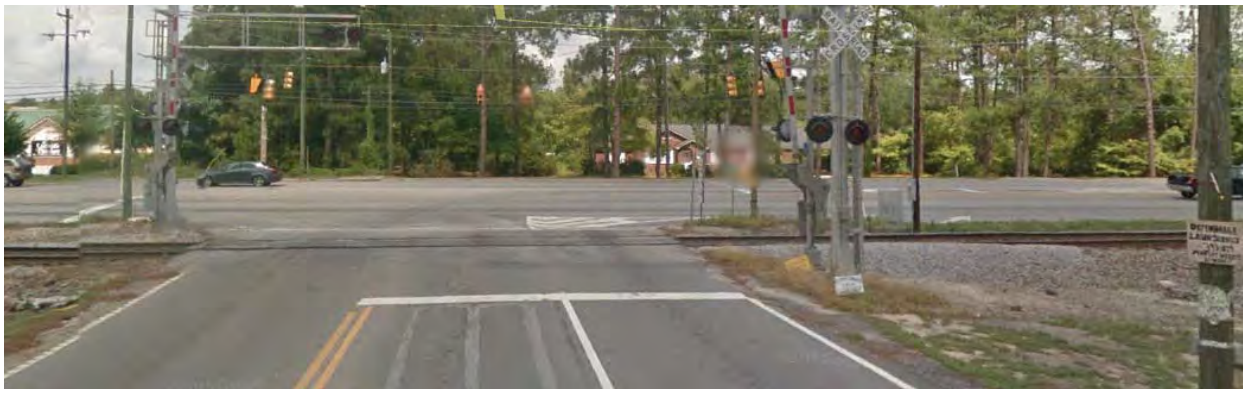
Connection between Railroad Cabana and Traffic Signal Cabinet

A physical electric cable connection is required between signal cabinet and railroad cabana. The cable connection is provided in a common splice box placed near the railroad cabana.

Vehicle Detection in Advance of Railroad Crossing

If engineers determine that vehicle detection is needed in advance of the railroad track(s), several options may be considered:

- inductive loops - this will require a physical connection (home run cable) between the detection loop and the signal cabinet. Providing this physical connection will require either underground conduit bored under the track or an overhead connection on span over the track. Railroad companies do not typically allow overhead spans. Railroad companies may require their own contractors to perform boring under the tracks. Coordinating with the railroad to provide these services may be time consuming and delay the work.



- Video Detection or Wireless Detection equipment can typically be installed on the same side of the track as the signal cabinet, eliminating the need to cross the track (under or over) with a physical connection. These alternatives to inductive loops may reduce the amount of time and coordination with the railroad company, making these tools a more viable option.

Battery Back Up System

Active railroad devices, such as railroad flashers and gate assemblies, have battery back ups in place. When traffic signals interconnected with railroads are upgradded, a battery backup system is installed.

Blank out Signs

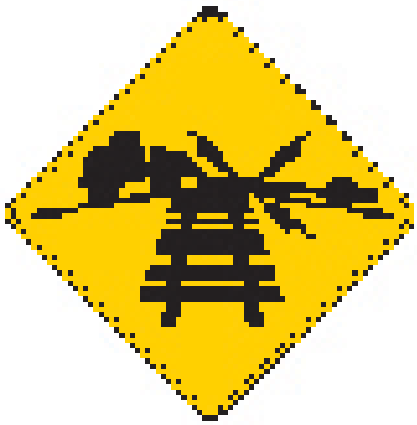
The MUTCD requires blank out signs or phase restrictions across the track during pre-emption. The SCDOT uses 24" No Right Turn or No Left Turn Blank out signs.

Signs and Markings pertinent to Railroad Preemption

At preempted locations we typically use the "Do Not Stop on Track" sign and the "Turn Restriction" blank out signs. Other signs that may be appropriate are the "Stop Here on Red", "Oncoming Traffic May Have Extended Green", signs or the "No Turn on Red" signs. We recommend the use of these signs as appropriate based on an engineering study.

For more information on railroad signs refer to the Manual on Uniform Traffic Control Devices Chapter 8.

R8-8



W10-1