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Development of Minimum Standards for Event-based Data Collection Loggers and Performance Measure Definitions for Signalized Intersections

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Disclaimer

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation (FDOT) or the U.S. Department of Transportation.

Metric Conversion Table

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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16. Abstract The arterial traffic signal performance measures were not used to their fullest potential in the past. The development of traffic signal controllers with event-based, high-resolution data logging capabilities enabled the advances in derivation and visualization of traffic signal performance measures. Florida Department of Transportation (FDOT) engaged in an effort to standardize those measures across various traffic controller types to ensure uniform implementation of such practices in the future controllers' deployments. This report contains the findings of a study whose goal was to investigate the capabilities and features of six different controllers from six vendors, which were connected simultaneously into a Hardware-in-a-Loop Simulation (HILS) test setup. The first objective of the study was to determine the minimum standards that the new event-based high-resolution traffic signal controller needs to fulfill to be approved for future installations in Florida. For this purpose, a unique set of mandatory and optional event codes was determined. The second objective was to check ability to retrieve and consistency of various performance measures from different controllers. The characteristics of each controller, the procedures for building the HILS test setup, controller configurations, retrieving of the high resolution data locally (by using File Transfer Protocol), and the online tool (FDOT server) for calculating and graphically representing relevant performance measures (Purdue Coordination Diagram, Percentage of Arrivals on Green, Platoon Ratio, and others) were tested.			
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Executive Summary

The development of traffic signal controllers with event-based, high resolution data logging capabilities introduced new possibilities for data collection and derivation and visualization of signal performance measures (SPMs). The Florida Department of Transportation (FDOT) decided to consider using high resolution data logging for future acquisitions of traffic controllers. Also, the FDOT has decided to introduce standards for HR data logging for any future controllers to be deployed within the state of Florida. Such standards should prescribe what event logs are mandatory for controllers and vendors to report to ensure that HR SPMs can be retrieved through the Web-interface software adopted by FDOT, and originally developed by Utah DOT based on the preliminary projects from Indiana DOT and Purdue University. Although specifications for HR event logs have been established by Purdue University, vendors have not always adhered to those specifications. Thus, there is a need to ensure standardization of controllers' logs within FDOT jurisdiction in order to ensure compatibility with the SPM-generating software.

Hardware-In-the-Loop Simulation (HILS) has a relatively long history of being used in engineering research, dating back as early as 1930's. Since the late '90s, HILS has been used significantly in traffic signal systems research, where it served to realistically introduce traffic controller logic in the operations of traffic simulation models. The need for HILS systems has been revived with an introduction of new high resolution (HR) traffic signal performance measures (SPMs). HR SPMs are derived from HR event logs, which are logged in traffic signal controllers every tenth of a second and represent time-stamped events of traffic detector actuations, signal statuses, and other electronically recorded events (e.g., from cabinet). The HR SPMs have attracted much attention in the recent years. Researchers have shown that these SPMs are highly effective in understanding and monitoring traffic signal operations. The research experiments were quickly followed by real-world implementations where several Departments of Transportation (DOTs) installed systems to generate HR event logs and retrieve HR SPMs from their traffic signals.

The goal of this research was to determine the minimum standards that the new event-based high resolution traffic signal controllers need to fulfill to be approved for installation in Florida. For that purpose, the unique set of mandatory and optional event codes was created. All six controllers were connected simultaneously, but also independently, into a Hardware-in-a-Loop Simulation (HILS) test setup. The characteristics of each controller, the procedures for building the HILS test setup, controller configurations, retrieving of the high resolution data locally (by using File Transfer Protocol), and the online tool (FDOT server) for calculating and graphically representing relevant performance measures (Purdue Coordination Diagram, Percentage of Arrivals on Green, etc.) were examined.

The significance of this research lies in the fact that for the first time, six controllers from six different vendors were tested simultaneously in the HILS setup. This newly established HILS test setup can be used for evaluation of new signal control strategies, effects of proposed signal retiming or for training of personnel where the evaluation of the caused impacts can be conducted by using the performance measures that became available with the introduction of high resolution event-logging traffic controllers.

For future steps, it is recommended that additional performance measures are evaluated, including those that involve pedestrians, preemptions, overlaps, and transit signal priority. From the safety

perspective, it would be very useful to test event logs regarding the yellow and red actuations. Finally, incorporating some of the suggested improvements for existing performance measures (e.g., delays and percentage of arrivals on green - AoG) could significantly improve the accuracy of measuring performance on signalized arterials.

Table of contents

Disclaimer	iii
Metric Conversion Table.....	iv
Technical Report Documentation.....	v
Acknowledgements	vi
Executive Summary	vii
List of Figures.....	xiii
List of Tables	xxi
1 Introduction.....	1
1.1 Background Statement	1
1.2 Research Objectives.....	1
1.3 Research Approach	2
2 Development of Traffic Controller Test Environment.....	3
2.1 Project Equipment.....	3
2.2 VISSIM Setup for NIATT CID Configuration	6
2.3 Controller Setup for NIATT CID Configuration	9
2.3.1 Econolite (Cobalt) Controller NIATT CID Configuration	9
2.3.2 Siemens (m50) Controller NIATT CID Configuration	12
2.3.3 PEEK (ATC-1000) Controller NIATT CID Configuration.....	14
2.3.4 Trafficware (ATC 900) Controller NIATT CID Configuration	17
2.3.5 McCain (ATC eX) Controller NIATT CID Configuration.....	20
2.3.6 Intelight (Model 2070-LDX) Controller NIATT CID Configuration.....	22
2.4 Trafficware Controller Interface Device Configuration	25
2.5 Controller Hardware-in-the-Loop Setup.....	26
2.6 VISSIM Setup for Trafficware CID Configuration	27
2.7 VISSIM Network Model.....	33
2.8 Controller Setup for Trafficware CID Configuration	38
2.8.1 Econolite (Cobalt) Controller Trafficware CID Configuration	38
2.8.2 Siemens (m50) Controller Trafficware CID Configuration.....	38
2.8.3 PEEK (ATC-1000) Controller Trafficware CID Configuration	41
2.8.4 Trafficware (ATC 900) Controller Trafficware CID Configuration	42
2.8.5 McCain (ATC eX) Controller Trafficware CID Configuration.....	43
2.8.6 Intelight (Model 2070-LDX) Controller Trafficware CID Configuration.....	44

2.9 High Resolution Data Manual Download from Controllers	46
2.9.1 Econolite (Cobalt) High Resolution Data Manual Download	46
2.9.2 Siemens (m50) High Resolution Data Manual Download	47
2.9.3 PEEK (ATC-1000) High Resolution Data Manual Download.....	49
2.9.4 Trafficware (ATC 900) High Resolution Data Manual Download	51
2.9.5 McCain (ATC eX) High Resolution Data Manual Download.....	52
2.9.6 Intelight (Model 2070-LDX) High Resolution Data Manual Download.....	54
2.10 Manual Transfer High Resolution Data from DAT to CSV Files	56
2.10.1 Econolite (Cobalt) Manual Transfer of High Resolution Data to CSV Files	56
2.10.2 Siemens (m50) Manual Transfer of High Resolution Data to CSV Files.....	57
2.10.3 PEEK (ATC-1000) Manual Transfer of High Resolution Data to CSV Files	57
2.10.4 Trafficware (ATC 900) Manual Transfer of High Resolution Data to CSV Files	58
2.10.5 McCain (ATC eX) Manual Transfer of High Resolution Data to CSV Files.....	59
2.10.6 Intelight (2070-LDX) Manual Transfer of High Resolution Data to CSV Files	60
2.11 ASPMS High Resolution Data Download.....	62
2.11.1 Run FTP/SCP and Decode and Import for Controllers	62
2.11.2 Multipoint Simultaneous Access of ASPMSs from six Different Computers.....	63
2.12 SPM Tool Configuration.....	65
2.12.1 Purdue Coordination Diagram Detectors Configuration	66
2.12.2 Turning Movement Counts Detectors Configuration	67
2.12.3 Yellow & Red Actuations Detectors Configuration	68
2.12.4 Purdue Split Failure Detectors Configuration.....	69
3 Development of Minimum Standards for Event-based High-Resolution Data.....	71
3.1 Event-based Data Elements	71
3.2 Minimum Standard Specification for Future Controllers	81
3.3 High resolution Data Logging Quality Test.....	81
3.4 Testing Detector and Other Faults	96
3.4.1 Testing for False Detections	96
3.4.2 Testing for Actuation Interruptions – Stop Bar Detectors	97
3.4.3 Testing for Actuation Interruptions – Advanced Detectors	99
3.4.4 Intelight – Detectors Status Screen	100
3.4.5 McCain – Detectors Status Screen.....	101
3.4.6 Trafficware – Detectors Status Screen.....	102
3.4.7 PEEK – Detectors Status Screen.....	103

3.4.8 Econolite – Detectors Status Screen	104
3.4.9 Siemens – Detectors Status Screen	105
3.5 User Manual for HILS Setup and Retrieval of High Resolution Data	107
3.5.1 Software Interface (Virtual CID) Between the Controllers and the VISSIM	107
3.5.2 Checking the Connection with the Controller(s) – Test Box TS2	109
3.5.3 Starting Up HILS	110
3.5.4 Run FTP/SCP Decode and Import for Controllers	115
3.5.5 Configuration of the SPM Tool	117
3.6 Validation of Operations and Training in HILS Testing System	118
4 Definitions of Measures of Effectiveness Based on High-Resolution Controller	119
4.1 Existing Signal Performance Measures Available Through FDOT ASPMS Software	119
4.2 Literature Review of Previous Work	126
4.3 Additional Performance Measures Based on Existing High Resolution Enumerations ...	128
4.4 Potential Changes in the FDOT ASPMS Software.....	137
4.5 Statewide Implementation of FDOT ASPMS Software	137
4.6 VISSIM Model.....	138
4.6.1 Corridor Description	138
4.6.2 Signal Timings	140
4.6.3 Intersections Geometry	143
4.6.4 Controller Detector Setup for Purdue Coordination Diagram	149
4.6.4.1 PEEK Advanced Detector Setup	149
4.6.4.2 Trafficware Advanced Detector Setup.....	151
4.6.4.3 Siemens Advanced Detector Setup	153
4.6.4.4 Econolite Advanced Detector Setup	155
4.6.4.5 Intelight Advanced Detector Setup	157
4.6.4.6 McCain Advanced Detector Setup.....	160
4.6.5 Controller Detector Setup for Trafficware Controller Interface Device (CID)	161
4.6.5.1 PEEK Controller Interface Device (CID) Setup	161
4.6.5.2 Trafficware Controller Interface Device (CID) Setup	163
4.6.5.3 Siemens Controller Interface Device (CID) Setup	163
4.6.5.4 Econolite Controller Interface Device (CID) Setup.....	165
4.6.5.5 Intelight Controller Interface Device (CID) Setup	166
4.6.5.6 McCain Controller Interface Device (CID) Setup	167
4.6.6 Manual Coordination Setup for Controllers	168

4.6.6.1 PEEK Controller Coordination Manual Setup.....	168
4.6.6.2 Trafficware Controller Coordination Manual Setup.....	170
4.6.6.3 Siemens Controller Coordination Manual Setup	171
4.6.6.4 Econolite Controller Coordination Manual Setup	173
4.6.6.5 Intelight Controller Coordination Manual Setup	176
4.6.6.6 McCain Controller Coordination Manual Setup.....	178
References	181
A Appendix: High Resolution Data Performance Metrics Graphs.....	183
A.1 Econolite (Cobalt) High Resolution Data Performance Metrics	184
A.2 Siemens (m50) High Resolution Data Performance Metrics	200
A.3 PEEK (ATC-1000) High Resolution Data Performance Metrics	216
A.4 Trafficware (ATC 900) High Resolution Data Performance Metrics.....	231
A.5 McCain (ATC eX) High Resolution Data Performance Metrics	246
A.6 Intelight (2070-LDX) High Resolution Data Performance Metrics	262
B Appendix: Multipoint Simultaneous Access of ASPMSs from Six Computers.....	278

List of Figures

Figure 2-1. ViewSonic monitor and Dell Precision Tower (7810).....	3
Figure 2-2. Six traffic signal controllers	4
Figure 2-3. NIATT controller interface device.....	5
Figure 2-4. Trafficware controller interface device	5
Figure 2-5. “Signal Groups” menu in VISSIM.....	6
Figure 2-6. *.CID file example	7
Figure 2-7. Setup VISSIM for CID communication.....	8
Figure 2-8. ASC3 SNMP client application interface	9
Figure 2-9. Cobalt detector setup for high resolution data storage	10
Figure 2-10. Cobalt mapping configuration application interface.....	11
Figure 2-11. Siemens detector configuration interface.....	12
Figure 2-12. ABC input status interface	13
Figure 2-13. Siemens controller mapping interface (Mode 1).....	14
Figure 2-14. Advanced Cu log setup interface	15
Figure 2-15. Vehicle detector options interface.....	15
Figure 2-16. Input outputs pin status interface	16
Figure 2-17. I/O cabinet setup interface	17
Figure 2-18. I/O logging interface	17
Figure 2-19. I/O mode interface.....	19
Figure 2-20. High resolution log setup interface	20
Figure 2-21. Vehicle detector setup interface	21
Figure 2-22. NEMA ABCD input mapping interface.....	22
Figure 2-23. System events interface.....	22
Figure 2-24. Vehicle detector parameters interface	23
Figure 2-25. Output points status interface.....	24
Figure 2-26. Input points interface.....	25
Figure 2-27. Trafficware TS2 test box software interface	26
Figure 2-28. Controller hardware-in-the-loop setup	27
Figure 2-29. Virtual CID file example.....	28
Figure 2-30. Detector count used for the phase that detector is assigned to.....	28
Figure 2-31. Virtual CID interface.....	29
Figure 2-32. Virtual CID “Load File” menu.....	30
Figure 2-33. Multiple CID file selection.....	30
Figure 2-34. Virtual CID “Controller” menu.....	31
Figure 2-35. Port number check.....	32
Figure 2-36. Virtual CID “SIM” menu	32
Figure 2-37. Intersection layout for the project	33
Figure 2-38. Intersection phases layout	34
Figure 2-39. WB Advanced detectors (9 & 10) and presence detectors for phases 1 & 6	35
Figure 2-40. NB Advanced detectors (11 & 12) and presence detectors for phases 3 & 8	35
Figure 2-41. EB Advanced detectors (13 & 14) and presence detectors for phases 2 & 5.....	36
Figure 2-42. SB Advanced detectors (15 & 16) and presence detectors for phases 4 & 7	36
Figure 2-43. Six intersections testing model.....	37
Figure 2-44. Six intersections with six different signalized controllers	37
Figure 2-45. Cobalt SDLC setup example	38

Figure 2-46. Siemens controller operating mode change	39
Figure 2-47. SDLC communication for Siemens controller.....	40
Figure 2-48. I/O cabinet setup interface	41
Figure 2-49. PEEK controller Port 1 interface.....	42
Figure 2-50. Trafficware SDLC interface.....	42
Figure 2-51. I/O mapping interface	43
Figure 2-52. NEMA TS2 device setup interface	44
Figure 2-53. IO modules interface	45
Figure 2-54. Econolite (Cobalt) ethernet interface	46
Figure 2-55. FileZilla setup for Econolite test environment.....	47
Figure 2-56. Siemens (m50) network configuration interface.....	48
Figure 2-57. FileZilla setup for Siemens test environment.....	49
Figure 2-58. PEEK (ATC-1000) IP cabinet address setup interface	50
Figure 2-59. FileZilla setup for PEEK test environment	51
Figure 2-60. Trafficware (ATC 900) IP setup interface	51
Figure 2-61. FileZilla setup for Trafficware test environment	52
Figure 2-62. McCain (ATC eX) ethernet port setting interface.....	53
Figure 2-63. FileZilla setup for McCain test environment	54
Figure 2-64. Intelight (Model 2070-LDX) ethernet port setting interface.....	54
Figure 2-65. FileZilla setup for Intelight test environment.....	55
Figure 2-66. Econolite (Cobalt) controller DAT to CSV file transfer	56
Figure 2-67. Siemens (m50) controller DAT to CSV file transfer	57
Figure 2-68. PEEK (ATC-1000) controller DAT to CSV file transfer.....	58
Figure 2-69. Trafficware (ATC 900) controller DAT to CSV file transfer	59
Figure 2-70. McCain (ATC ext.) controller DAT to CSV file transfer	60
Figure 2-71. Asclog.dbfile opened in SqliteBrowser application.....	60
Figure 2-72. FTP and SCP high resolution data download	62
Figure 2-73. FDOT signal performance metrics site access from one computer	64
Figure 2-74. SPM Configurator Tool interface.....	65
Figure 2-75. Add new signal interface.....	65
Figure 2-76. Purdue coordination diagram detectors.....	66
Figure 2-77. New detector configuration interface	66
Figure 2-78. Purdue coordination diagram detector configuration example	67
Figure 2-79. Turning movement count detectors.....	67
Figure 2-80. Turning movement count detector configuration.....	68
Figure 2-81. Yellow & red actuation detectors.....	68
Figure 2-82. Turning movement count detector configuration.....	69
Figure 2-83. Purdue split failure detectors.....	69
Figure 2-84. Purdue split failure detector configuration.....	70
Figure 3-1. PCD for phase 2, EB on controller 4000 (Cobalt) from VISSIM .ldp file	82
Figure 3-2. PCD for phase 2, EB on controller 4000 (Cobalt) from HILS setup	82
Figure 3-3. PCD for phase 4, SB on controller 4000 (Cobalt) from VISSIM .ldp file	83
Figure 3-4. PCD for phase 4, SB on controller 4000 (Cobalt) from HILS setup	83
Figure 3-5. PCD for phase 6, WB on controller 4000 (Cobalt) from VISSIM .ldp file	84
Figure 3-6. PCD for phase 6, WB on controller 4000 (Cobalt) from HILS setup.....	84
Figure 3-7. PCD for phase 8, NB on controller 4000 (Cobalt) from VISSIM .ldp file	85

Figure 3-8. PCD for phase 8, NB on controller 4000 (Cobalt) from HILS setup.....	85
Figure 3-9. PCD for phase 2, EB on controller 4003 (Trafficware) from VISSIM .ldp file	86
Figure 3-10. PCD for phase 2, EB on controller 4003 (Trafficware) from HILS setup.....	86
Figure 3-11. PCD for phase 4, SB on controller 4003 (Trafficware) from VISSIM .ldp file	87
Figure 3-12. PCD for phase 4, SB on controller 4003 (Trafficware) from HILS setup	87
Figure 3-13. PCD for phase 6, WB on controller 4003 (Trafficware) from VISSIM .ldp file	88
Figure 3-14. PCD for phase 6, WB on controller 4003 (Trafficware) from HILS setup.....	88
Figure 3-15. PCD for phase 8, NB on controller 4003 (Trafficware) from VISSIM .ldp file.....	89
Figure 3-16. PCD for phase 8, NB on controller 4003 (Trafficware) from HILS setup	89
Figure 3-17. PCD for phase 2, EB on controller 4004 (McCain) from VISSIM .ldp file	90
Figure 3-18. PCD for phase 2, EB on controller 4004 (McCain) from HILS setup.....	90
Figure 3-19. PCD for phase 4, SB on controller 4004 (McCain) from VISSIM .ldp file	91
Figure 3-20. PCD for phase 4, SB on controller 4004 (McCain) from HILS setup	91
Figure 3-21. PCD for phase 6, WB on controller 4004 (McCain) from VISSIM .ldp file	92
Figure 3-22. PCD for phase 6, WB on controller 4004 (McCain) from HILS setup	92
Figure 3-23. PCD for phase 8, NB on controller 4004 (McCain) from VISSIM .ldp file	93
Figure 3-24. PCD for phase 8, NB on controller 4004 (McCain) from HILS setup	93
Figure 3-25. PCD for phase 4, SB on Econolite controller from VISSIM (one intersection).....	94
Figure 3-26. PCD for phase 4, SB on Econolite controller from HILS (one intersection).....	94
Figure 3-27. PCD for phase 6, WB on Econolite controller from VISSIM (one intersection)	95
Figure 3-28. PCD for phase 6, WB on Econolite controller from HILS (one intersection)	95
Figure 3-29. Changing the detectors activation setup in VISSIM	97
Figure 3-30. Changing the signal heads to newly created constant red signal plan in VISSIM...	98
Figure 3-31. Testing for actuation interruptions – stop bar detectors (constant red signal)	99
Figure 3-32. Intelight detector status screen	101
Figure 3-33. McCain detector status screen.....	102
Figure 3-34. Trafficware detector status screen.....	103
Figure 3-35. PEEK detector status screen.....	104
Figure 3-36. Econolite detector status screen	105
Figure 3-37. Siemens detector status screen	106
Figure 3-38. Virtual CID file example.....	107
Figure 3-39. Detector number assigned to a phase of the same number	108
Figure 3-40. Testbox configuration file	108
Figure 3-41. Trafficware TS2 Test Box software	109
Figure 3-42. Virtual CID interface.....	110
Figure 3-43. Virtual CID “Load file” menu.....	111
Figure 3-44. Multiple CID file selection.....	112
Figure 3-45. Virtual CID “Controller” menu.....	113
Figure 3-46. Virtual CID “Controller” menu.....	114
Figure 3-47. Virtual CID “SIM” menu	115
Figure 3-48. FTP and SCP high resolution data download	116
Figure 3-49. SPM Configurator Tool interface.....	117
Figure 3-50. Add New Signal interface	117
Figure 4-1. Approach volume	120
Figure 4-2. Approach volume (tabular)	121
Figure 4-3. Arrivals on red.....	122

Figure 4-4. Purdue coordination diagram	123
Figure 4-5. Purdue phase termination	124
Figure 4-6. Split monitor.....	125
Figure 4-7. Calculation of AAOG and PR	129
Figure 4-8. Derivation of the AAOG and PR on the example of fixed-time traffic control	130
Figure 4-9. The pseudo code for calculation of AAOG and modified approach delay (D_n) ...	132
Figure 4-10. Average delay from simulation and proposed methodology	133
Figure 4-11. Average delay per vehicle from existing and newly proposed methodology	134
Figure 4-12. Location of Glades Rd	138
Figure 4-13. Overview of the intersections 1-6 on Glades Rd	139
Figure 4-14. Overview of the intersections 7-12 on Glades Rd	140
Figure 4-15. Geometry of Glades Rd - N Dixie Hwy for PEEK controller.....	143
Figure 4-16. Geometry of Glades Rd – Boca Raton Blvd for Trafficware controller	144
Figure 4-17. Geometry of Glades Rd – NW 4 th Ave for Siemens controller	145
Figure 4-18. Geometry of Glades Rd – FAU Blvd for Econolite controller	146
Figure 4-19. Geometry of Glades Rd – NW 10 th Avenue for Intelight controller.....	147
Figure 4-20. Geometry of Glades Rd – Airport Rd for McCain controller	148
Figure 4-21. Advanced Cu log setup interface	149
Figure 4-22. Vehicle detector options interface.....	150
Figure 4-23. Input output pin status interface	151
Figure 4-24. I/O logging interface	152
Figure 4-25. I/O mode interface.....	153
Figure 4-26. Siemens detector configuration interface.....	154
Figure 4-27. ABC input status interface	154
Figure 4-28. Siemens controller mapping interface (Mode 1).....	155
Figure 4-29. Cobalt detector setup for high resolution data storage.....	156
Figure 4-30. Cobalt mapping configuration application interface	157
Figure 4-31. System events interface.....	158
Figure 4-32. Vehicle detector parameters interface	159
Figure 4-33. Output points status interface.....	159
Figure 4-34. High resolution log setup interface	160
Figure 4-35. Vehicle detector setup interface	161
Figure 4-36. PEEK controller Port 1 interface.....	162
Figure 4-37. Trafficware SDLC interface.....	163
Figure 4-38. SDLC communication for Siemens controller	164
Figure 4-39. Cobalt SDLC setup example.....	165
Figure 4-40. IO modules interface	166
Figure 4-41. NEMA TS2 device setup interface	167
Figure 4-42. PEEK Unit/Global settings interface	168
Figure 4-43. PEEK pattern table interface	169
Figure 4-44. PEEK split table interface	170
Figure 4-45. Trafficware modes + interface	170
Figure 4-46. Trafficware pattern table interface	171
Figure 4-47. Trafficware splits interface	171
Figure 4-48. Siemens setup coordination interface.....	172
Figure 4-49. Siemens manual control interface	172

Figure 4-50. Siemens offset interface	173
Figure 4-51. Siemens split interface	173
Figure 4-52. Econolite coordination interface	174
Figure 4-53. Econolite coordination overview interface	175
Figure 4-54. Econolite coordination pattern interface	175
Figure 4-55. Econolite coordination splits interface	176
Figure 4-56. Intelight coordination parameters interface	176
Figure 4-57. Intelight patterns interface.....	177
Figure 4-58. Intelight split interface	178
Figure 4-59. McCain pattern interface.....	178
Figure 4-60. McCain pattern interface.....	179
Figure 4-61. McCain split table interface	180
Figure A-1. Cobalt – Approach Delay – EB.....	184
Figure A-2. Cobalt – Approach Delay – SB	184
Figure A-3. Cobalt – Approach Delay – WB	185
Figure A-4. Cobalt – Approach Delay – NB	185
Figure A-5. Cobalt – Approach Volume – WB & EB	186
Figure A-6. Cobalt – Approach Volume – NB & SB	186
Figure A-7. Cobalt – Approach Volume – WB	187
Figure A-8. Cobalt – Arrivals on Red – EB.....	188
Figure A-9. Cobalt – Arrivals on Red – SB	188
Figure A-10. Cobalt – Arrivals on Red – WB	189
Figure A-11. Cobalt – Arrivals on Red – NB	189
Figure A-12. Cobalt – Purdue Coordination Diagram – EB.....	190
Figure A-13. Cobalt – Purdue Coordination Diagram – SB	190
Figure A-14. Cobalt – Purdue Coordination Diagram – WB	191
Figure A-15. Cobalt – Purdue Coordination Diagram – NB	191
Figure A-16. Cobalt – Purdue Phase Termination.....	192
Figure A-17. Cobalt – Approach Speed – EB.....	193
Figure A-18. Cobalt – Approach Speed – SB.....	193
Figure A-19. Cobalt – Approach Speed – WB	194
Figure A-20. Cobalt – Approach Speed – NB	194
Figure A-21. Cobalt – Split Monitor – Phase 1	195
Figure A-22. Cobalt – Split Monitor – Phase 2	196
Figure A-23. Cobalt – Split Monitor – Phase 3	196
Figure A-24. Cobalt – Split Monitor – Phase 4	197
Figure A-25. Cobalt – Split Monitor – Phase 5	197
Figure A-26. Cobalt – Split Monitor – Phase 6	198
Figure A-27. Cobalt – Split Monitor – Phase 7	198
Figure A-28. Cobalt – Split Monitor – Phase 8	199
Figure A-29. Siemens – Approach Delay – EB.....	200
Figure A-30. Siemens – Approach Delay – SB	200
Figure A-31. Siemens – Approach Delay – WB.....	201
Figure A-32. Siemens – Approach Delay – NB	201
Figure A-33. Siemens – Approach Delay – WB & EB	202
Figure A-34. Siemens – Approach Delay – NB & SB	202

Figure A-35. Siemens – Approach Volume – WB	203
Figure A-36. Siemens – Arrivals on Red – EB.....	204
Figure A-37. Siemens – Arrivals on Red – SB.....	204
Figure A-38. Siemens – Arrivals on Red – WB	205
Figure A-39. Siemens – Arrivals on Red – NB	205
Figure A-40. Siemens – Purdue Coordination Diagram – EB.....	206
Figure A-41. Siemens – Purdue Coordination Diagram – SB	206
Figure A-42. Siemens – Purdue Coordination Diagram – WB	207
Figure A-43. Siemens – Purdue Coordination Diagram – NB	207
Figure A-44. Siemens – Purdue Phase Termination.....	208
Figure A-45. Siemens – Approach Speed – EB.....	209
Figure A-46. Siemens – Approach Speed – SB.....	209
Figure A-47. Siemens – Approach Speed – WB	210
Figure A-48. Siemens – Approach Speed – NB	210
Figure A-49. Siemens – Split Monitor – Phase 1	211
Figure A-50. Siemens – Split Monitor – Phase 2	212
Figure A-51. Siemens – Split Monitor – Phase 3	212
Figure A-52. Siemens – Split Monitor – Phase 4	213
Figure A-53. Siemens – Split Monitor – Phase 5	213
Figure A-54. Siemens – Split Monitor – Phase 6	214
Figure A-55. Siemens – Split Monitor – Phase 7	214
Figure A-56. Siemens – Split Monitor – Phase 8	215
Figure A-57. PEEK – Approach Delay – EB	216
Figure A-58. PEEK – Approach Delay – SB.....	216
Figure A-59. PEEK – Approach Delay – WB	217
Figure A-60. PEEK – Approach Delay – NB	217
Figure A-61. PEEK – Approach Delay – WB & EB	218
Figure A-62. PEEK – Approach Delay – NB & SB	218
Figure A-63. PEEK – Approach Volume – WB	219
Figure A-64. PEEK – Arrivals on Red – EB	220
Figure A-65. PEEK – Arrivals on Red – SB	220
Figure A-66. PEEK – Arrivals on Red – WB	221
Figure A-67. PEEK – Arrivals on Red – NB	221
Figure A-68. PEEK – Purdue Coordination Diagram – EB	222
Figure A-69. PEEK – Purdue Coordination Diagram – SB.....	222
Figure A-70. PEEK – Purdue Coordination Diagram – WB	223
Figure A-71. PEEK – Purdue Coordination Diagram – NB	223
Figure A-72. PEEK – Purdue Phase Termination	224
Figure A-73. PEEK – Approach Speed – EB	225
Figure A-74. PEEK – Approach Speed – SB	225
Figure A-75. PEEK – Approach Speed – WB	226
Figure A-76. PEEK – Approach Speed – NB	226
Figure A-77. PEEK – Split Monitor – Phase 1.....	227
Figure A-78. PEEK – Split Monitor – Phase 2.....	228
Figure A-79. PEEK – Split Monitor – Phase 4.....	228
Figure A-80. PEEK – Split Monitor – Phase 6.....	229

Figure A-81. PEEK – Split Monitor – Phase 7	229
Figure A-82. PEEK – Split Monitor – Phase 8.....	230
Figure A-83. Trafficware – Approach Delay – EB.....	231
Figure A-84. Trafficware – Approach Delay – SB.....	231
Figure A-85. Trafficware – Approach Delay – WB	232
Figure A-86. Trafficware – Approach Delay – NB	232
Figure A-87. Trafficware – Approach Delay – WB & EB	233
Figure A-88. Trafficware – Approach Delay – NB & SB	233
Figure A-89. Trafficware – Approach Volume – WB	234
Figure A-90. Trafficware – Arrivals on Red – EB	235
Figure A-91. Trafficware – Arrivals on Red – SB.....	235
Figure A-92. Trafficware – Arrivals on Red – WB	236
Figure A-93. Trafficware – Arrivals on Red – NB	236
Figure A-94. Trafficware – Purdue Coordination Diagram – EB	237
Figure A-95. Trafficware – Purdue Coordination Diagram – SB.....	237
Figure A-96. Trafficware – Purdue Coordination Diagram – WB	238
Figure A-97. Trafficware – Purdue Coordination Diagram – NB	238
Figure A-98. Trafficware – Purdue Phase Termination.....	239
Figure A-99. Trafficware – Approach Speed – EB	240
Figure A-100. Trafficware – Approach Speed – SB.....	240
Figure A-101. Trafficware – Approach Speed – WB	241
Figure A-102. Trafficware – Approach Speed – NB	241
Figure A-103. Trafficware – Split Monitor – Phase 1	242
Figure A-104. Trafficware – Split Monitor – Phase 2	243
Figure A-105. Trafficware – Split Monitor – Phase 3	243
Figure A-106. Trafficware – Split Monitor – Phase 4	244
Figure A-107. Trafficware – Split Monitor – Phase 5	244
Figure A-108. Trafficware – Split Monitor – Phase 7	245
Figure A-109. Trafficware – Split Monitor – Phase 8	245
Figure A-110. McCain – Approach Delay – EB.....	246
Figure A-111. McCain – Approach Delay – SB	246
Figure A-112. McCain – Approach Delay – WB	247
Figure A-113. McCain – Approach Delay – NB	247
Figure A-114. McCain – Approach Delay – WB & EB	248
Figure A-115. McCain – Approach Delay – NB & SB	248
Figure A-116. McCain – Approach Volume – WB	249
Figure A-117. McCain – Arrivals on Red – EB	250
Figure A-118. McCain – Arrivals on Red – SB.....	250
Figure A-119. McCain – Arrivals on Red – WB	251
Figure A-120. McCain – Arrivals on Red – NB	251
Figure A-121. McCain – Purdue Coordination Diagram – EB	252
Figure A-122. McCain – Purdue Coordination Diagram – SB.....	252
Figure A-123. McCain – Purdue Coordination Diagram – WB	253
Figure A-124. McCain – Purdue Coordination Diagram – NB	253
Figure A-125. McCain – Purdue Phase Termination.....	254
Figure A-126. McCain – Approach Speed – EB	255

Figure A-127. McCain – Approach Speed – SB.....	255
Figure A-128. McCain – Approach Speed – WB	256
Figure A-129. McCain – Approach Speed – NB.....	256
Figure A-130. McCain – Split Monitor – Phase 1	257
Figure A-131. McCain – Split Monitor – Phase 2	258
Figure A-132. McCain – Split Monitor – Phase 3	258
Figure A-133. McCain – Split Monitor – Phase 4	259
Figure A-134. McCain – Split Monitor – Phase 5	259
Figure A-135. McCain – Split Monitor – Phase 6	260
Figure A-136. McCain – Split Monitor – Phase 7	260
Figure A-137. McCain – Split Monitor – Phase 8	261
Figure A-138. Intelight – Approach Delay – EB	262
Figure A-139. Intelight – Approach Delay – SB	262
Figure A-140. Intelight – Approach Delay – WB.....	263
Figure A-141. Intelight – Approach Delay – NB	263
Figure A-142. Intelight – Approach Delay – WB & EB	264
Figure A-143. Intelight – Approach Delay – NB & SB	264
Figure A-144. Intelight – Approach Volume – WB	265
Figure A-145. Intelight – Arrivals on Red – EB.....	266
Figure A-146. Intelight – Arrivals on Red – SB	266
Figure A-147. Intelight – Arrivals on Red – WB	267
Figure A-148. Intelight – Arrivals on Red – NB	267
Figure A-149. Intelight – Purdue Coordination Diagram – EB	268
Figure A-150. Intelight – Purdue Coordination Diagram – SB	268
Figure A-151. Intelight – Purdue Coordination Diagram – WB	269
Figure A-152. Intelight – Purdue Coordination Diagram – NB	269
Figure A-153. Intelight – Purdue Phase Termination.....	270
Figure A-154. Intelight – Approach Speed – EB.....	271
Figure A-155. Intelight – Approach Speed – SB	271
Figure A-156. Intelight – Approach Speed – WB	272
Figure A-157. Intelight – Approach Speed – NB	272
Figure A-158. Intelight – Split Monitor – Phase 1	273
Figure A-159. Intelight – Split Monitor – Phase 2	274
Figure A-160. Intelight – Split Monitor – Phase 3	274
Figure A-161. Intelight – Split Monitor – Phase 4	275
Figure A-162. Intelight – Split Monitor – Phase 5	275
Figure A-163. Intelight – Split Monitor – Phase 6	276
Figure A-164. Intelight – Split Monitor – Phase 7	276
Figure A-165. Intelight – Split Monitor – Phase 8	277
Figure B-1. Accessing FDOT SPM site from Station 1/Intersection 1 (ControllerID 3000)	279
Figure B-2. Accessing FDOT SPM site from Station 2/Intersection 2 (ControllerID 3001)	280
Figure B-3. Accessing FDOT SPM site from Station 3/Intersection 3 (ControllerID 3002)	281
Figure B-4. Accessing FDOT SPM site from Station 4/Intersection 4 (ControllerID 3003)	282
Figure B-5. Accessing FDOT SPM site from Station 5/Intersection 5 (ControllerID 3004)	283
Figure B-6. Accessing FDOT SPM site from Station 6/Intersection 6 (ControllerID 3005)	284

List of Tables

Table 2-1. Cobalt mapping detector configuration	11
Table 2-2. ABC input modes	13
Table 2-3. PEEK mapping detector configuration.....	16
Table 2-4. High resolution data log parameters and descriptions.....	18
Table 2-5. I/O mapping modes	19
Table 2-6. McCain mapping detector configuration.....	21
Table 3-1. Legend for the Table 3.2	72
Table 3-2. Standards for generating SPMs from TERL-approved signal controllers.....	72
Table 3-3. Performance measures and event codes used for their derivation.....	80
Table 4-1. Arrival types based on platoon ratio.....	123
Table 4-2. Possible performance measures and their status in the project	135
Table 4-3. Controllers used for the HILS setup	137
Table 4-4. Basic signal timings for Glades Rd - N Dixie Hwy for PEEK controller	141
Table 4-5. Basic signal timing for Glades Rd - Boca Raton Blvd for Trafficware controller....	141
Table 4-6. Basic signal timing for Glades Rd – NW 4 th Ave for Siemens controller.....	141
Table 4-7. Basic signal timing for Glades Rd – FAU Blvd for Econolite controller	141
Table 4-8. Basic signal timing for Glades Rd – NW 10 th Avenue for Intelight controller.....	141
Table 4-9. Basic signal timing for Glades Rd – Airport Rd for McCain controller	142
Table 4-10. Signal timings for the six intersections operated by hardware controllers.....	142
Table 4-11. High-resolution data log parameters and description	152

1 Introduction

1.1 Background Statement

The 2012 National Traffic Signal Report Card gives an overall score of D+ and an F for traffic monitoring and data collection. The results of that assessment by the National Transportation Operations Coalition suggest that in most cases, information about the quality of service in signal systems is made up of anecdotal knowledge and complaint calls from the public rather than systematic monitoring of traffic conditions. The F score implies that improvements are needed so that agencies know what is occurring in their systems.

Recent research in Event-Based Data Collection for Generating Actuated Controller Performance Measures has created new tools for assessing and reporting real-time performance data from individual signalized intersections and coordinated/adaptive signalized arterials. To assure that minimum performance measures are attainable from signal controllers, the Florida Department of Transportation (FDOT) seeks exploratory research into high resolution data logging for existing signal controllers from various manufacturers and development of minimum standards for data logging that can be implemented for all existing and future controllers.

Since the advent works of Smaglik et al. in 2007, several signal controller manufacturers have enhanced their respective controller software to include a data logger module for collecting high resolution time-stamped phase and detector state changes. These data loggers differ in the type and number of unique data elements recorded based on the desired measures of effectiveness (MOEs). Furthermore, several controller manufacturers produce and promote proprietary central traffic signal control software (closed-loop system) that utilizes specific types of high-resolution data types to quantize and visualize (through graphs and tables) arterial progression and intersection delay. Traffic engineers use MOEs from such traffic signal software to evaluate traffic conditions visually and act accordingly.

The FDOT wishes to develop minimum non-proprietary standards for high-resolution data elements (such as the type and number) recorded and reported by signal controller data logger modules, develop definitions for the MOEs, and clearly define the methods by which they are calculated. More specifically, the FDOT seeks analysis and recommendations regarding the capability of current controllers to produce high-resolution event-based traffic signal data and their potential for use with the Automatic Signal Performance Measurement System (ASPMS) software developed by the Utah Department of Transportation (and based on the original research from Purdue University).

1.2 Research Objectives

The main objective of this research is to develop a set of specifications that will define enumerations (e.g. type, size, frequency) required for traffic controller data logging and reporting as well as methods to convert this data into real-time performance measures. This research will be used to set minimum standards that current and future providers (e.g. controller manufacturers) of high-resolution event-based traffic signal data must satisfy in order for their data logs to be transferable into traffic signal performance measures adopted by the Department. Recommendations of such real-time performance measures and systems (e.g. hardware and

software that can produce those performance measures) should also be an outcome of this research.

1.3 Research Approach

The research approach is defined by the steps or tasks from the scope of the project. After project kickoff teleconference the following group of tasks were designated to be developed:

1. Traffic controller test environment
2. Minimum standards for event-based high-resolution data
3. Definitions for measures of effectiveness based on high-resolution controller data
4. Report with summarized results and finds

For creating the traffic controller test environment, the equipment needed to be selected, purchased, delivered and installed. The main components of the system are the test computer, signal controllers capable to log high-resolution event-based traffic signal data from six different manufacturers, CID devices and other equipment. Also software components like VISSIM microsimulation or Virtual CID software were acquired in order to create the test environment. Hardware-in-the-Loop testing system was assembled and integrated. All six controllers were tested separately on the same intersection with the same input in microsimulation software, as well as simultaneously on a corridor of 6 geometrically identical intersections. The collected high-resolution data were transmitted to ASPMS software in order to test the functionality of the test setup, but also were extracted locally by using the File Transfer Protocol (FTP). The simultaneous access of six operators from six different computers was tested

After documenting of all available event based data, their analysis and evaluation, a minimum set of event-based data codes evident in all tested controllers was defined as a standard for incorporating into FDOT signal controller specifications. The quality of high-resolution data was tested by comparing the logged events from the controllers and the VISSIM event-based data elements. Also, the set of scenarios for testing faulty detectors that can negatively impact quality of ASPMS operation was developed.

The existing performance measures, already available in the FDOT ASPMS software were reviewed and the definitions for each of them was developed. Previous work of other researchers was examined in order to identify the performance measures which are used to describe performance of traffic signals. Suggestions for additional performance measures and the modifications of the existing ones were made based on the existing high-resolution data enumerations. The suitability of the existing FDOT ASPMS software for statewide implementation is investigated. Finally, the calibrated and validated VISSIM model (corridor of 12 intersections) with the clear instructions how to set up each controller was created. The entire setup was delivered, installed and configured in the FDOT TERL. Basic training was also conducted.

2 Development of Traffic Controller Test Environment

2.1 Project Equipment

For the project, six ViewSonic monitors (VX2452mh) were purchased, delivered and assembled with Dell Precision Tower (7810) at FAU LATOM and all are in working conditions.

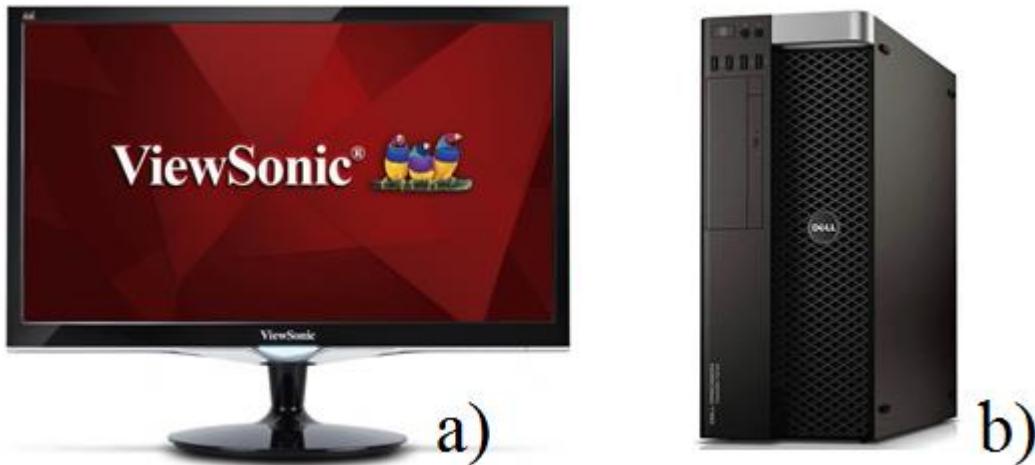


Figure 2-1. ViewSonic monitor and Dell Precision Tower (7810)

Traffic controller testing apparatus is purchased and installed. Testing apparatus consist of a test computer with Hardware-In-the-Loop connected with Controller Interface Devices (CID) that is communicating with six (6) signal controllers separately and together. Controllers that are purchased and part of the testing are:

1. Econolite (Cobalt) – delivered and in working conditions.
2. Siemens (m50) – delivered and in working conditions.
3. PEEK (ATC-1000) – delivered and in working conditions.
4. Trafficware (900 ATC) – delivered and in working conditions.
5. Intelight (2070-LDX) – delivered and in working conditions.
6. McCain (ATC eX) – delivered and in working conditions



Figure 2-2. Six traffic signal controllers

To perform tests and simulations needed for the project, Hardware-In-the-Loop-Simulation (HILS) is used. HILS connects software, in this case PTV VISSIM, with real controller hardware so that controller can receive inputs (detector actuations) from VISSIM simulation, and VISSIM can receive traffic signal lights states from controller. In order for HILS to work, Controller Interface Device (CID) is needed to allow the controller and VISSIM to communicate. There are two types of CID's, one is NIATT CID and other is Trafficware CID. NIATT CID was ordered and delivered to Florida Atlantic University (FAU), Laboratory for Adaptive Traffic Operations and Management (LATOM). Figure 2-3 shows NIAT CID that was the first CID for HILS project, but due to unavailability, only 3 CID's were delivered, while two of them were in working conditions.



Figure 2-3. NIATT controller interface device

Further on, FAU LATOM and FL DOT TERL agreed to transfer from NIATT CID to Trafficware CID so that project can be tested with 6 controllers connected and simulated at the same time in VISSIM simulation tool. FAU LATOM ordered 6 Trafficware CID's and the tests and simulations are performed with Trafficware CID (Figure 2-4).



Figure 2-4. Trafficware controller interface device

NIATT CID is hardware device used for HILS with controllers using ABC and USB cables. Connection between controller and CID is with ABC cable while connection between CID and PC is with USB cable. NIATT CID drivers must be installed on the PC with Windows 32 bit system because NIATT CID driver only supports 32 bit system. After initial installation CID is ready for use and simulation. Testing of the NIATT CID is done through self-test button in front panel of the CID. Front panel of CID contains LED lights representing phases (maximum 16 phases can be simulated) with red, yellow and green lights. Beside phases there are 64 LED lights representing detector inputs that are received from ABC cables, in this case from VISSIM simulation platform and detector channels in the VISSIM model.

2.2 VISSIM Setup for NIATT CID Configuration

PTV VISSIM 5.40 is software used for NIATT CID testing's. VMware (Workstation 11) is installed on PC with 32-bit Windows 7. To this point HILS with NIATT CID works only with 32-bit operating systems. VISSIM network model used for testing is created version 4.30, while the testing and simulations are done in VISSIM version 5.40. Currently, the NIATT CID does not work with network created in VISSIM version above 5.0 or Windows 64 bit environment.

To configure VISSIM to work with NIATT CID, network that will be used for simulation needs to be created in VISSIM (version under 5.0). After the network is created, open the VISSIM application from all programs menu, if VISSIM file is already existing than open the file from VISSIM browse menu. If there is no existing network, create the network or intersection that will be used for simulation and choose VAP controller type in Signal Controller menu.

“Signal Groups” for the project need to be created so they correspond to the signal controller phases. To create signal groups in VISSIM:

1. Open Signal Controller menu – Edit controllers
2. Configuration tab “Signal Groups” is opened
3. To create signal group press right mouse click, menu will open, choose “new”
4. Create “Signal Groups” for the project

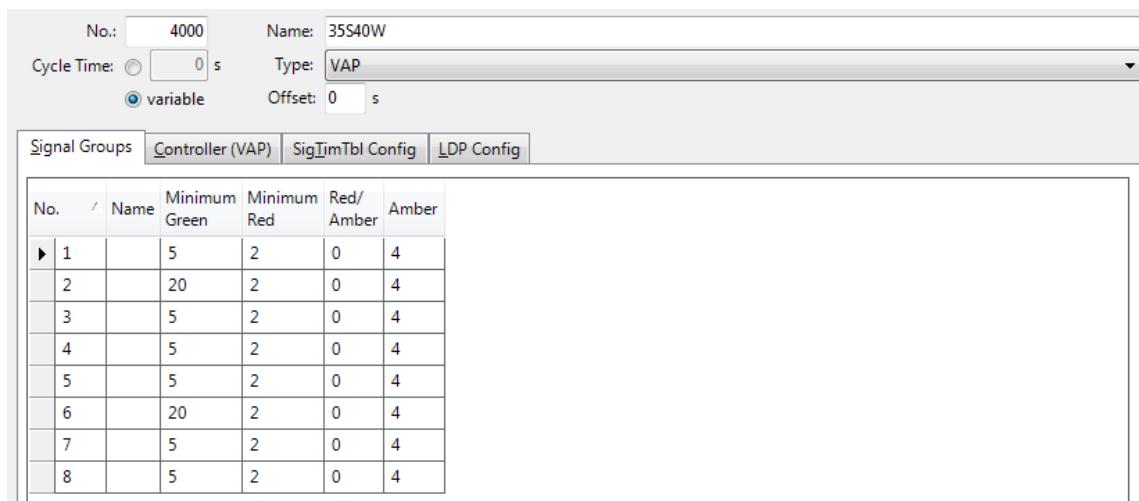


Figure 2-5. “Signal Groups” menu in VISSIM

After creating a network in VISSIM, CID file is required for communication between VISSIM and the controller. CID file contains detector settings, phase settings as well as communication channel setup so that data can be sent to controller and back to VISSIM.

CID file is created in notepad (saved as *.CID) and contains 5 major sections:

```

1 SCJ Assignment [SCJ number, CID-ID, Controller-Type] 1
2 4000,1,1
3
4 Phases [CID-ID, SignalGroup-ID, Phase-Called] 2
5 1,1,1
6 1,2,2
7 1,3,3
8 1,4,4
9 1,5,5
10 1,6,6
11 1,7,7
12 1,8,8
13 1,102,13
14 1,104,14
15 1,106,15
16 1,108,16
17
18 Detectors [CID-ID, Detector-Number, Detector-Length, Channel-ID] 3
19 1,1,30,1
20 1,2,30,2
21 1,3,30,3
22 1,4,30,4
23 1,5,30,5
24 1,6,30,6
25 1,7,30,7
26 1,8,30,8
27 1,102,5,21
28 1,104,5,22
29 1,106,5,23
30 1,108,5,24
31
32 Channels [CID-ID, SCJ-Channel-ID, CID-Channel-ID/Phase, Channel-Direction-1/0] 4
33 1,1,1,1
34
35 Frequency 5
36 10

```

Figure 2-6. *.CID file example

1. Communication between VISSIM, signal controller and CID
 - a. SCJ number: Signal Controller ID in VISSIM setup
 - b. CID-ID: ID index associated with the hardware CID
 - c. Controller-Type: the type of the controller. Type of the controller can be – NEMA TS1 and NEMA TS2 (mode 0, 1 and 2). For the project is used 1 “Controller-Type”
2. Phase setup
 - a. CID-ID: ID index associated with the hardware CID
 - b. SignalGroup-ID: the signal group number used in VISSIM file (under same Signal Controller ID)
 - c. Phase-Called: the phase used in controller configuration corresponding to signal group from VISSIM
3. Detector setup
 - a. CID-ID: ID index associated with the hardware CID
 - b. Detector-Number: the port number used for detector configuration in VISSIM file
 - c. Detector-Length: the length of the associated detector in VISSIM file

- d. Channel-ID: the detector channel/number used in controller configuration for specific detector in VISSIM file
4. Communication channels
- a. CID-ID: ID index associated with the hardware CID
 - b. SCJ-Channel-ID: the signal control communication channel from VISSIM file
 - c. CID-Channel-ID/Phase: CID channel corresponding to VISSIM intersection channel
 - d. Channel-Direction-1/0: input and output direction of the CID channel. “1” is used when sending detector actuations from VISSIM to signal controller, and “0” when sending phase status of signal controller to VISSIM.
5. Resolution frequency (Hz): defines data communication resolution. Maximum value is 10 steps per second and it needs to be the same as in Simulation parameters from VISSIM file. After CID file is saved in *.CID format, VISSIM needs to be setup so that CID can receive data from the VISSIM and send it to controller and the other way around. To setup the VISSIM file, user needs to open the network created for the simulation:
1. Open Signal Controller menu – Edit controllers (check if the Type of the signal controller is setup to VAP)
 2. Press tab Controller (VAP) shown in Figure 2-7.
 3. Under “Program file” select cid.exe application that needs to be stored in C:\Program Files\PTV_Vision\VISSIM\Exe
 4. Open “Interstage file” and go to folder where network for simulation is located, type under “File name” the name of the project (example “4000w.CID”) and hit the enter key
 5. Open “Logic file” and go to folder where network for simulation is located, type under “File name” the name of the project (example “4000w.CID”) and hit the enter key

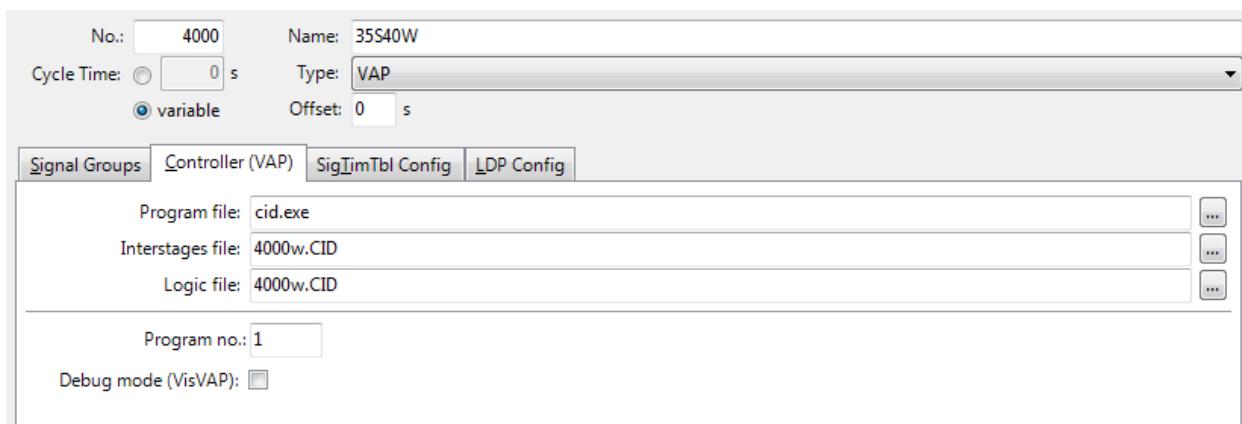


Figure 2-7. Setup VISSIM for CID communication

2.3 Controller Setup for NIATT CID Configuration

2.3.1 Econolite (Cobalt) Controller NIATT CID Configuration

Econolite controller by itself doesn't have enabled High Resolution Data storage, and that needs to be done manually by the user. ASC3 SNMP Client application provided from the Econolite is used so that High Resolution Data storage can be enabled. Figure 2-8 shows interface of ASC3 SNMP Client application with necessary steps. To enable High Resolution Data storage user needs to run the application and then follow these steps:

1. To "Set" column give value "1".
2. Choose "UDP" radio button.
3. IP address and IP port must correspond to controller setup of IP address.
4. After everything is done, press "Set".

To check if controller is enable High Resolution Data storage press "Get" from first OID column, if High Resolution Data is enabled in the controller than ASC3 SNMP Client application will return "1" under Value column.

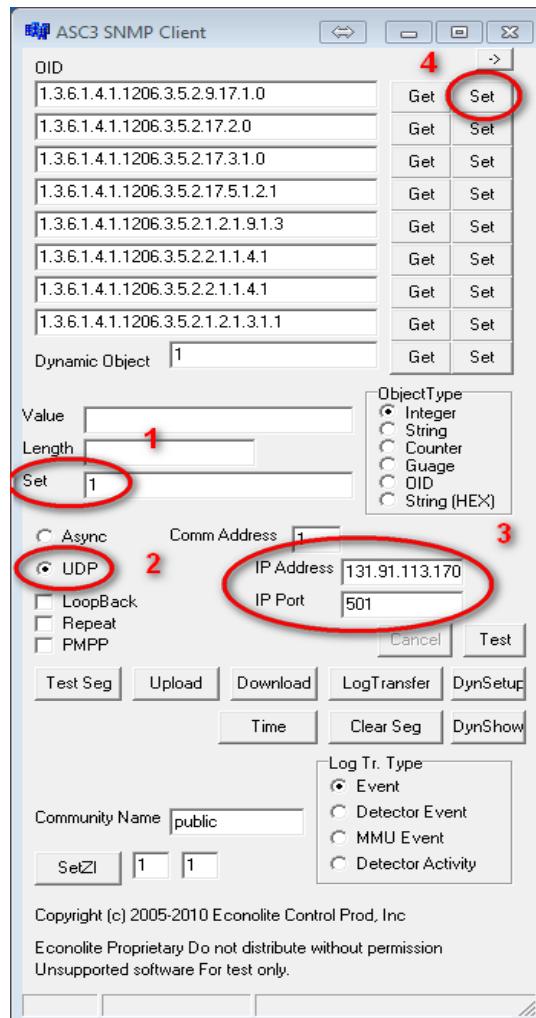


Figure 2-8. ASC3 SNMP client application interface

When data is enabled, the controller starts to store high resolution data by 15 minute intervals for up to 30 hours. After that time, the data is deleted so that new data can be stored.

The configuration of the controller itself is done over the Cobalt touch screen in color, which is user friendly and easy to operate. For high resolution data to be stored in the controller, the user needs to configure the detector options accordingly. Figure 2-9 shows how to set up detectors so that detector actuations are stored in high resolution data file.



Figure 2-9. Cobalt detector setup for high resolution data storage

Controller default mapping of detectors is set up in such a way that only the first eight detectors are received from ABC cables. For this project 16 detectors are used and because of that mapping needs to be changed. To remap the detector configuration for the Cobalt controller, follow these steps:

1. Insert USB drive in Cobalt controller.
2. Select “save current configuration” or “save all” from the USB menu.
3. Remove the USB drive, and insert it in your PC with the Configurator application (provided by the Econolite).
4. Open the Configurator, and select “Base DB”.
5. Then select the L3000.CFG file found inside the same directory as the Configurator application.
6. Select “Current DB”, and navigate to your USB drive where the configuration file from the controller is located.
7. Go to the various tabs at the top of the Configurator to view (Figure 2-10) and change the pin mapping as needed (Table 2-1).

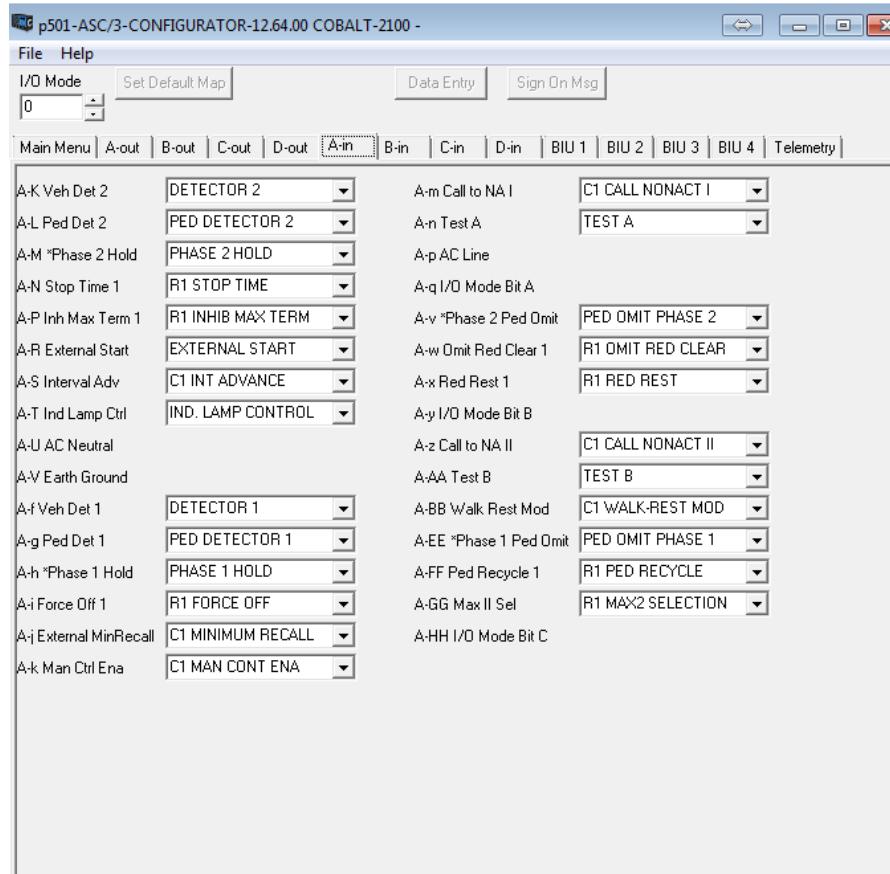


Figure 2-10. Cobalt mapping configuration application interface

Table 2-1. Cobalt mapping detector configuration

Input pins	Old Output commands	New Output commands
MSB-i	Phase hold 3	Detector Channel 9
MSB-h	Phase hold 4	Detector Channel 10
MSB-U	Phase omit 1	Detector Channel 11
MSB-S	Phase omit 2	Detector Channel 12
MSC-m	Phase hold 5	Detector Channel 13
MSC-p	Phase hold 6	Detector Channel 14
MSC-EE	Phase hold 7	Detector Channel 15
MSC-X	Phase hold 8	Detector Channel 16

After changing the mapping of detectors in Configuration application database, that database needs to be returned to controller so that changes will have effect:

1. Go to File Menu.
2. Select Save DB (this will overwrite the configuration file on USB drive with the new mapping).
3. Eject your USB drive from PC and insert it back into the Cobalt controller.

- In the USB menu, select “Database Update” (this will import the saved configuration and make the needed mapping change in the Cobalt controller).

2.3.2 Siemens (m50) Controller NIATT CID Configuration

Siemens controller stores High Resolution Data by default. Data stored in the controller is in 1 hour intervals and data is kept for over 24 hours after when old data is deleted so that space for new data can be made.

Configuration of Siemens controller and detectors is done through display attached to the controller which can be removed if necessary. Each detector used for High Resolution Data storage needs to be configured properly. Configuration of detectors:

- Press number “3” – Phase Data
- Press number “8” Spec. Detectors
- Press number “1” for Vehicle detectors 1-8
- Press number “2” for Vehicle detectors 9-16
- Setup vehicle detectors

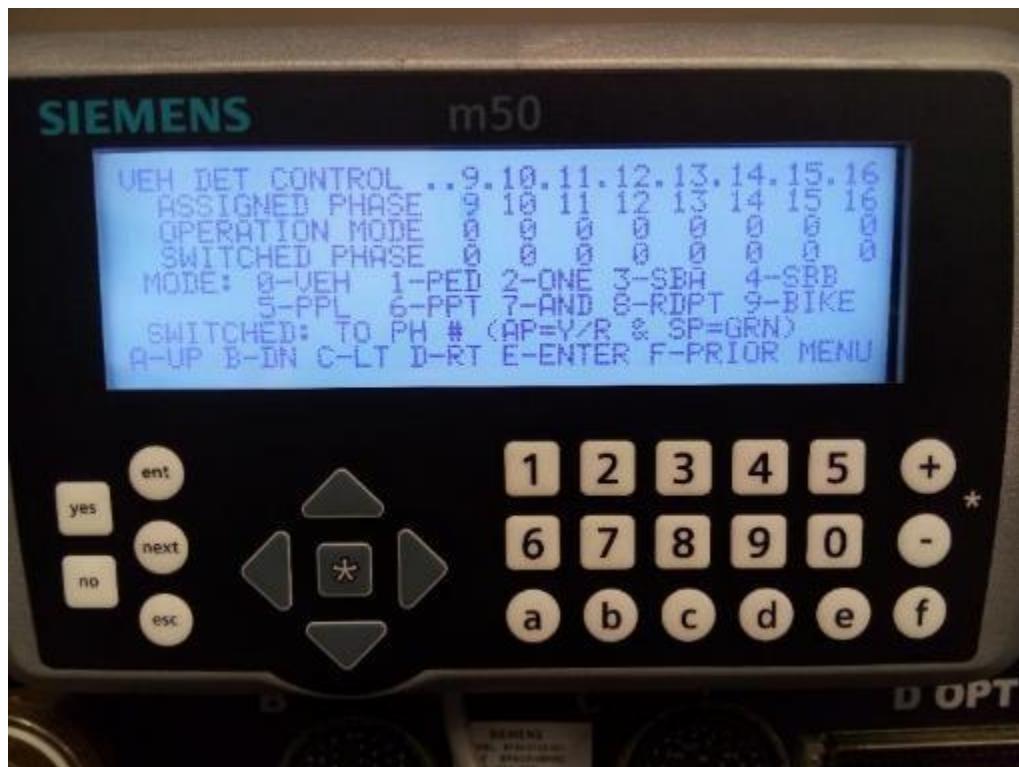


Figure 2-11. Siemens detector configuration interface

Detector configuration for NEMA TS1 ABC Connector Pins is default for 1-8 detectors while 9-16 needs to be done by user manually. Before remapping the detectors, test can be performed to confirm the need of remapping. Simulation requires 1-16 detectors to be active and stored in High Resolution Data file, while only 1-8 are stored properly. Navigate to Siemens controller screen ABC Input Status (Figure 2-12 ABC Input Status):

- Press number “1” – Active Status

2. Press number “9” – Input/Output
3. Press number “1” – ABC Input Status



Figure 2-12. ABC input status interface

In the Figure 2-12 there it is possible to notice that when vehicle passes over detector 9 the phase hold 3 will be active (red mark “X”). From the “SEPAC Activated Signal Control Software with ECOM and NTCIP” manual we can see that controller can operate in different ABC Input Modes (Table 2-2).

Table 2-2. ABC input modes

Pin	Mode 0	Mode 1	Mode 2	Mode ?	Mode 7
A-h	Phase 1 Hold	Preempt 1 Detector	Preempt 1 Detector		Vehicle Detector 23
A-M	Phase 2 Hold	Preempt 3 Detector	Preempt 3 Detector		Vehicle Detector 24
B-i	Phase 3 Hold	Vehicle Detector 9	Vehicle Detector 9		Vehicle Detector 9
B-h	Phase 4 Hold	Vehicle Detector 10	Vehicle Detector 10		Vehicle Detector 10
C-m	Phase 5 Hold	Vehicle Detector 13	Vehicle Detector 13		Vehicle Detector 13
C-p	Phase 6 Hold	Vehicle Detector 14	Vehicle Detector 14		Vehicle Detector 14
C-EE	Phase 7 Hold	Vehicle Detector 15	Vehicle Detector 15		Vehicle Detector 15
C-X	Phase 8 Hold	Vehicle Detector 16	Vehicle Detector 16		Vehicle Detector 16
B-U	Phase 1 Phase Omit	Vehicle Detector 11	Vehicle Detector 11		Vehicle Detector 11
B-S	Phase 2 Phase Omit	Vehicle Detector 12	Vehicle Detector 12		Vehicle Detector 12
B-R	Phase 3 Phase Omit	Timing Plan C	Vehicle Detector 17		Vehicle Detector 17
B-g	Phase 4 Phase Omit	Timing Plan D	Vehicle Detector 18		Vehicle Detector 18
C-n	Phase 5 Phase Omit	Alternate Sequence A	Vehicle Detector 19		Vehicle Detector 19
C-q	Phase 6 Phase Omit	Alternate Sequence B	Vehicle Detector 20		Vehicle Detector 20
C-r	Phase 7 Phase Omit	Alternate Sequence C	Special Status 1 (Alarm 1)		Vehicle Detector 21

Detectors 9-16 can be enabled, respectively input pins can be remapped just by changing the Mode of operation of Siemens controller. Default operation Mode is 0 and for testing environment Mode 1 is necessary. To change the mapping of detectors 9-16 we need to change from Mode 0 to Mode 1:

1. Press number “4” – Unit Data
2. Press number “8” – I/O Misc
3. Navigate to “ABC” Conn column
4. Under row Input change to “1”
5. Restart the controller



Figure 2-13. Siemens controller mapping interface (Mode 1)

After restarting controller test can be made to confirm that detector mapping is updated by going to Final Input Status Screen:

1. Press number “1” – Active Status
2. Press number “9” – Input/Output
3. Press number “5” – Final Input Status Screen (now when vehicle passes detector 9, detector input 9 should be active)

2.3.3 PEEK (ATC-1000) Controller NIATT CID Configuration

Storage of High Resolution Data files on PEEK controller needs to be done manually through display on controller. To enable storage of High Resolution Data files, the following steps are required:

1. Press “MNU” button
2. Press number “4” – Logs
3. Press number “3” – Advanced Controller Log
4. Press number “1” – Setup Logging Options
5. Enable Advanced Logging (X)
6. Enable necessary logs for High Resolution Data storage



Figure 2-14. Advanced Cu log setup interface

After High Resolution Data storage is enabled it is necessary to setup detectors so that they can be stored in the High Resolution Data files. Detector setup for High Resolution Data storing is done through 7 steps:

1. Press "MNU" button
2. Press number "2" – Programming
3. Press number "5" – Detectors
4. Press number "1" – Vehicle Detector Options
5. Enable Detectors Call (For High Resolution Data storing)
6. Enable Detectors Occupancy (Only High Resolution Data detectors)
7. Enable Detectors Volume (Only High Resolution Data detectors)

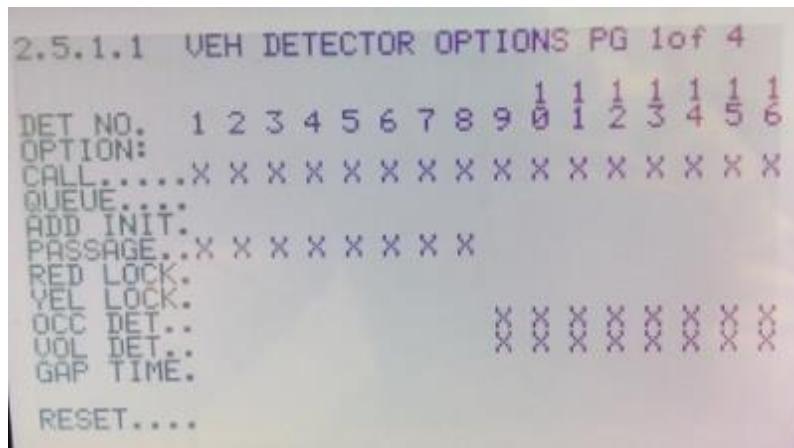


Figure 2-15. Vehicle detector options interface

Storage for detectors 1-8 is done by default because of the mapping of the I/O module. Because detectors 8-16 also need to be stored in High Resolution Data files, that mapping needs to be changed. First we need to check which inputs do we need to change and that is done through Input Outputs Pin Status screen. Navigate to Input Outputs Pin Status screen:

1. Press "MNU" button

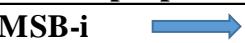
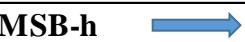
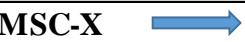
2. Press number “1” – Status
3. Press number “2” – Input/Outputs/Port 1
4. Press number “4” – Input Outputs Pin Status
5. Change pages to locate detector actuation (write down which Pin and Function is activated when detector is activated)

1.2.4 INPUTS OUTPUTS PIN STATUS PG10F5			
DEV.TS2 MSA CONN (Active)	Pin	Function	State
	MSA-A	: Fault Monitor	[0]x
	MSA-B	: DC+ (24V)	[x]
	MSA-C	: Voltage Monitor	[0]x
	MSA-D	: Phase 1 Red Driver	[0]x
	MSA-E	: Phase 1 DWLK Driver	[0]
	MSA-F	: Phase 2 Red Driver	[0]
	MSA-G	: Phase 2 DWLK Driver	[0]x
	MSA-H	: Phase 2 Ped Clr Drvr	[0]
	MSA-J	: Phase 2 Walk Driver	[0]
	MSA-K	: Det Channel 2 Call	[1]
	MSA-L	: Pedestrian Det 2	[1]
[A] Selects Device, x means Pin active			

Figure 2-16. Input outputs pin status interface

Input Outputs Pin Status screen provides necessary information so detector pins can be changed.

Table 2-3. PEEK mapping detector configuration

Input pins	Old Output commands	New Output commands
MSB-i 	Phase hold 3	Detector Channel 9
MSB-h 	Phase hold 4	Detector Channel 10
MSB-U 	Phase omit 1	Detector Channel 11
MSB-S 	Phase omit 2	Detector Channel 12
MSC-m 	Phase hold 5	Detector Channel 13
MSC-p 	Phase hold 6	Detector Channel 14
MSC-EE 	Phase hold 7	Detector Channel 15
MSC-X 	Phase hold 8	Detector Channel 16

After all detector data is collected from Input Outputs Pin Status screen, next step is to remap PEEK controller I/O module. To remap I/O module:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “1” – Unit Configuration
4. Press number “5” – Comms and I/O Setup Menu
5. Press number “4” – I/O Cabinet Setup
6. Navigate through “Pin” enumerations and find the ones needed to be changed (change them to Vehicle Detector number that is needed)
7. Save the changes and restart controller

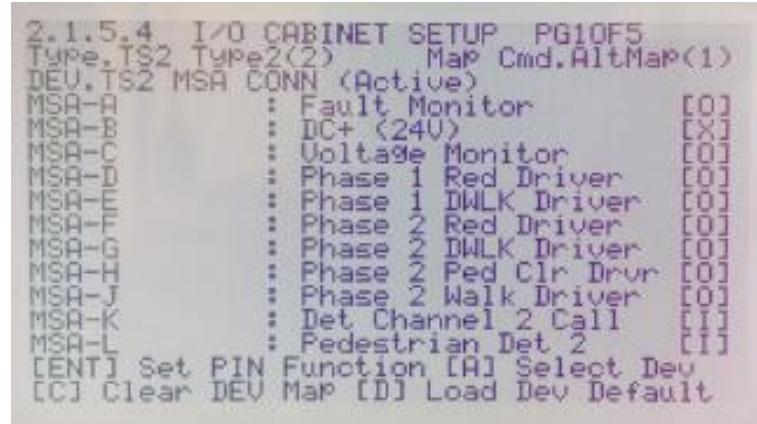


Figure 2-17. I/O cabinet setup interface

2.3.4 Trafficware (ATC 900) Controller NIATT CID Configuration

Trafficware controller needs to enable High Resolution Data storage manually so that files can be stored in the controller for 24 hours in 1 hour format. User needs to get to I/O Logging screen to enable High Resolution Data:

1. Press “Main Menu” button
2. Press number “1” – Controller
3. Press number “9” – I/O
4. Press number “5” – Logging
5. EnableLogs (ON)
6. Enable necessary logs for High Resolution Data storage

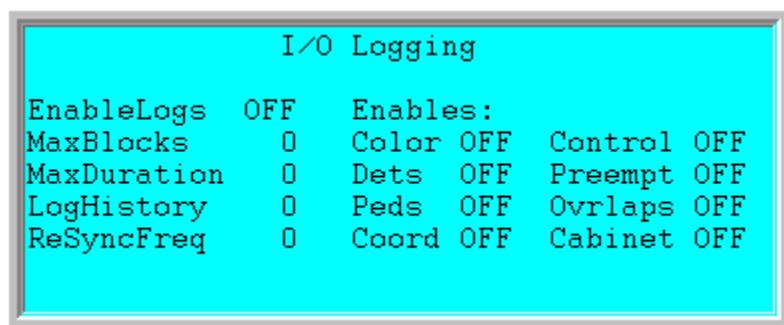


Figure 2-18. I/O logging interface

There are some additional possibilities to be enabled or changed on I/O Logging screen. Table 2-4 shows the possible storing options of specific Log parameters on Trafficware controller. These parameters don't need to be changed, but after EnableLogs is set to “ON” the High Resolution Data files will be stored. Changing the parameters just enables the user to have more options on High Resolution Data storage.

Table 2-4. High resolution data log parameters and descriptions

Parameter	Definition	Default Value
EnableLogs	Turns logging on/off	N/A
MaxBlocks	The maximum log file size measured in 100KB “blocks”	0 defaults to 512K Bytes
MaxDuration	The number of minutes before the log file rolls to the next period (synchronized to midnight)	0 defaults to 60 minutes
LogHistory	The number of hours to store log files	0 defaults to 24 hours
ResyncFreq	The number of hours between resyncing enumeration data	0 defaults to 24 hours
Enables	Enables Enables/disable specific enumeration sets: Color, Control, Detectors, Preemption, Pedestrians, Overlaps, Coordination and Cabinet.	ALL off defaults to ALL on

After High Resolution Data logs are enabled, the detectors need to be setup so that they can be stored in High Resolution Data file. Detector setup:

1. Press “Main Menu” button
2. Press number “5” – Detectors
3. Press number “1” – Veh Params
4. Enable Call for all detectors needed (High Resolution Data detectors need to Call their channel (Dett# 9 – Call 9))
5. Press “Back” button
6. Press number “2” – Veh Options
7. Enable Call for all detectors needed and Extend to ones that need extend option
8. Press “Back” button
9. Press number “8” – V/O Speed
10. Press number “1” – Report Params
11. Input Volume and Occupancy period

Trafficware controller as well by default only activate detectors 1-8 while if user wants to use more than eight detectors, the I/O mode needs to be changed. Depending on how many detectors are needed for the project, user chooses the I/O mode. For this project Trafficware controller Mode 0 is changed to Mode 1:

1. Press “Main Menu” button
2. Press number “1” – Controller
3. Press number “2” – Unit, Ring
4. Press number “1” – Parameters
5. Navigate to “IO Mode” (Press number 1 to change mode – change to Mode 1)
6. Press “ENTR” button and restart the controller

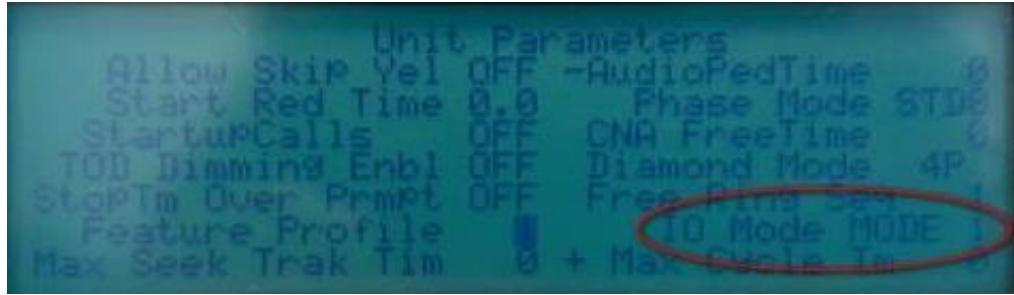


Figure 2-19. I/O mode interface

User can chose between few Modes for I/O mapping and inputs are shown in Table 2-5.

Table 2-5. I/O mapping modes

Input	Mode 0	Mode 1	Mode 2	Mode 3
1	Ph1 Hold	Prmpt 1	Prmpt 1	Prmpt 1
2	Ph2 Hold	Prmpt 3	Prmpt 3	Prmpt 3
3	Ph3 Hold	Det Ch 9	Det Ch 9	
4	Ph4 Hold	Det Ch 10	Det Ch 10	
5	Ph5 Hold	Det Ch 13	Det Ch 13	
6	Ph6 Hold	Det Ch 14	Det Ch 14	
7	Ph7 Hold	Det Ch 15	Det Ch 15	
8	Ph8 Hold	Det Ch 16	Det Ch 16	
9	Ph1 Phase Omit	Det Ch 11	Det Ch 11	
10	Ph2 Phase Omit	Det Ch 12	Det Ch 12	
11	Ph3 Phase Omit	Timing Plan C	Det Ch 17	Timing Plan C
12	Ph4 Phase Omit	Timing Plan D	Det Ch 18	Timing Plan D
13	Ph5 Phase Omit	Alt Seq A	Det Ch 19	Alt Seq A
14	Ph6 Phase Omit	Alt Seq B	Det Ch 20	Alt Seq B
15	Ph7 Phase Omit	Alt Seq C	Alarm 1	Alt Seq C
16	Ph8 Phase Omit	Alt Seq D	Alarm 2	Alt Seq D
17	Ph1 Ped Omit	Dimming Enabled	Dimming Enabled	Dimming Enabled
18	Ph2 Ped Omit	Auto Flash	Local Flash Status	Auto Flash
19	Ph3 Ped Omit	Timing Plan A	Addr Bit 0	Timing Plan A
20	Ph4 Ped Omit	Timing Plan B	Addr Bit 1	Timing Plan B
21	Ph5 Ped Omit	Offset 1	Addr Bit 2	Offset 1
22	Ph6 Ped Omit	Offset 2	Addr Bit 3	Offset 2
23	Ph7 Ped Omit	Offset 3	Addr Bit 4	Offset 3
24	Ph8 Ped Omit	TBC On Line	MMU Flash Status	TBC On Line

2.3.5 McCain (ATC eX) Controller NIATT CID Configuration

High Resolution Data logs in McCain controller need to be enabled before controller can start with storing High Resolution Data files. Enabling High Resolution Data storage in McCain controller:

1. Press number “9” – Logs
2. Press number “4” – Enable Logs
3. High Resolution – Enabled
4. Press “ESC” button
5. Press number “3” – Setup Logs
6. Press number “4” – High Resolution
7. Enable necessary logs for High Resolution Data storage



Figure 2-20. High resolution log setup interface

After the High Resolution Data storage is enabled and parameters are modified, the detector setup needs to be done so that data from the detectors used in the project can be stored properly. The detector setup is done through 5 steps:

1. Press number “4” – Detectors
2. Press number “1” – Vehicle Detectors
3. Press number “1” – Select a Vehicle Detector Set
4. Enable Call for all detectors needed (High Resolution Data detectors need to Call their channel (Dett# 9 – Call 9))
5. Press “ENT” than press “YES-Finalize DB Transaction”

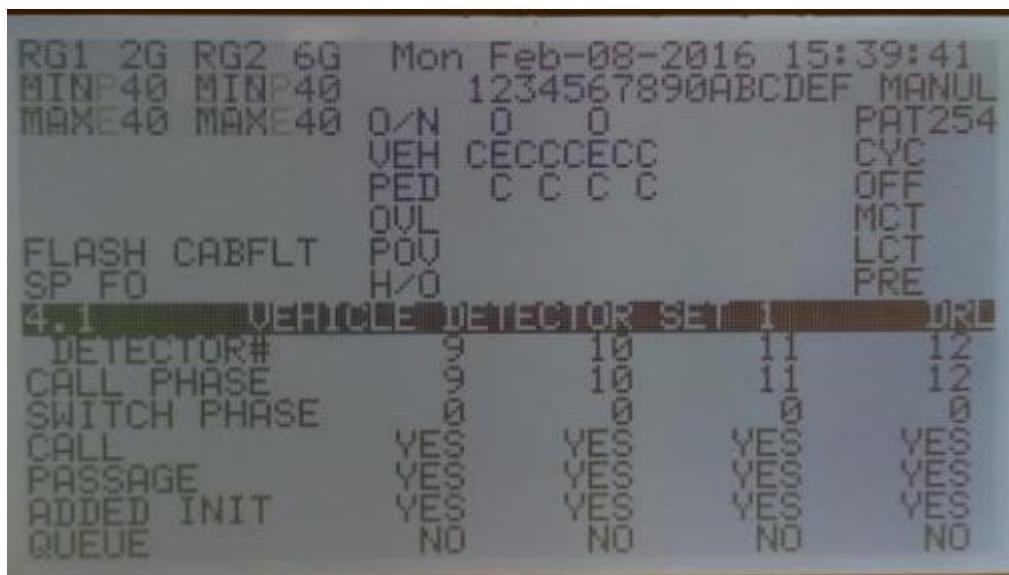


Figure 2-21. Vehicle detector setup interface

Table 2-6. McCain mapping detector configuration

Input pins	Old Output commands	New Output commands
MSB-i	Phase hold 3	Detector Channel 9
MSB-h	Phase hold 4	Detector Channel 10
MSB-U	Phase omit 1	Detector Channel 11
MSB-S	Phase omit 2	Detector Channel 12
MSC-m	Phase hold 5	Detector Channel 13
MSC-p	Phase hold 6	Detector Channel 14
MSC-EE	Phase hold 7	Detector Channel 15
MSC-X	Phase hold 8	Detector Channel 16

From the Table 2-6 can be seen which pins are required to be changed in order to have detector 8-16 actuators. To change the mapping on the McCain controller user needs to follow these steps:

1. Press number “1” – Unit
2. Press number “5” – I/O Mapping
3. Press number “1” – NEMA ABCD
4. Press number “1” – Inputs
5. Navigate through “Pin” enumerations and find the ones needed to be changed (change them to Vehicle Detector number that is needed)
6. Save the changes and restart the controller

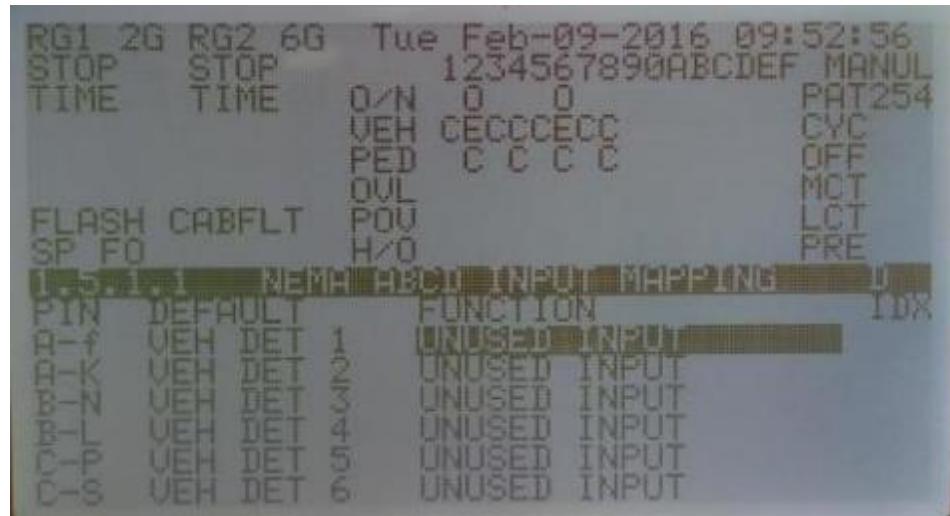


Figure 2-22. NEMA ABCD input mapping interface

2.3.6 Intelight (Model 2070-LDX) Controller NIATT CID Configuration

Intelight controller High Resolution Data storage is by default disabled and user needs to enable it in order to store high resolution data. To enable high resolution data user has two options: directly through controller display or through the web browser. For enabling High Resolution Data storage, the controller display is used. These steps are necessary in order to enable High Resolution Data storage:

1. Press number “3” – Administration
2. Press number “6” – Event Recorder
3. Press number “1” – System Events
4. Log Enabled – Set to “Enabled”, also user can chose where logs will be stored and log history (hours)
5. Press “ENT” button and restart the controller

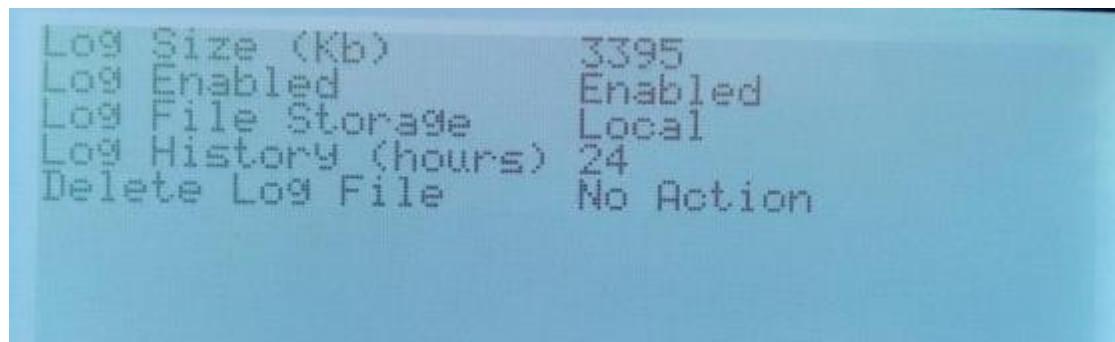


Figure 2-23. System events interface

Detector setup for Intelight controller is also done through controller display and following steps are necessary to setup detectors to be stored in High Resolution Data files:

1. Press number “2” – Controller

2. Press number “4” – Detector
3. Press number “1” – Vehicle Detector Parameters
4. Enable Call Phase for all detectors needed (High Resolution Data detectors need to Call their channel (Det# 9 – Call 9))
5. Press “ECS” button
6. Press number “2” – Vehicle Detector Options
7. Press number “4” – Detector
8. Enable Volume Detectors (Only High Resolution Data detectors)
9. Press “ECS” button
10. Press number “4” – Volume and Occupancy Setting
11. Set Data Collection Period and Number of Periods

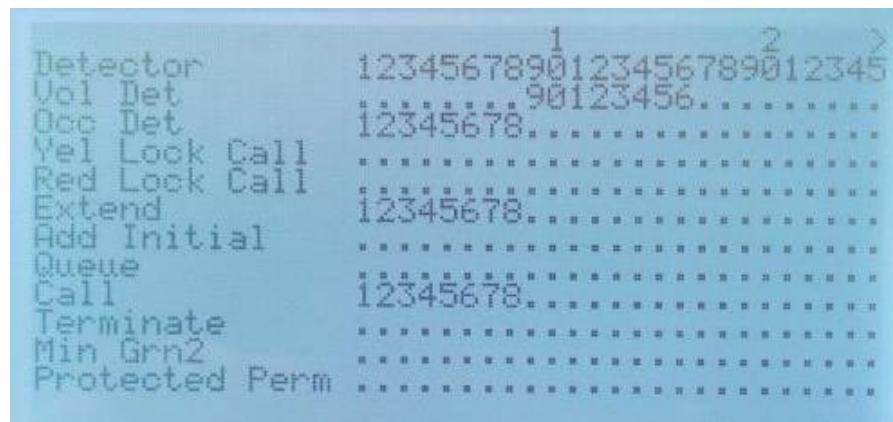


Figure 2-24. Vehicle detector parameters interface

Intelight mapping as well is by default set only for detectors 1-8 while detectors 9-16 need to be introduced by I/O remapping. To remap Intelight controller over controller display is not an easy process, that is why this is usually done through Web browser. To access Web interface of Intelight, controller user need to connect the controller to the same network as the computer or directly to the computer. For this project, controller and computer are on the same network, controller IP address is set up in that way. After accessing the controller over Web browser, using IP address needed, follow these steps to remap I/O module:

1. Open Web browser and input IP address of the Intelight controller
2. Press “Status” on the left Menu
3. Press “Input & Output Status”
4. Find under “Output Points Status” which pin does specific detector activate (write that down)

Figure 2-25. Output points status interface

5. Press “Controller” on the left Menu
 6. Press “Advance IO” on the left Menu
 7. Press “Cabinet Configuration” on the left Menu
 8. Press “Input Points”
 9. Under column “Index” find the appropriate Output Points Status (Detector activation on previous step) and change that Index to new Index that is real detector channel from project

To confirm that changes are as required by the project, go to “Vehicle Detector Status & Alarms” by going to “Status” menu and then to “Detector Status”. If the configuration and remapping is correct, the detector that is set at channel 9 should activate detector 9 on “Vehicle Detector Status & Alarms” interface.

Input Points

IO Module: 1 ▾

Input Point	Description	Input Control Type	Index
1	I/O 1	Vehicle Det Call	29
2	I/O 2	Vehicle Det Call	0
3	I/O 3	Vehicle Det Call	0
4	I/O 4	Not Active	0
5	I/O 5	Not Active	0
6	I/O 6	Not Active	0
7	I/O 7	Not Active	0
8	I/O 8	Vehicle Det Call	0
9	I/O 9	Not Active	0
10	I/O 10	Not Active	0
11	I/O 11	Not Active	0
12	I/O 12	Not Active	0
13	I/O 13	Not Active	0
14	I/O 14	Preempt Input	1
15	I/O 15	Preempt Input	2
16	I/O 16	Unit Test Input A	1
17	I/O 17	Unit Test Input B	1
18	I/O 18	Unit Automatic Flash	1
19	I/O 19	Unit Dimming	1
20	I/O 20	Unit Manual Control Enable	1
21	I/O 21	Unit Interval Advance	1
22	I/O 22	Unit External Min Recall	1
23	I/O 23	Unit External Start	1
24	I/O 24	Unit TBC Online	1
25	In 1	Ring Stop Timing	1
26	In 2	Ring Stop Timing	2
27	In 3	Ring Max II Selection	1
28	In 4	Ring Max II Selection	2
29	In 5	Ring Force Off	1
30	In 6	Ring Force Off	2
31	In 7	Unit Call To Non Actuated A	1
32	In 8	Unit Walk Rest Modifier	1

[Apply](#)

[Next](#)

Figure 2-26. Input points interface

2.4 Trafficware Controller Interface Device Configuration

Trafficware CID is the hardware device used for HILS with controllers using SDLC and RS232 cables. The controller and the CID are connected with an SDLC cable. While the CID and the PC are connected with an RS232 cable. Trafficware CID doesn't require drivers, but Trafficware TS2 Test Box software is necessary in order to test the connection and to operate the Trafficware CID. Windows 64 bit is operating system used for testing the Trafficware CID with the controllers. The Trafficware CID doesn't have physical outputs to the user for red, yellow, or green light or detector actuation, but these are simulated in the Trafficware TS2 Test Box software that the user gets with purchase of the Trafficware CID. After initial installation and establishing connection to the controller and computer, the user can try to connect the controller to Trafficware CID by using connect button in the software. If the communication works, Trafficware CID physical green lights on front panel will indicate that the communication is established on the SDLC cable as well as

the RS232 cable. Besides physical lights, Trafficware TS2 Test Box software also provides red, yellow, and green lights, and if they are active, the user can know that communication is working.

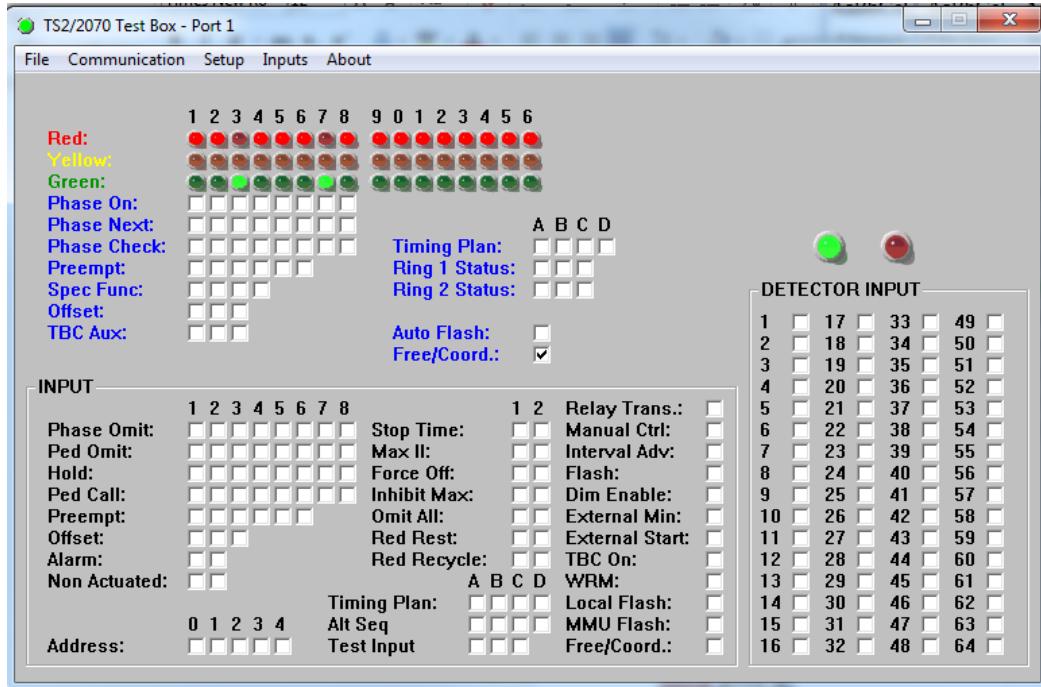


Figure 2-27. Trafficware TS2 test box software interface

2.5 Controller Hardware-in-the-Loop Setup

Hardware-In-the-Loop setup starts from the controller configuration for Trafficware CID, which has SDLC communication. Not all controllers were prepared for SDLC communication so a new I/O module was ordered for the Intelight controller. After the new I/O module is installed, all necessary hardware was in place to test the HILS setup. Connection of the controller to the Trafficware CID was made with SDLC cable, than RS232 cable was used to connect Trafficware CID with computer which was used to run VISSIM software so that VISSIM and controller can communicate. All controllers were connected with the CID and the computer, and were tested with Naztec TS2 Test Box software to check if the communication was working.

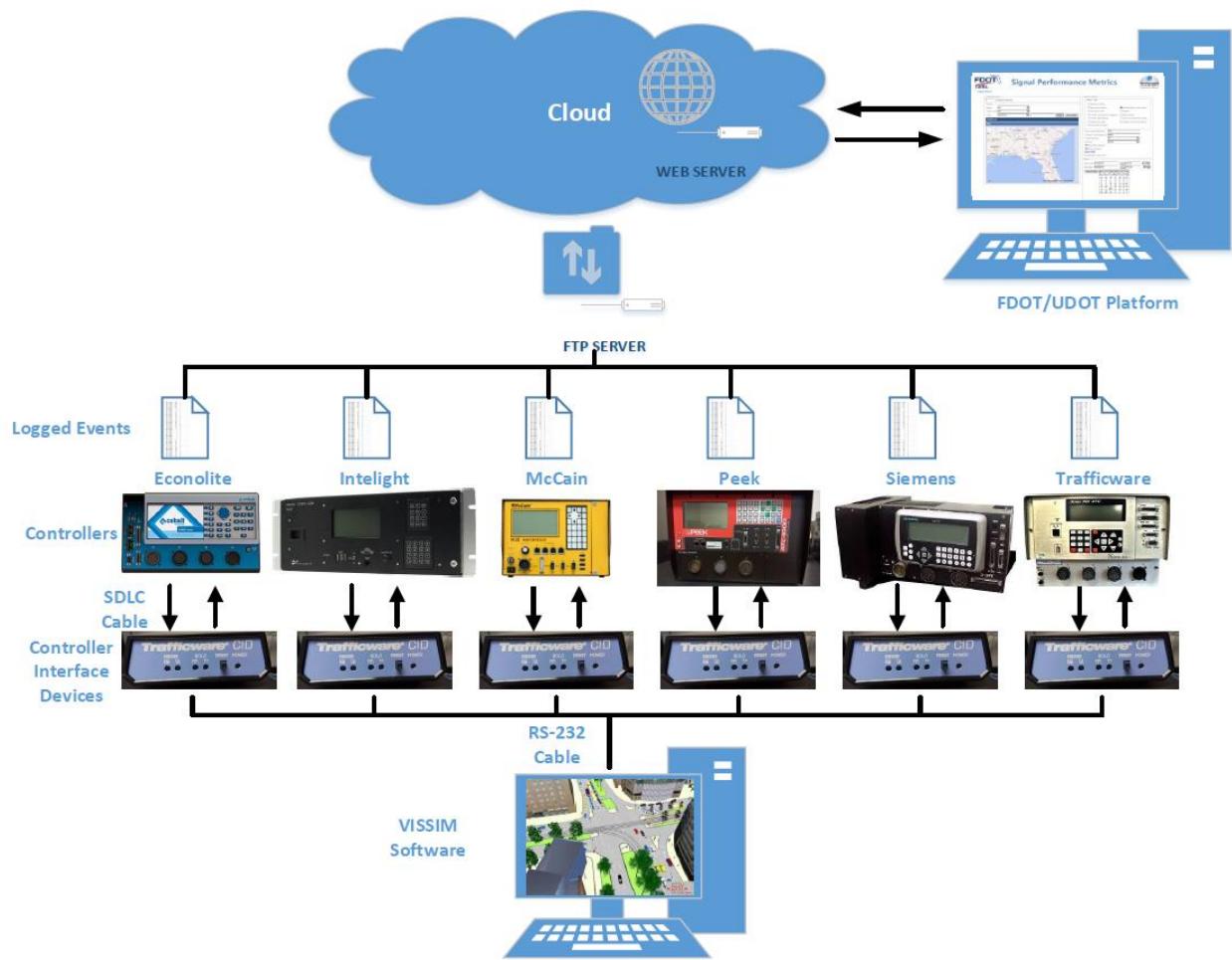


Figure 2-28. Controller hardware-in-the-loop setup

2.6 VISSIM Setup for Trafficware CID Configuration

VISSIM is simulation tool used for the project and therefore network needs to be created in VISSIM before starting the simulations. If there is an existing network, the network can be modified and used for simulation. Simulation with Trafficware CID and VISSIM doesn't have restrictions regarding version of VISSIM used, but it requires software called "VirtualCID" that allows signal controller to communicate to VISSIM and vice versa. For this project and for described trafficware CID device, VISSIM 7.13 on Windows 7 environment 64 bits is used so all the instructions are related to this laboratory setup. Before any configuration of VISSIM is done, VirtualCID software needs to be installed on the computer. After installation is done, VISSIM setup needs to be adjusted for Trafficware CID. To configure VISSIM to communicate with signal controller, changes need to be made to VISSIM file as well as to CID files. Setup controller "Type" to External in VISSIM file:

1. Open Signal Control menu in VISSIM
2. Select Signal Controllers
3. Under "Type" select External

If VISSIM file has all necessary detectors and signal heads that will be used in the project, CID file needs to be created:

```

1  VISSIM setting [SC, SG, Phase]
2  1,1,1
3  1,2,2
4  1,3,3
5  1,4,4
6  1,5,5
7  1,6,6
8  1,7,7
9  1,8,8
10
11 Detector setting [Detector, SC, Phase]
12 1,1,9
13 2,1,15
14 3,1,12
15 4,1,14
16 5,1,13
17 6,1,10
18 7,1,11
19 8,1,16
20 9,1,2
21 10,1,6
22 11,1,4
23 12,1,8
24
25 Port setting [SC, Port]
26 1,6
27
28 Ethernet setting [SC, Port]

```

Figure 2-29. Virtual CID file example

1. VISSIM Setting
 - a. **SC** - Signal controller (Intersection used in VISSIM to correspond to controller)
 - b. **SG** - Signal Group in VISSIM
 - c. **Phase** - Phase used in the controller (Configured controller – Cobalt, Siemens, PEEK, McCain, Trafficware or Intelight)
2. Detector Setting
 - a. **Detector** -

Detectors								
Count: 32	PortNo	Name	Lane	Pos	Length	SC	Type	
1	1		5 - 3	89.873	3.000	1	Standard	
2	2		5 - 2	90.498	3.000	1	Standard	
3	3		2 - 3	154.856	3.000	1	Standard	
4	4		2 - 2	157.049	3.000	1	Standard	
5	5		7 - 3	85.303	3.000	1	Standard	
6	6		7 - 2	85.535	3.000	1	Standard	

Figure 2-30. Detector count used for the phase that detector is assigned to

- b. **SC** - Signal controller (Intersection used in VISSIM to correspond to controller)
 - c. **Phase** - Phase used in controller (Configured controller – Cobalt, Siemens, PEEK, McCain, Trafficware or Intelight)
3. Port Setting
- a. **SC** - Signal controller (Intersection used in VISSIM to correspond to controller)
 - b. **Port** - Communication port (Serial port RS232) on computer that is connected to controller over Trafficware CID.

Note: To find out which serial port is used for different controllers, user needs to connect Naztec TS2 Test Box software and test each port changing it in “testbox.config” file. Ethernet setting is not used for serial connection and SDLC communication to signal controller, but it must remain in the CID file.

When VISSIM file is configured, and CID file is configured, open the Virtual CID application with right click “Run as administrator”.

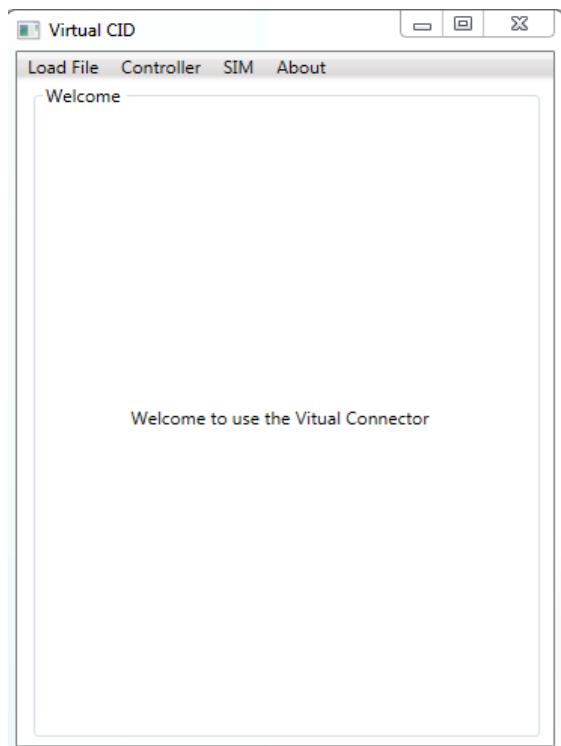


Figure 2-31. Virtual CID interface

After Virtual CID interface is opened:

1. Select “Load file” from VirtualCID tab menu, then select “VISSIM” to open network

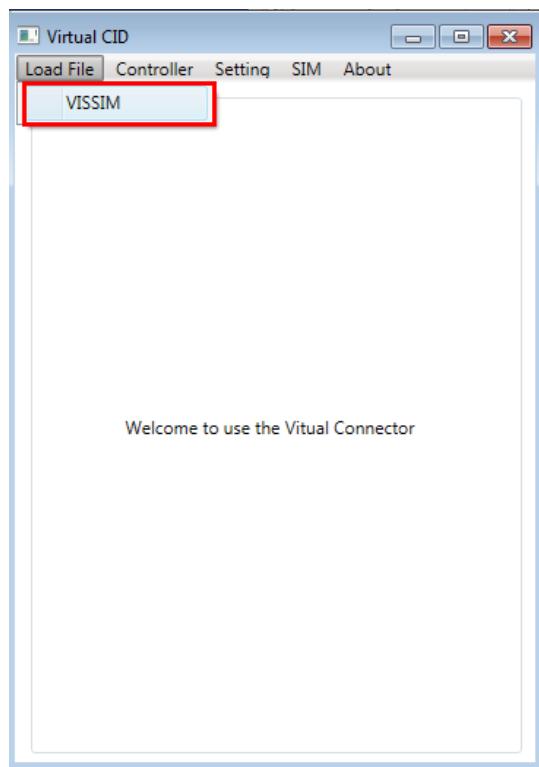


Figure 2-32. Virtual CID “Load File” menu

2. Select multiple appropriate files: *.txt (Virtual CID file), *inp file (VISSIM file of the project) and *.layx file (project VISSIM file with extension .layx) and then press “Open” button

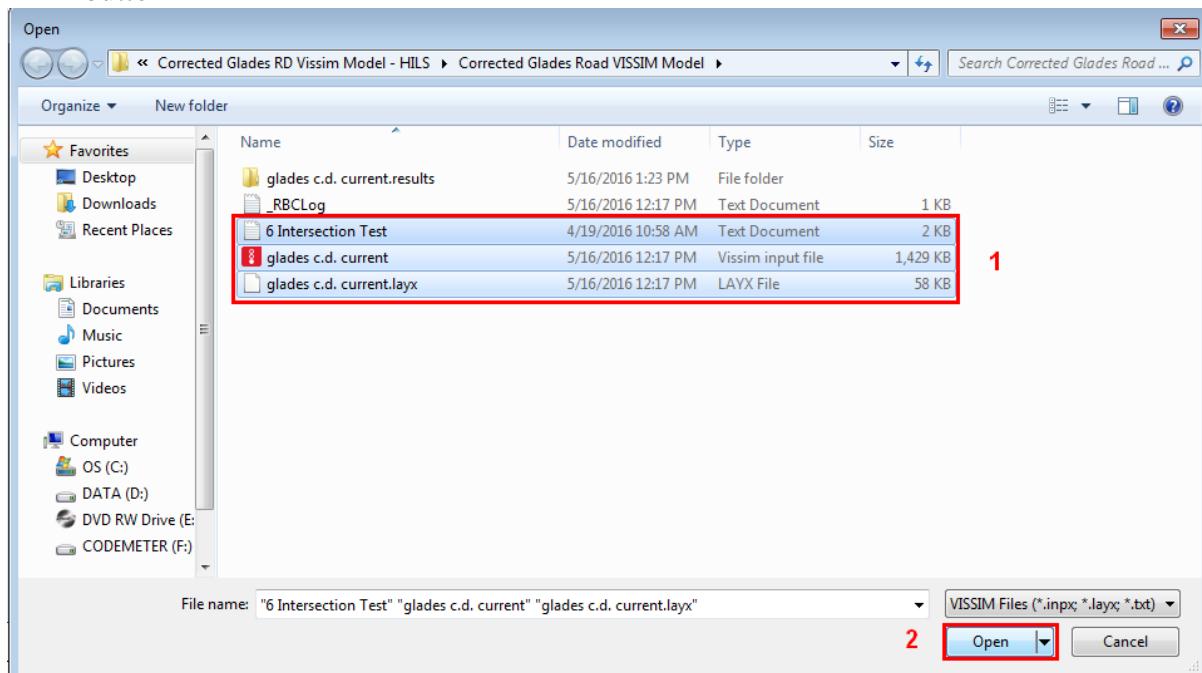


Figure 2-33. Multiple CID file selection

3. Select “Controller” from VirtualCID tab menu, then select “Naztec Test Box”

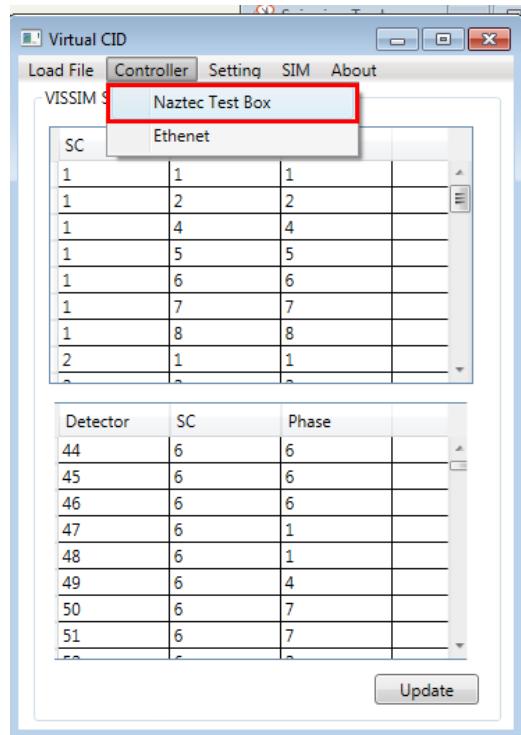


Figure 2-34. Virtual CID “Controller” menu

4. Press “Open” button

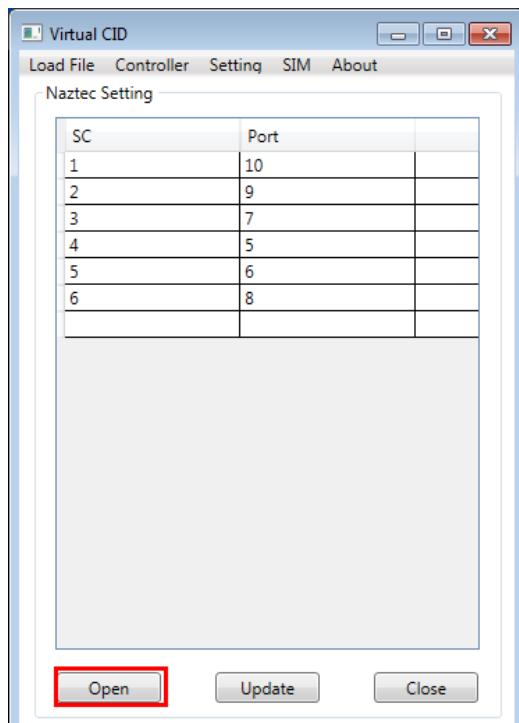


Figure 2-35. Port number check

5. Select “SIM” from VirtualCID tab menu, then select “Start” to start the simulation

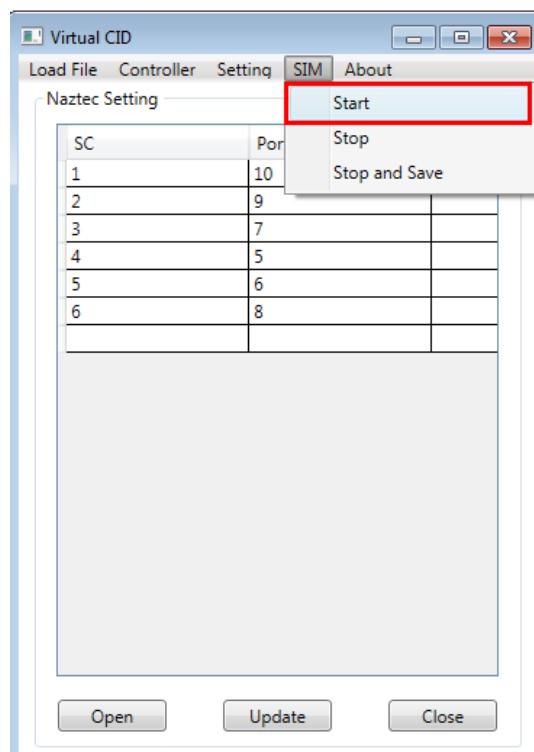


Figure 2-36. Virtual CID “SIM” menu

2.7 VISSIM Network Model

Hypothetical VISSIM network model signal control was created containing eight phases, four are trough movement while other four are left movement. Trough movements have two lanes each and left turn movement has one pocket lane for each approach. Each phase is protected for this project. Minimum timings are as follow: minimum green time – 5 s, red clearance – 2 s and yellow clearance – 4 s. Right turning vehicles have “turn on red” allowed for this intersection.

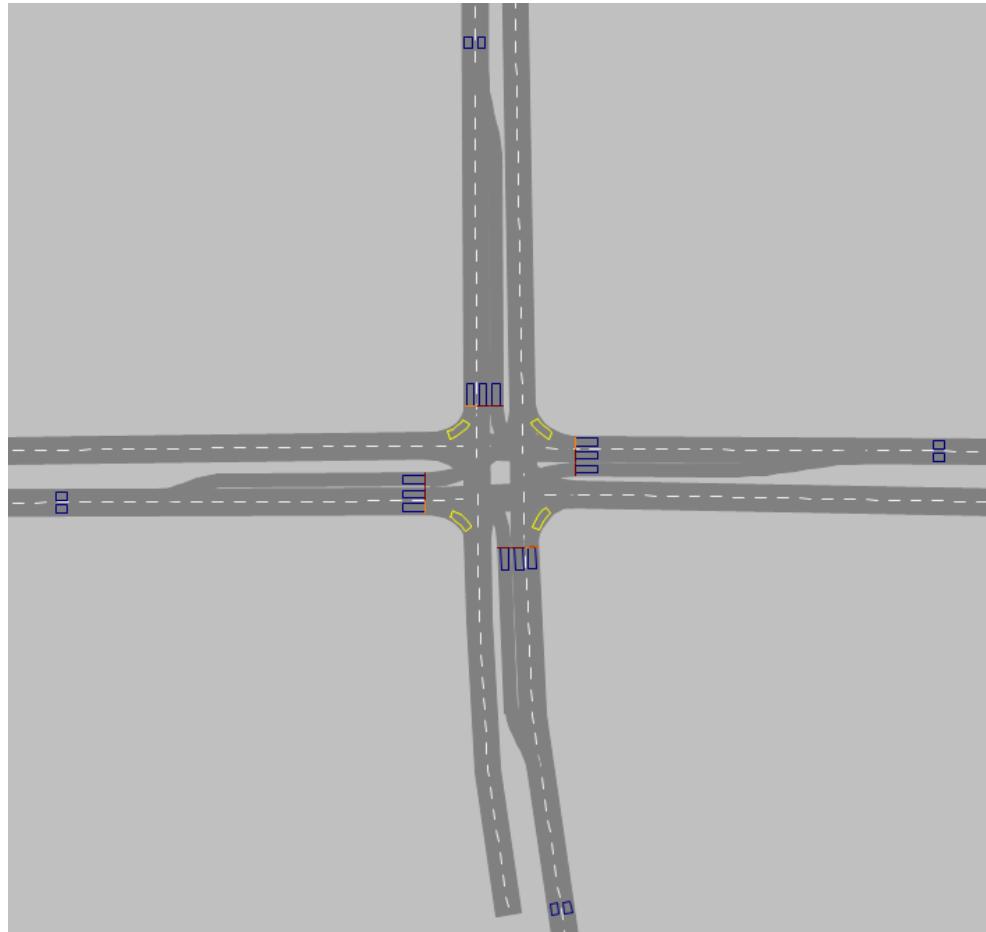


Figure 2-37. Intersection layout for the project

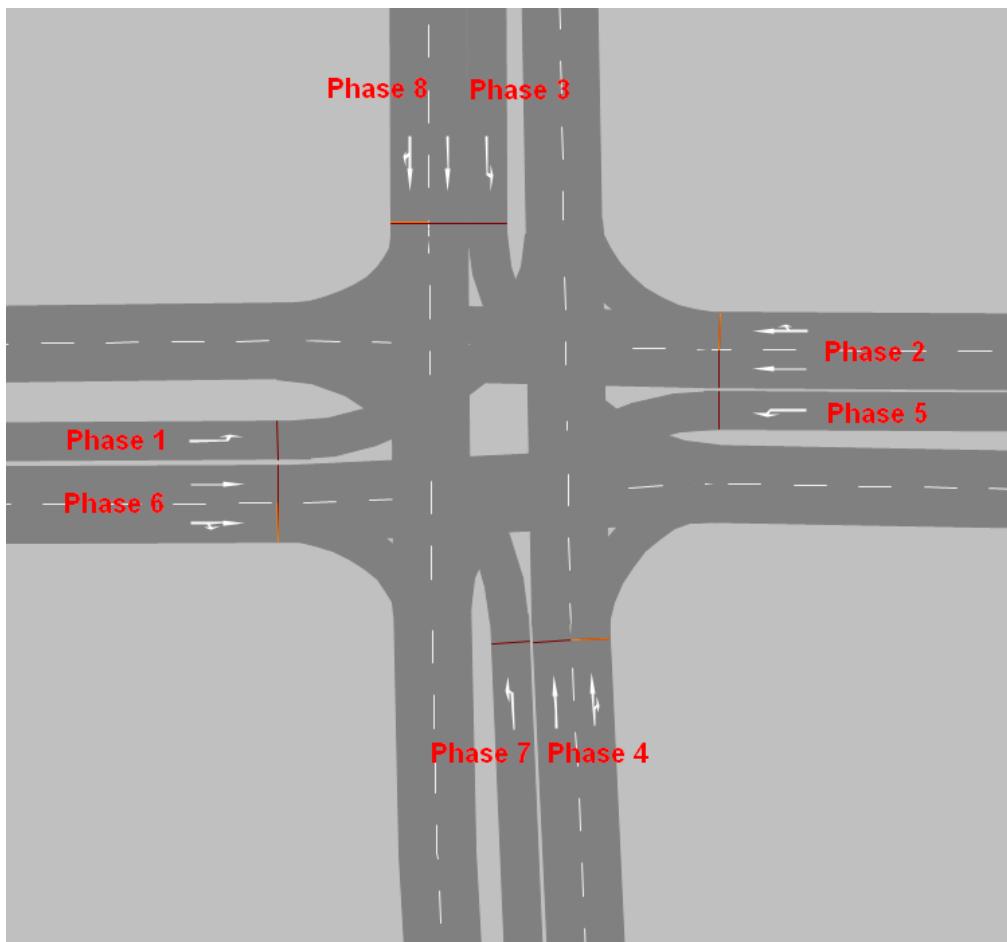


Figure 2-38. Intersection phases layout

There are presence detectors for each lane calling the assigned phase on that lane. The length of the presence detectors is 20 feet, and they are placed before the stop line. Presence detectors are used only for calling and extension of the phases. Besides presence detectors, there are also advanced detectors that are necessary for creating performance metrics graphs (Purdue Coordination Diagram, Approach Volume, etc.). Each advanced detector is placed 300 feet from the stop line and is 9.8 feet long. Advanced detectors are only placed on through movement on each approach in each lane, meaning that eight advanced detectors exist on one intersection. Each approach has two advanced detectors, and they are monitoring phases 2, 4, 6 and 8. Phase 2 is eastbound approach, Phase 4 is southbound approach, Phase 6 is westbound approach and Phase 8 is northbound approach.

1. Westbound approach

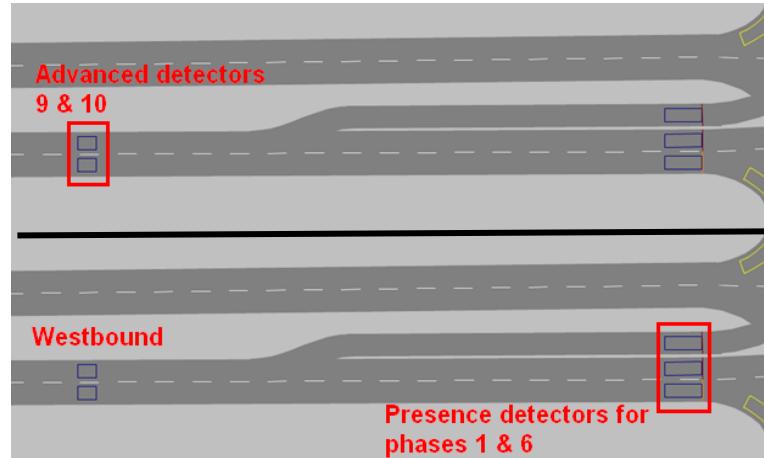


Figure 2-39. WB Advanced detectors (9 & 10) and presence detectors for phases 1 & 6

2. Northbound approach

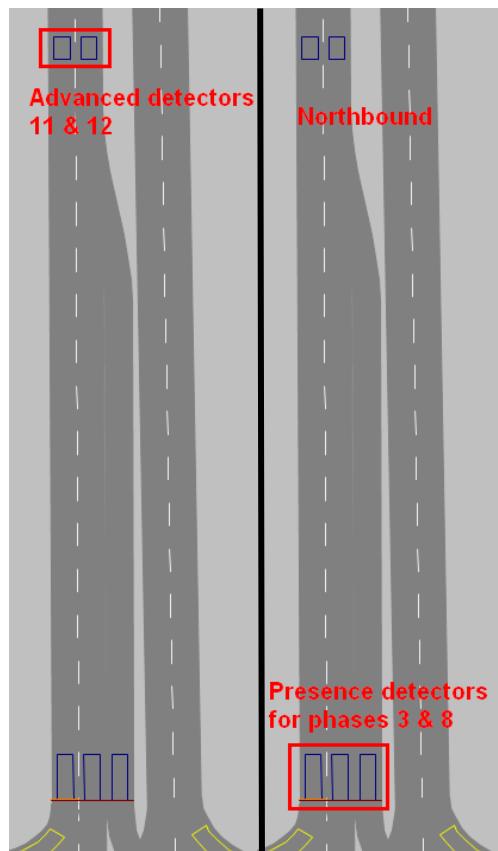


Figure 2-40. NB Advanced detectors (11 & 12) and presence detectors for phases 3 & 8

3. Eastbound approach

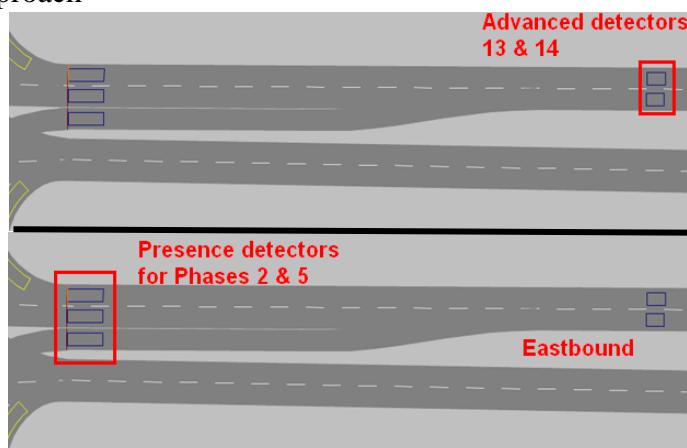


Figure 2-41. EB Advanced detectors (13 & 14) and presence detectors for phases 2 & 5

4. Southbound approach

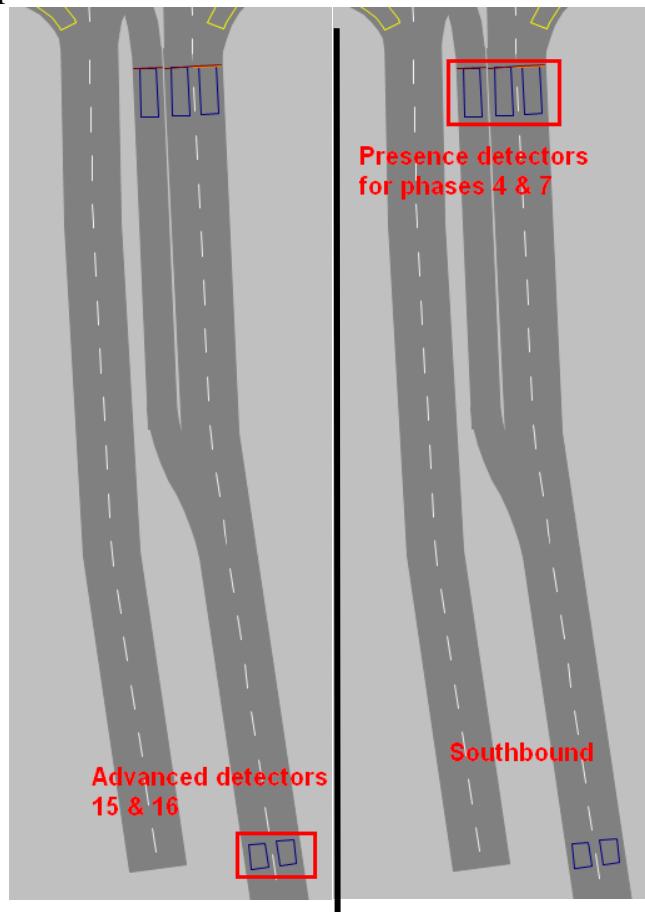


Figure 2-42. SB Advanced detectors (15 & 16) and presence detectors for phases 4 & 7

The model with six intersections is also created for testing purposes, it has the same hypothetical single intersection described above replicated on the corridor. Simulation and configuration of the controllers for the model are done in free operation due to easier testing of the High Resolution

event codes. In the project deliverables, subtask is to create the model that is configured, validated and calibrated in the corridor of six intersections. That network model will be introduced later in the project.

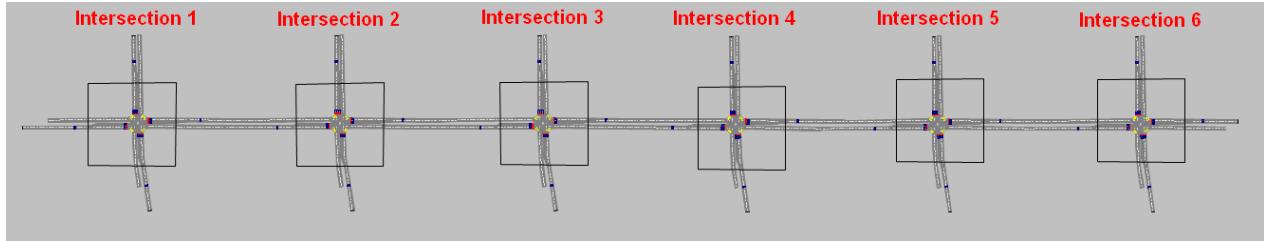


Figure 2-43. Six intersections testing model

The six intersection model was tested in VISSIM running six different controllers at the same time. Model was configured so that Intersection 1 was operated by Cobalt controller, Intersection 2 - Siemens controller, Intersection 3 - Trafficware controller, Intersection 4 - PEEK controller, Intersection 5 - Intelight controller and Intersection 6 by McCain controller.

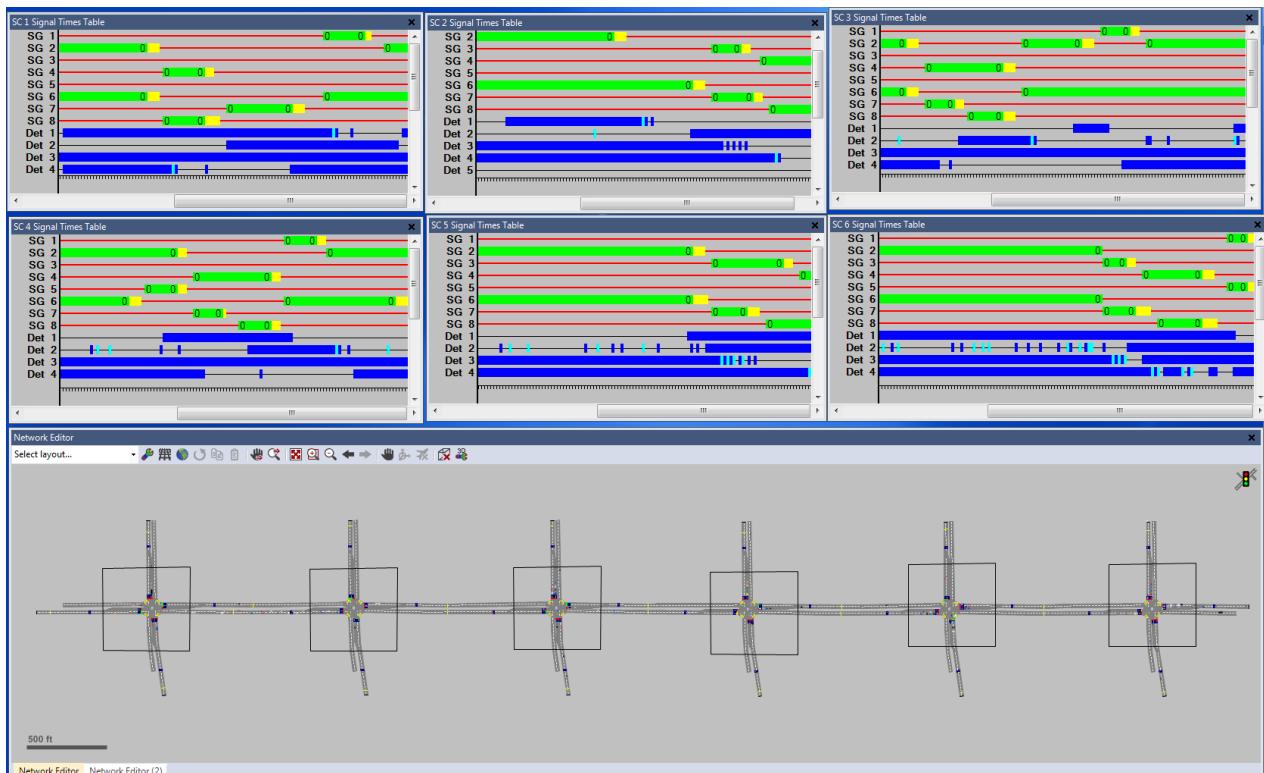


Figure 2-44. Six intersections with six different signalized controllers

2.8 Controller Setup for Trafficware CID Configuration

2.8.1 Econolite (Cobalt) Controller Trafficware CID Configuration

The controller needs to be connected to Trafficware Test Box with SDLC cable and Trafficware Test Box needs to be connected to the computer with RS232 cable before continuing with the setup. Cobalt controller uses the same detector setup as explained before (see Chapter 3.1.). Trafficware CID uses SDLC communication with the controller and it needs to be enabled if user wants to run simulations with Trafficware Test Box. To turn on SDLC communication, follow these steps:

1. Go to “Home” icon in left upper corner of the controller
2. Go to “Cabinet Config” icon
3. Press “SDLC Devices” to change tab
4. Enable “Term & Facility” 1 and 2
5. Enable “Detector Rack” 1 and 2
6. Enable “Malfunction Management Unit (MMU)”
7. Restart the controller

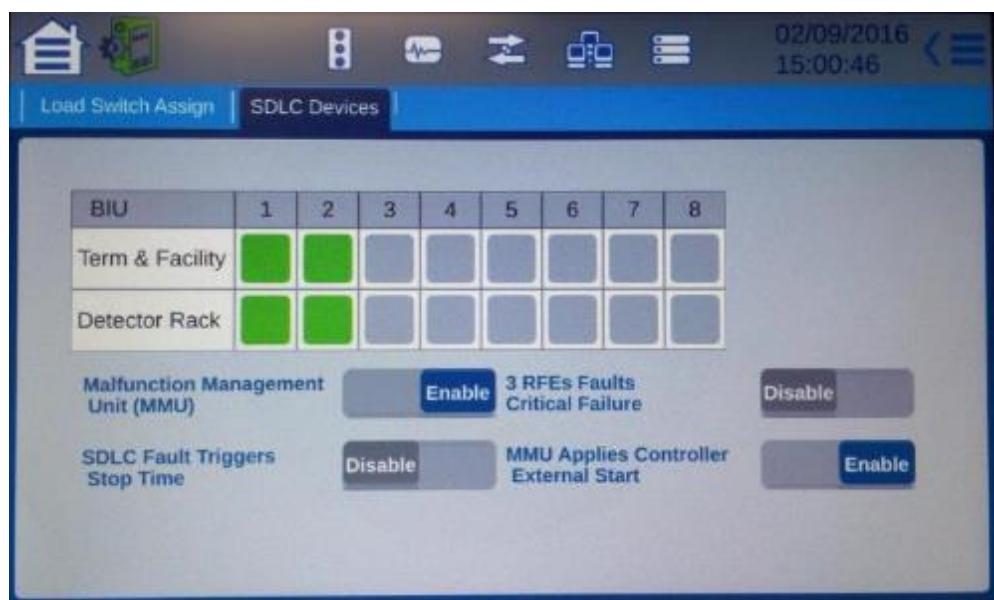


Figure 2-45. Cobalt SDLC setup example

2.8.2 Siemens (m50) Controller Trafficware CID Configuration

Controller needs to be connected to Trafficware Test Box with SDLC cable and Trafficware Test Box needs to be connected to computer with RS232 cable before continuing with the setup. Siemens controller uses the same detector setup as explained before (see Chapter 3.2.). For SDLC communication user needs to change Siemens operation mode (TS2). Siemens operation mode change instructions are shown in next few steps:

1. Press number “2” – Utilities
2. Press number “6” – Load Default

3. Press letter “C” – Than press number “2” to change Siemens controller operating mode to TS2
4. Restart the controller

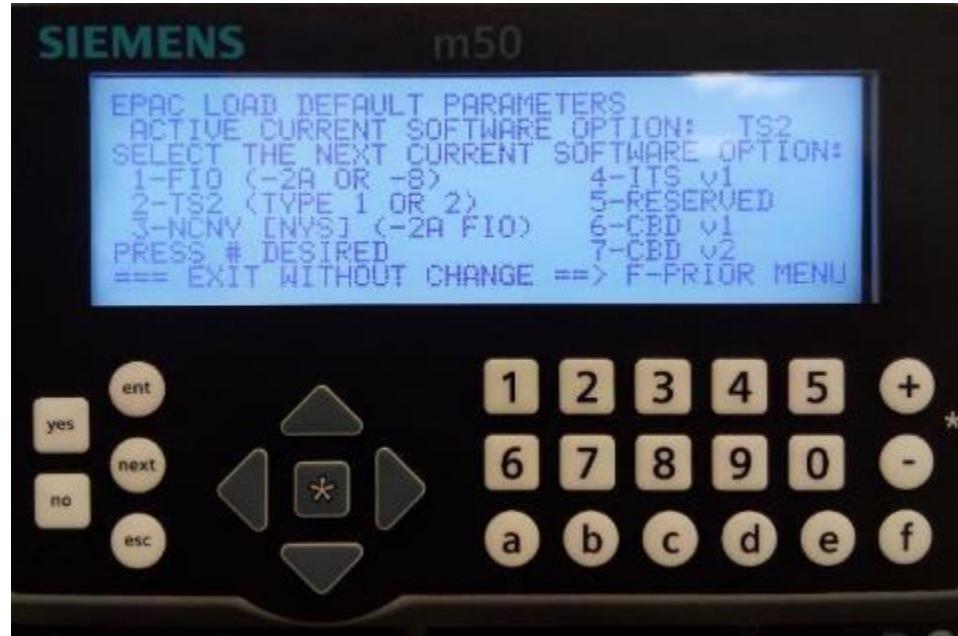


Figure 2-46. Siemens controller operating mode change

After operating mode is changed, SDLC communication needs to be enabled. Enabling SDLC communication:

1. Press number “4” – Unit Data
2. Press number “7” – Port 1/ITS Data
3. Under column “PRES”, change T&F BIU #1,2,3,4 and DET BIU #1,2 and Malfunction Unit to “1”
4. Restart the controller



Figure 2-47. SDLC communication for Siemens controller

Trafficware test box has the default overlaps on 9, 10, 11 & 12 channels and the Siemens controller is set for the overlaps on channels 13, 14, 15, 16 and that needs to be changed for SDLC communication and MMU to operate normally. Channing overlaps on Siemens controller is shown below:

1. Press number “4” – Unit Data
2. Press number “5” – Ring Structure
3. Edit Phase 2 and move Pedestrian Channel from 9 to 13
4. Edit phase 4 and move Pedestrian Channel from 10 to 14
5. Edit phase 6 and move Pedestrian Channel from 11 to 15
6. Edit Phase 8 and move Pedestrian Channel from 12 to 16
7. Press button “ENT” to save changes
8. Press button “ESC” to return one menu back
9. Press number “3” – Overlap Standard
10. Press button “A” – Change Overlap A from channel 13 to channel 9
11. Press button “B” – Change Overlap B from channel 14 to channel 10
12. Press button “C” – Change Overlap C from channel 15 to channel 11
13. Press button “D” – Change Overlap D from channel 16 to channel 12
14. Press button “ENT” to save changes
15. Press button “ESC” to return one menu back
16. Press number “9” – Signal Driver Outputs
17. Change Pedestrian channels from 2,4,6,8 to channels 13, 14,15,16
18. Change Overlap on A,B,C,D to output pins 17,18,19,20

2.8.3 PEEK (ATC-1000) Controller Trafficware CID Configuration

Controller needs to be connected to Trafficware Test Box with SDLC cable and Trafficware Test Box needs to be connected to computer with RS232 cable before continuing with the setup. First in order to enable SDLC communication PEEK operation mode needs to be changed. SDLC communication only works with TS2 Type 1 operation mode. To change PEEK operation mode user needs to follow these steps:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “1” – Unit Configuration
4. Press number “5” – Comms and I/O Setup Menu
5. Press number “4” – I/O Mapping
6. Change Operation Type to “TS2 Type 1”

```
2.1.5.4 I/O CABINET SETUP PG10F5
TYPE, TS2 TYPE1(1) Map Cmd.AltMap(1)
DEV, TF BIU 1 (Inactive)
01-OUTPUT 1 :: Chnl/Load Sw 1 Red [0]
02-OUTPUT 2 :: Chnl/Load Sw 1 Yel [0]
03-OUTPUT 3 :: Chnl/Load Sw 1 Grn [0]
04-OUTPUT 4 :: Chnl/Load Sw 2 Red [0]
05-OUTPUT 5 :: Chnl/Load Sw 2 Yel [0]
06-OUTPUT 6 :: Chnl/Load Sw 2 Grn [0]
07-OUTPUT 7 :: Chnl/Load Sw 3 Red [0]
08-OUTPUT 8 :: Chnl/Load Sw 3 Yel [0]
09-OUTPUT 9 :: Chnl/Load Sw 3 Grn [0]
10-OUTPUT 10 :: Chnl/Load Sw 4 Red [0]
11-OUTPUT 11 :: Chnl/Load Sw 4 Yel [0]
[ENT] Set PIN Function [A] Select Dev
[C] Clear DEV Map [D] Load Dev Default
```

Figure 2-48. I/O cabinet setup interface

PEEK controller has the same detector setup as for ABC communication so if user needs to setup detectors for first time see Chapter 3.3. Changing PEEK controller communication from ABC to SDLC:

7. Press “MNU” button
8. Press number “2” – Programming
9. Press number “1” – Unit Configuration
10. Press number “5” – Comms and I/O Setup Menu
11. Press number “1” – Port 1
12. Enable “Term & Facils” 1,2,3,4
13. Enable “Detector rack” 1,2,3,4
14. MMU Enable – “X”

Figure 2-49. PEEK controller Port 1 interface

2.8.4 Trafficware (ATC 900) Controller Trafficware CID Configuration

Controller needs to be connected to Trafficware Test Box with SDLC cable and Trafficware Test Box needs to be connected to computer with RS232 cable before continuing with the setup. Trafficware controller detector setup is the same as in ABC communication so for detector setup, see Chapter 3.4.

1. Press “Main Menu” button
 2. Press number “1” – Controller
 3. Press number “7” – Enable Run
 4. Navigate to “Change to: Off” and press “ENTR” button
 5. Go back by pressing “Main Menu” button
 6. Press number “1” – Controller
 7. Press number “3” – SDLC
 8. Press number “1” – TS2 Devices
 9. Enable “Term/Fac” 1,2,3,4
 10. Enable “Detector” 1,2,3,4
 11. Enable MMU – “X”
 12. Press “ENTR” button to save and restart the controller



Figure 2-50. Trafficware SDLC interface

2.8.5 McCain (ATC eX) Controller Trafficware CID Configuration

Controller needs to be connected to Trafficware Test Box with SDLC cable and Trafficware Test Box needs to be connected to computer with RS232 cable before continuing with the setup. McCain controller detector setup is the same as in ABC communication so for detector setup, see Chapter 3.5. To change ABC communication to SDLC communication between CID and controller user needs to change controllers operating mode to TS2 Type 1 BIU:

1. Press letter “B” on Main Menu screen - Miscellaneous
2. Press number “2” – DB Management
3. Press number “1” – Initialize Database
4. Press number “2” – I/O Map Only
5. Press number “1” – NEMA TS2 Type 1 BIU
6. Press button “YES” and then button “ENT”
7. Press button “YES” – Finalize Database Transaction to save the changes
8. Restart the controller

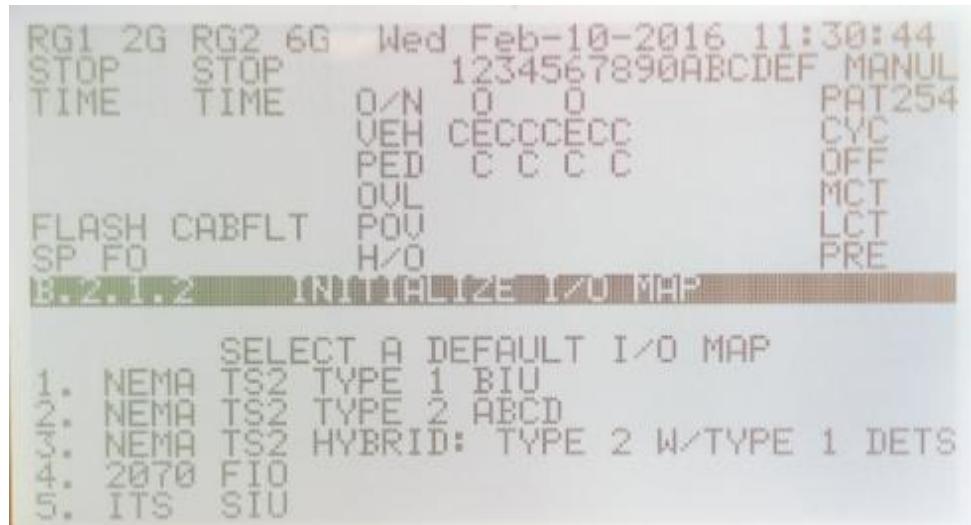


Figure 2-51. I/O mapping interface

After operating mode is changed user needs to enable SDLC communication for the Trafficware CID:

1. Press number “1” – Unit
2. Press number “7” – NEMA TS2 Setup
3. Enable “TF BIU” 1,2,3,4
4. Enable “Det BIU” 1,2,3,4
5. MMU – “NO”
6. Press button “ENT” and then button “YES” to Finalize Database Transaction

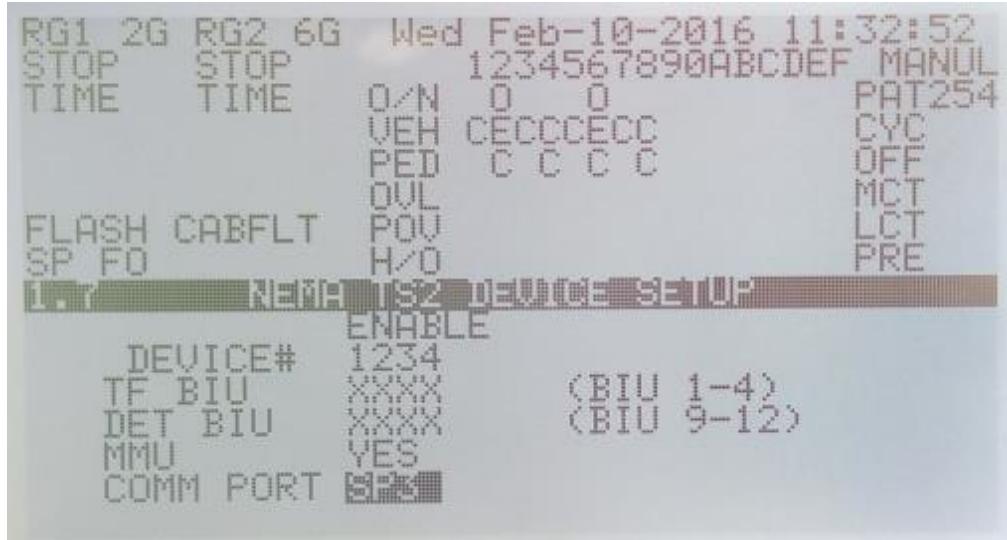


Figure 2-52. NEMA TS2 device setup interface

2.8.6 Intelight (Model 2070-LDX) Controller Trafficware CID Configuration

Before connection Trafficware Test Box with the controller, user needs to see if right I/O Module is in place because Intelight controller by default doesn't have ABC module and SDLC module connected to the controller, so they need to be changed depending on what type of communication is necessary for the project. After right I/O Module is in place, the user needs to connect controller and Trafficware Test Box with SDLC cable and Trafficware Test Box needs to be connected to computer with RS232 cable in order to continue with the setup. To connect Intelight controller with Trafficware Test Box user needs to enable right I/O Modules:

1. Press "Controller" on the left Menu
2. Press "Advance IO" on the left Menu
3. Press "Cabinet Configuration" on the left Menu
4. Press "IO Modules"
5. Under IO Module 1 select "TS2 TF1 BIU"
6. Under IO Module 2 select "TS2 TF2 BIU"
7. Under IO Module 3 select "TS2 DR1 BIU"
8. Under IO Module 4 select "TS2 DR2 BIU"
9. Under IO Module 5 select "TS2 MMU"
10. Under IO Module 6 select "2070 2N"
11. Press "Apply" button

IO Modules

IO Module	Type
1	TS2 TF1 BIU
2	TS2 TF2 BIU
3	TS2 DR1 BIU
4	TS2 DR2 BIU
5	TS2 MMU
6	2070 2N
7	None
8	None
9	None
10	None

WARNING:

Changing the type of an IO Module will
reset any custom input/output point configuration.

Figure 2-53. IO modules interface

2.9 High Resolution Data Manual Download from Controllers

Retrievability of high resolution data from the controllers can be done in two ways; one of them is manual download over File Transfer Protocol (FTP), and the second is done automatically by the SPM application installed on the FDOT server. FTP is a standard network protocol used to transfer data from a client, in this case controllers, to a computer to which the controller is connected by an Internet cable. For the communication to work, IP addresses need to be set in the controller in range of addresses of the computer used for downloading the data. After physical setup (connecting the controllers to the computer using an Internet cable) and IP address setup (setup IP addresses of the controllers) are done, the communication can be tested using the Command Prompt (CMD.exe) application.

2.9.1 Econolite (Cobalt) High Resolution Data Manual Download

High resolution data are stored in the Econolite controller. To download the data from the Econolite controller, the IP address needs to be set up in the controller:

1. Go to “Ethernet” icon.
2. Input “Address” – Controller IP address.
3. Input “Net mask” – Network mask.
4. Input “Gateway” – Network gateway.
5. Input “FTP Server” – Computer IP address connected to controller.
6. If column “Server Reachable” is “Yes,” then proceed with manual download.

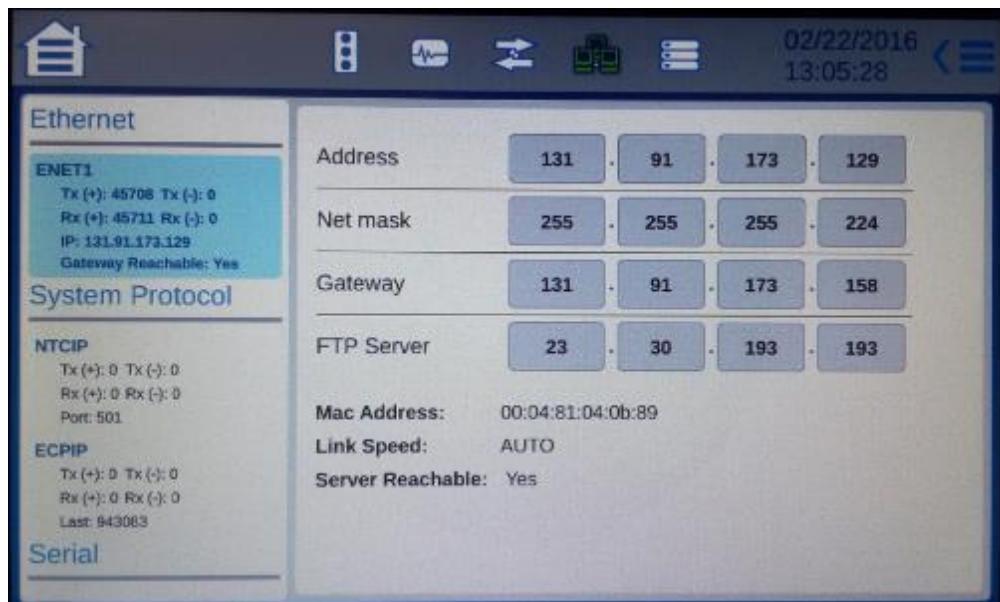


Figure 2-54. Econolite (Cobalt) ethernet interface

IP addresses are set in the controller, which means that high resolution data can be manually downloaded from the controller. FileZilla is the application used for FTP connection to the controller and for manual data download. CMD as well can be used for downloading the data. Before connecting to the controller over FTP, test if the controller is reachable over CMD tool

(“ping” controller’s IP address). If the controller is not reachable, check again if the setup is done properly. To download the *.dat files, which contain high resolution data, from the controller:

1. Open FileZilla application
2. Press “File” and select “Site Manager” from the dropdown menu
3. Create “New Site” and input the name “Econolite”
4. Under “Host” – input Econolite’s controller IP address
5. Under “Protocol” – choose “FTP (File Transfer Protocol)”
6. Under “Encryption” – choose “Only use plain FTP”
7. Under “Logon Type” – choose “Normal”
8. Under “User” – input “econolite”
9. Under “Password” – input “ecpi2ecpi”
10. Go to “Advanced” tab on FileZilla
11. Under “Default remote directory” – input “/set1”
12. Go to “Transfer Setting” tab on FileZilla
13. Under “Transfer Mode” – choose “Active”
14. Press “Connect” – Econolite *.dat files should be available to download

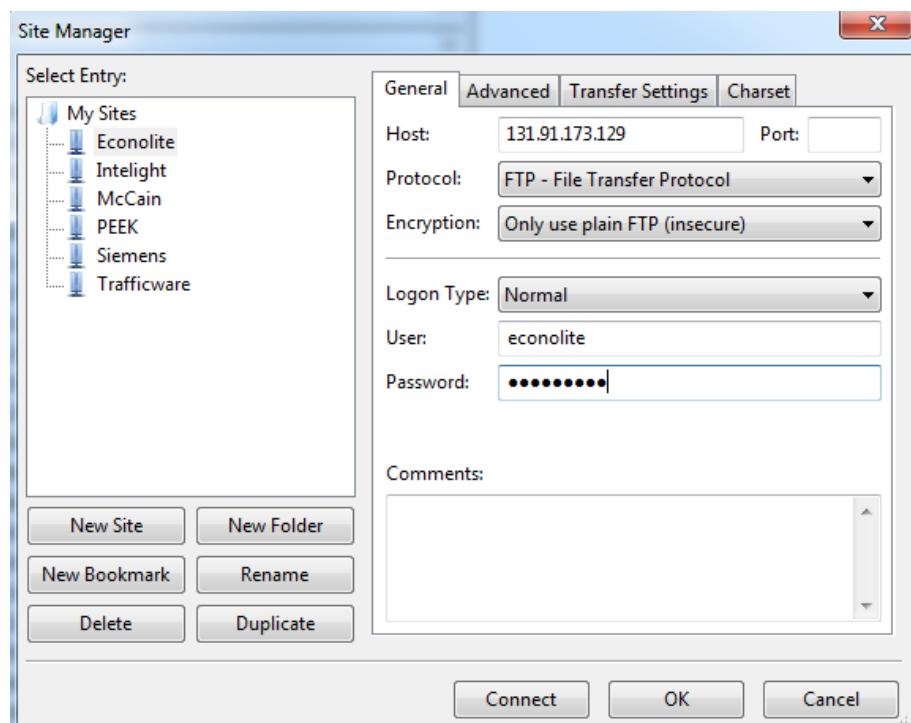


Figure 2-55. FileZilla setup for Econolite test environment

2.9.2 Siemens (m50) High Resolution Data Manual Download

High resolution data are stored in Siemens controller. To download the data from Siemens controller, the IP address needs to be set up in the controller:

1. Press number “2” – Utilities
2. Press number “8” – Configure Ports
3. Press number “5” – Network Config
4. Input “Destination” – Controller IP address

5. Input “Gateway” – Network gateway
6. Input “Net mask” – Network mask
7. Press “ent” button to save



Figure 2-56. Siemens (m50) network configuration interface

IP addresses are set in the controller, which means that High Resolution Data can be manually downloaded from the controller. FileZilla is the application used for FTP connection to the controller and for manual data download. CMD as well can be used for downloading the data. Before connecting to the controller over FTP, test if the controller is reachable over CMD application (“ping” controllers IP address). If the controller is not reachable, check again if the setup is done properly. To download the *.dat files from the controller:

1. Open FileZilla application
2. Press “File” and select “Site Manager” from the dropdown menu
3. Create “New Site” and input the name “Siemens”
4. Under “Host” – input Siemens controller IP address
5. Under “Protocol” – choose “FTP (File Transfer Protocol)”
6. Under “Encryption” – choose “Use explicit FTP over TLS if available”
7. Under “Logon Type” – choose “Normal”
8. Under “User” – input “admin”
9. Under “Password” – input “\$adm*kon2”
10. Go to “Advanced” tab on FileZilla
11. Under “Default remote directory” – input “0/mnt/sd”
12. Press “Connect” – Siemens *.dat files should be available to download

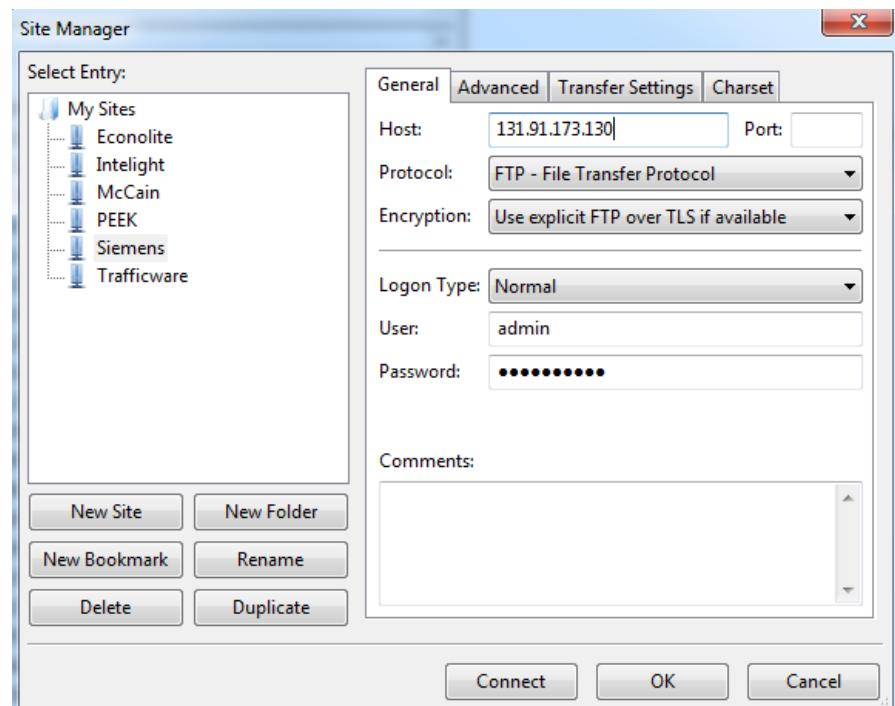


Figure 2-57. FileZilla setup for Siemens test environment

2.9.3 PEEK (ATC-1000) High Resolution Data Manual Download

High resolution data are stored inside PEEK controller. To download the data from PEEK controller, the IP address needs to be setup in the controller itself:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “1” – Unit Configuration
4. Press number “5” – Comms and I/O Setup Menu
5. Press number “3” – IP/Cabinet Address
6. Input “IP Address System” – Controller IP address
7. Input “SubNetAddr System” – Network mask
8. Input “Gateway System” – Network gateway
9. Save new configuration

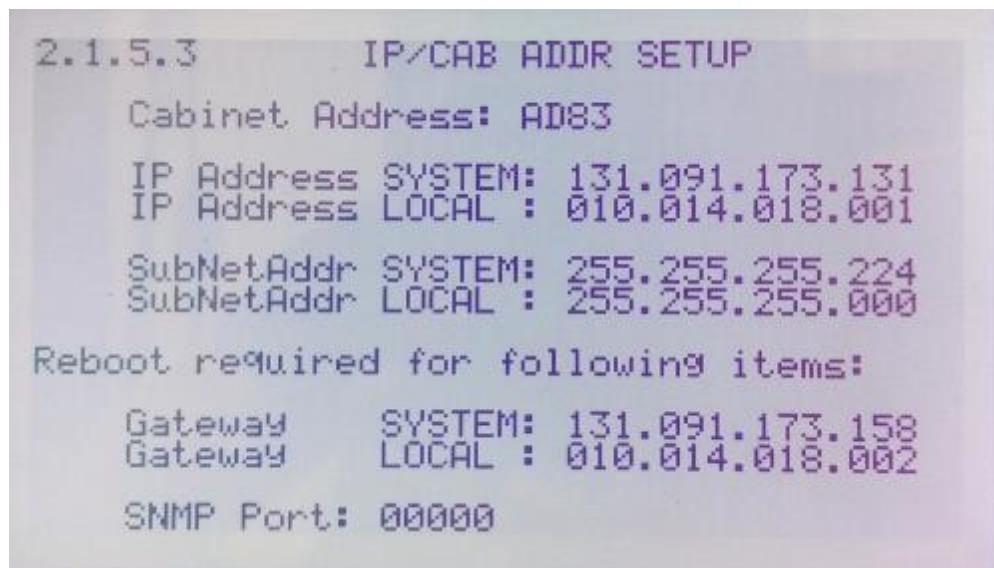


Figure 2-58. PEEK (ATC-1000) IP cabinet address setup interface

IP addresses are set in the controller, which means that High Resolution Data can be manually downloaded from the controller. FileZilla is the application used for FTP connection to the controller and for manual data download. CMD as well can be used for downloading the data. Before connecting to the controller over FTP, test if the controller is reachable over CMD application (“ping” controllers IP address). If the controller is not reachable, check again if the setup is done properly. To download the *.dat files from the controller:

1. Open FileZilla application
2. Press “File” and select “Site Manager” from the dropdown menu
3. Create “New Site” and input the name “PEEK”
4. Under “Host” – input PEEK’s controller IP address
5. Under “Protocol” – choose “FTP (File Transfer Protocol)”
6. Under “Encryption” – choose “Use explicit FTP over TLS if available”
7. Under “Logon Type” – choose “Normal”
8. Under “User” – input “admin”
9. Under “Password” – input “PeekAtc”
10. Go to “Advanced” tab on FileZilla
11. Under “Default remote directory” – input “mget/atc/ramdata/cuLogging”
12. Press “Connect” – PEEK*.dat files should be available to download

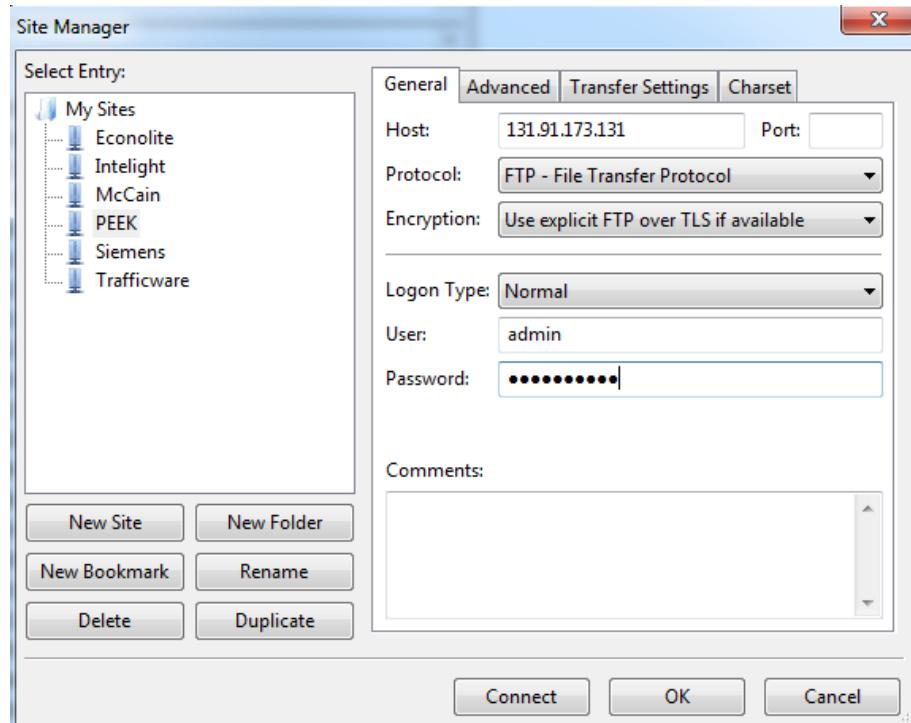


Figure 2-59. FileZilla setup for PEEK test environment

2.9.4 Trafficware (ATC 900) High Resolution Data Manual Download

High resolution data are stored in Trafficware controller. To download the data from Trafficware controller, the IP address needs to be set up in the controller:

1. Press “Main Menu” button
2. Press number “6” – Communication
3. Press number “5” – IP Setup
4. Input “Addr” – Controller IP address
5. Input “Mask” – Network mask
6. Input “Gate” – Network gateway
7. Save new configuration

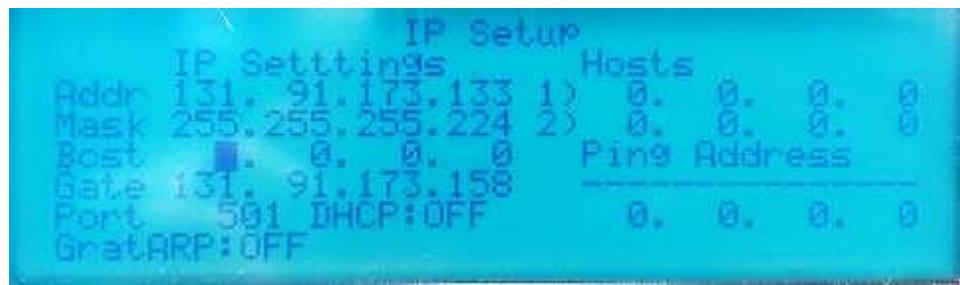


Figure 2-60. Trafficware (ATC 900) IP setup interface

IP addresses are set in the controller, which means that High Resolution Data can be manually downloaded from the controller. FileZilla is the application used for FTP connection to the controller and for manual data download. CMD as well can be used for downloading the data.

Before connecting to the controller over FTP, test if the controller is reachable over CMD application (“ping” controllers IP address). If the controller is not reachable, check again if the setup is done properly. To download the *.dat files from the controller:

1. Open FileZilla application
2. Press “File” and select “Site Manager” from the dropdown menu
3. Create “New Site” and input the name “Trafficware”
4. Under “Host” – input Trafficware’s controller IP address
5. Under “Protocol” – choose “FTP (File Transfer Protocol)”
6. Under “Encryption” – choose “Use explicit FTP over TLS if available”
7. Under “Logon Type” – choose “Normal”
8. Under “User” – input “root”
9. Under “Password” – input “root”
10. Go to “Advanced” tab on FileZilla
11. Under “Default remote directory” – input “/opt/logs”
12. Press “Connect” – Trafficware *.dat files should be available to download

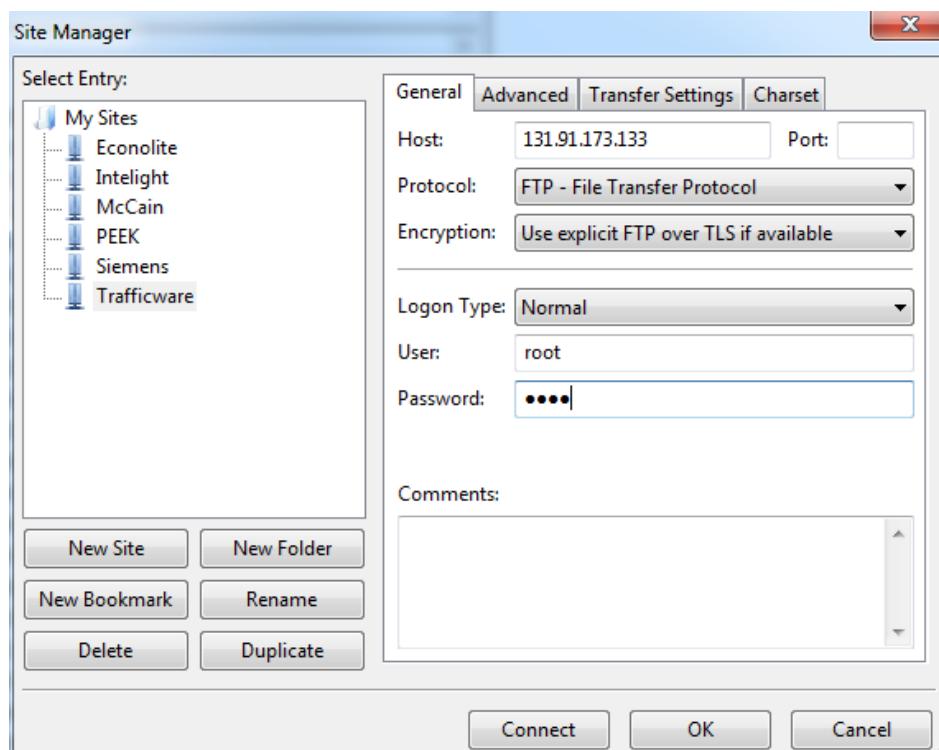


Figure 2-61. FileZilla setup for Trafficware test environment

2.9.5 McCain (ATC eX) High Resolution Data Manual Download

High resolution data are stored in McCain controller. To download the data from McCain controller, the IP address needs to be setup in the controller:

1. Press letter “A” on Main Menu screen - Communication
2. Press number “2” – Ethernet Ports
3. Input “IP Address” – Controller IP address

4. Input “Subnet Mask” – Network mask
5. Input “Gateway” – Network gateway
6. Save new configuration

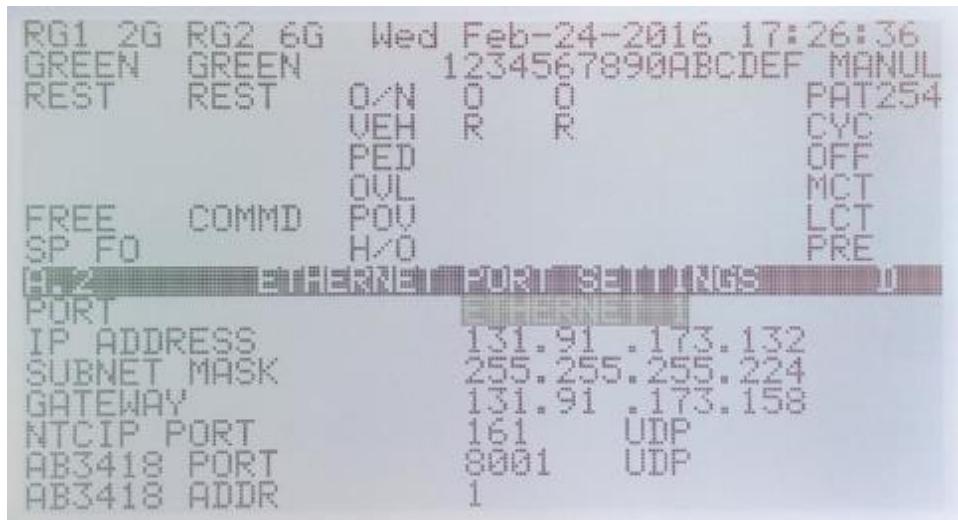


Figure 2-62. McCain (ATC eX) ethernet port setting interface

The IP addresses are set in the controller, which means that High Resolution Data can be manually downloaded from the controller. FileZilla is the application used for FTP connection to the controller and for manual data downloading. CMD as well can be used for downloading the data. Before connecting to the controller over FTP, test if the controller is reachable over CMD application (“ping” controllers IP address). If the controller is not reachable, check again if the setup is done properly. To download *.dat files from the controller:

1. Open FileZilla application
2. Press “File” and select “Site Manager” from the dropdown menu
3. Create “New Site” and input the name “McCain”
4. Under “Host” – input McCain’s controller IP address
5. Under “Protocol” – choose “FTP (File Transfer Protocol)”
6. Under “Encryption” – choose “Use explicit FTP over TLS if available”
7. Under “Logon Type” – choose “Normal”
8. Under “User” – input “root”
9. Under “Password” – input “root”
10. Go to “Advanced” tab on FileZilla
11. Under “Default remote directory” – input “/mnt/rd/hiResData”
12. Press “Connect” – McCain*.dat files should be available to download

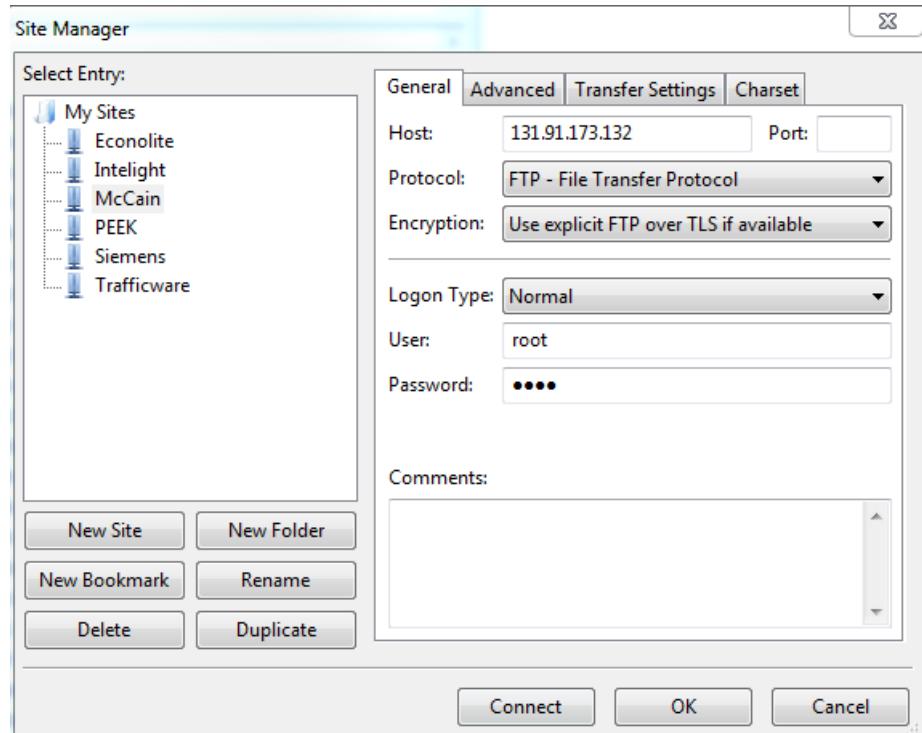


Figure 2-63. FileZilla setup for McCain test environment

2.9.6 Intelight (Model 2070-LDX) High Resolution Data Manual Download

High resolution data is stored in Intelight controller. To download the data from Intelight controller, the IP address needs to be set up in the controller:

1. Press number “2” – Administration
2. Press number “2” – Communication
3. Press number “1” – IP Settings
4. Input “IP Address” – Controller IP address
5. Input “Subnet Mask” – Network mask
6. Input “Gateway” – Network gateway
7. Save new configuration



Figure 2-64. Intelight (Model 2070-LDX) ethernet port setting interface

IP addresses are set in the controller, which means that High Resolution Data can be manually downloaded from the controller. WinSCP is the application used for FTP connection to the controller and for manual data download. Before connecting to the controller over FTP, test if the controller is reachable over CMD application (“ping” controllers IP address). If the controller is

not reachable, check again if the setup is done properly. To download the *.dat files from the controller:

1. Open WinSCP application
2. Press “New Site”
3. Create “New Site” and input the name “Intelight”
4. Under “File Protocol” – choose “SCP”
5. Under “Host name” – input Intelight’s controller IP address
6. Under “User Name” – input “root”
7. Under “Password” – input “intelight”
8. Press “Login” – Intelight asclog.db file should be available to download

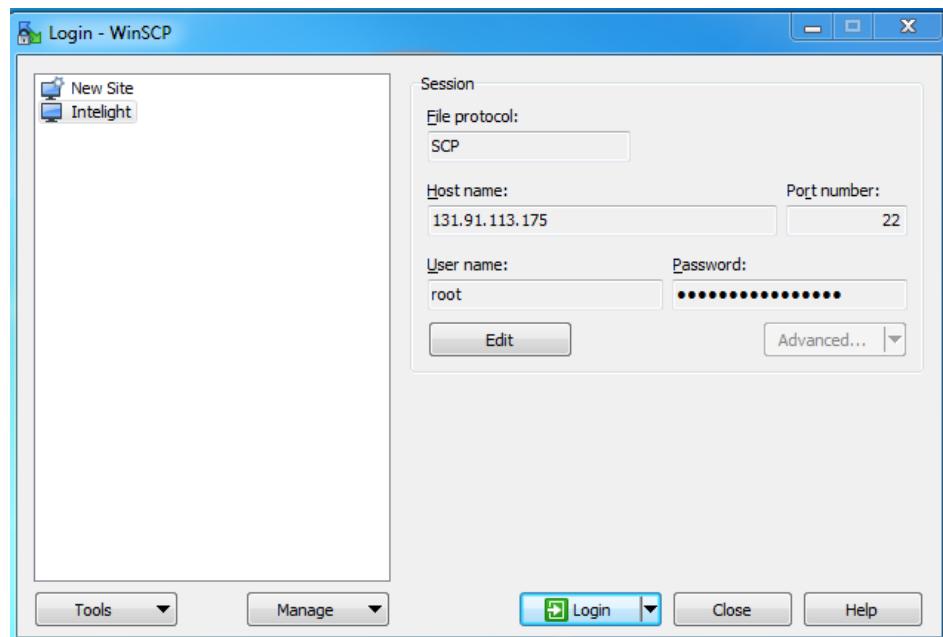


Figure 2-65. FileZilla setup for Intelight test environment

2.10 Manual Transfer High Resolution Data from DAT to CSV Files

High resolution data in Econolite, Siemens, PEEK, Trafficware and McCain controllers is stored as DAT files, except for Intelight controller where high resolution data are stored in the database. Data stored as DAT file needs to be converted to CSV files so that they can be used to read performance measures. Intelight data needs to be read with database application and be exported to CSV file.

6.1. Retrievability of logged high-resolution data through the FLDOT ASPMS software/server Setup

6.2. High Resolution Data Controller Configuration for Manual Download

2.10.1 Econolite (Cobalt) Manual Transfer of High Resolution Data to CSV Files

High resolution data in *.dat files are downloaded from Econolite controller to local computer. In order to read that data, files need to be converted to *.csv file with the “Translator.exe” application and “DataProcessing.lib” file provided from the vendor:

1. Create folder “Econolite” (root of D disk used for test environment)
2. Place “Translator.exe” and “DataProcessing.lib” in the folder
3. Place *.dat files downloaded from Cobalt controller to the folder
4. Open “Command Prompt” and navigate to the folder
 - a. Input “cd..” in Command Prompt to return back to the root disk (C:>)
 - b. To change disk, input disk letter “D” and “:” (C:>D:)
 - c. Input “cd” to navigate to folder (D:>cd Econolite)
5. In Command Prompt input “Translator.exe” and *.dat file name (Translator.exe ECON_131.91.173.129_2016_01_21_1500.dat), press Enter
6. Multiple *.dat file transfer can be done adding more *.dat file names
7. Open the folder “Econolite” and you should see *.csv files

The screenshot shows a Windows Command Prompt window titled 'C:\Windows\system32\cmd.exe'. The window displays the following command-line session:

```
C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright <c> 2009 Microsoft Corporation. All rights reserved.

C:\Users\iklanac2015>cd..
C:\Users>cd..
C:\>>d:
D:\>>cd Econolite

D:\Econolite>Translator.exe ECON_131.91.173.129_2016_01_21_1500.dat ECON_131.91.173.129_2016_01_21_1515.dat
Econolite High Resolution Log Decoder 2012
Version 3.0.0.4
www.econolite.com
Copyright <c> 2007-2012 Econolite Control Products, Inc. All rights reserved.

ECON_131.91.173.129_2016_01_21_1500.dat
ECON_131.91.173.129_2016_01_21_1515.dat
Complete

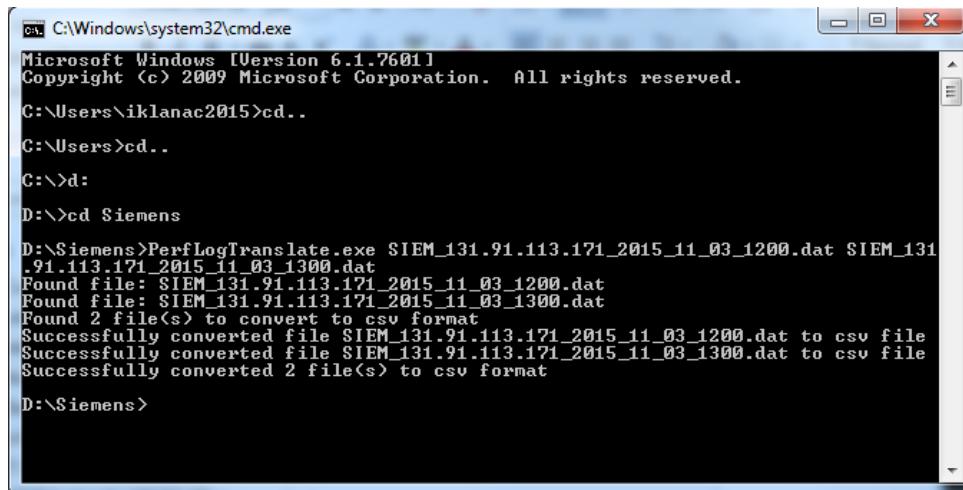
D:\Econolite>
```

Figure 2-66. Econolite (Cobalt) controller DAT to CSV file transfer

2.10.2 Siemens (m50) Manual Transfer of High Resolution Data to CSV Files

High resolution data in *.dat files are downloaded from Siemens controller to local computer. In order to read that data, files need to be converted to *.csv file with the “PerfLogTranslate.exe” application file provided by the vendor:

1. Create folder “Siemens” (root of D disk used for test environment)
2. Place “PerfLogTranslate.exe” in the folder
3. Place *.dat files downloaded from Siemens controller to the folder
4. Open “Command Prompt” and navigate to the folder
 - a. Input “cd..” in Command Prompt to return back to the root disk (C:>)
 - b. To change disk, input disk letter “D” and “:” (C:>D:)
 - c. Input “cd” to navigate to folder (D:>cd Siemens)
5. In Command Prompt input “PerfLogTranslate.exe” and *.dat file name (PerfLogTranslate.exe SIEM_131.91.113.171_2015_11_03_1200.dat), press Enter
6. Multiple *.dat file transfer can be done by adding more *.dat file names
7. Open the folder “Siemens,” and you should see *.csv files



The screenshot shows a Windows Command Prompt window titled "C:\Windows\system32\cmd.exe". The window displays the following text output:

```
Microsoft Windows [Version 6.1.7601]
Copyright <c> 2009 Microsoft Corporation. All rights reserved.

C:\Users\iklanac2015>cd..
C:\Users>cd..
C:>d:
D:>cd Siemens
D:\Siemens>PerfLogTranslate.exe SIEM_131.91.113.171_2015_11_03_1200.dat SIEM_131.91.113.171_2015_11_03_1300.dat
Found file: SIEM_131.91.113.171_2015_11_03_1200.dat
Found file: SIEM_131.91.113.171_2015_11_03_1300.dat
Found 2 file(s) to convert to csv format
Successfully converted file SIEM_131.91.113.171_2015_11_03_1200.dat to csv file
Successfully converted file SIEM_131.91.113.171_2015_11_03_1300.dat to csv file
Successfully converted 2 file(s) to csv format

D:\Siemens>
```

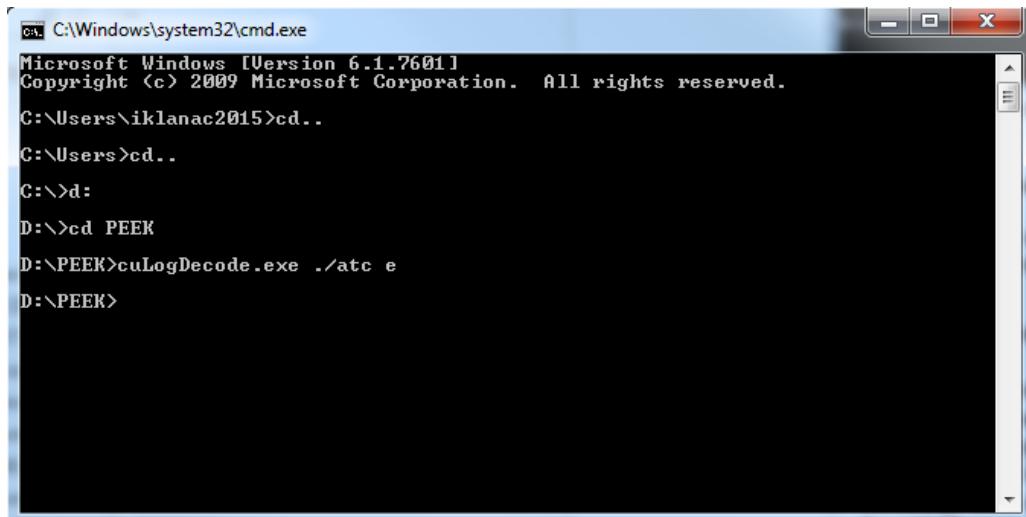
Figure 2-67. Siemens (m50) controller DAT to CSV file transfer

2.10.3 PEEK (ATC-1000) Manual Transfer of High Resolution Data to CSV Files

High resolution data in *.dat files are downloaded from PEEK controller to local computer. In order to read that data, files need to be converted to *.csv file with the “cuLogDecode.exe and gzip.exe” application files provided from the vendor:

1. Create folder “PEEK” and inside it, create another folder “atc” (root of D disk used for test environment)
2. Place “cuLogDecode.exe” and “gzip.exe” application in the folder “PEEK”
3. Place *.dat files downloaded from PEEK controller to the folder “atc”
4. Open “Command Prompt” and navigate to the folder
 - a. Input “cd..” in Command Prompt to return back to the root disk (C:>)
 - b. To change disk, input disk letter “D” and “:” (C:>D:)
 - c. Input “cd” to navigate to folder (D:>cd PEEK)
5. In Command Prompt input “cuLogDecode.exe” and type of decoding (cuLogDecode.exe ./atc e), press Enter

6. All *.dat files in “atc” folder will be converted to *.csv
7. When converting *.dat file user can use e - Econolite decoding and p - PEEK decoding (for this project e-Econolite decoding is used because it is High Performance Metrics format)
8. Open the folder “atc” and there will be another folder “csv_files_e” where you should see *.csv files



```

cmd C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright <c> 2009 Microsoft Corporation. All rights reserved.

C:\Users\iklanac2015>cd..
C:\Users>cd..
C:>d:
D:>cd PEEK
D:>cuLogDecode.exe ./atc e
D:>PEEK>

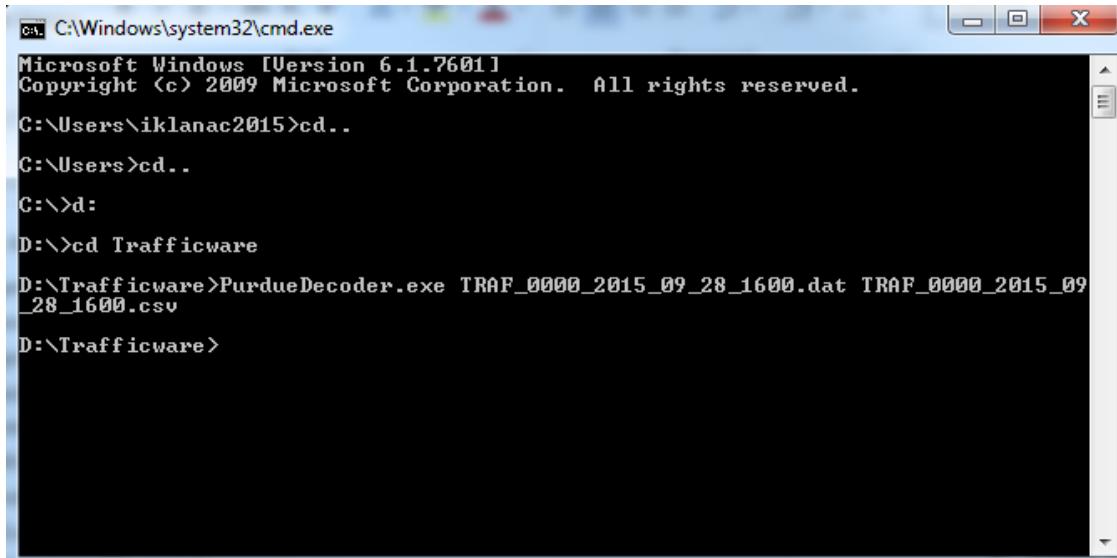
```

Figure 2-68. PEEK (ATC-1000) controller DAT to CSV file transfer

2.10.4 Trafficware (ATC 900) Manual Transfer of High Resolution Data to CSV Files

High resolution data in *.dat files are downloaded from Trafficware controller to local computer. In order to read that data, files need to be converted to *.csv file with the “PurdueDecoder.exe” and “go.bat” application files provided from the vendor:

1. Create folder “Trafficware” (root of D disk used for test environment)
2. Place “PurdueDecoder.exe” and “go.bat” in the folder
3. Place *.dat files downloaded from Trafficware controller to the folder
4. Open “Command Prompt” and navigate to the folder
 - a. Input “cd..” in Command Prompt to return back to the root disk (C:>)
 - b. To change disk, input disk letter “D” and “:” (C:>D:)
 - c. Input “cd” to navigate to folder (D:>cd Trafficware)
5. In Command Prompt input “PurdueDecoder.exe” and *.dat file name and *.csv with the same file name (PurdueDecoder.exe TRAF_0000_2015_09_28_1500.dat TRAF_0000_2015_09_28_1500.csv), press Enter
6. Open the folder “Trafficware” and you should see *.csv file



The screenshot shows a Windows Command Prompt window titled 'C:\Windows\system32\cmd.exe'. The window displays the following command-line session:

```
Microsoft Windows [Version 6.1.7601]
Copyright <c> 2009 Microsoft Corporation. All rights reserved.

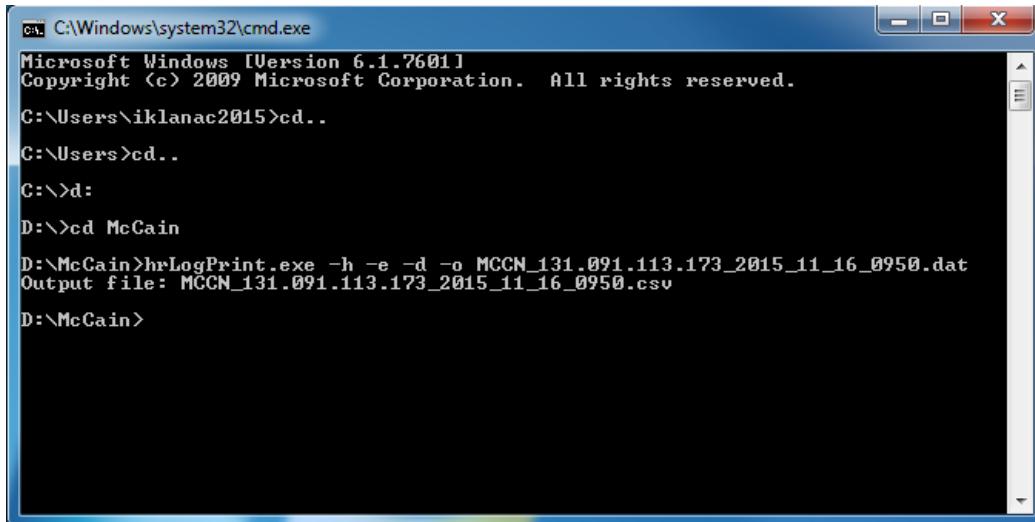
C:\Users\iklanac2015>cd..
C:\Users>cd..
C:>d:
D:>cd Trafficware
D:\Trafficware>PurdueDecoder.exe TRAF_0000_2015_09_28_1600.dat TRAF_0000_2015_09_28_1600.csv
D:\Trafficware>
```

Figure 2-69. Trafficware (ATC 900) controller DAT to CSV file transfer

2.10.5 McCain (ATC eX) Manual Transfer of High Resolution Data to CSV Files

High resolution data in *.dat files are downloaded from McCain controller to the local computer. In order to read that data, files need to be converted to *.csv file with the “hrLogPrint.exe” application file provided from the vendor:

1. Create folder “McCain” (root of D disk used for test environment)
2. Place “hrLogPrint.exe” in the folder
3. Place *.dat files downloaded from McCain controller to the folder
4. Open “Command Prompt” and navigate to the folder
 - a. Input “cd..” in Command Prompt to return back to the root disk (C:>)
 - b. To change disk, input disk letter “D” and “:” (C:>D:)
 - c. Input “cd” to navigate to folder (D:>**cd McCain**)
5. In Command Prompt input “hrLogPrint.exe” and -h -e -d -o with *.dat file name (hrLogPrint.exe -h -e -d -o MCCN_131.091.113.173_2015_11_16_0950.dat), press Enter
6. When converting *.dat file user needs to use options:
 - a. Include file header data in output (-h)
 - b. Include event data in output (-e)
 - c. Include textual descriptions of event codes (-d (use with -e))
 - d. Output to file (-o)
7. Multiple *.dat file transfer can be done adding more *.dat file names
8. Open the folder “McCain” and you should see *.csv files



```
C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright <c> 2009 Microsoft Corporation. All rights reserved.

C:\Users\iklanac2015>cd..
C:\Users>cd..
C:\>d:
D:\>cd McCain
D:\McCain>hrLogPrint.exe -h -e -d -o MCCN_131.091.113.173_2015_11_16_0950.dat
Output file: MCCN_131.091.113.173_2015_11_16_0950.csv
D:\McCain>
```

Figure 2-70. McCain (ATC ext.) controller DAT to CSV file transfer

2.10.6 Intelight (2070-LDX) Manual Transfer of High Resolution Data to CSV Files

High resolution data in asclog.db file is downloaded from Intelight controller to local computer. In order to read that data, files need to be exported to *.csv file with the “SqliteBrowser” application installed on the computer:

1. Open “SqliteBrowser” application
2. Navigate to “asclog.db” downloaded to computer
3. Open “asclog.db” database file

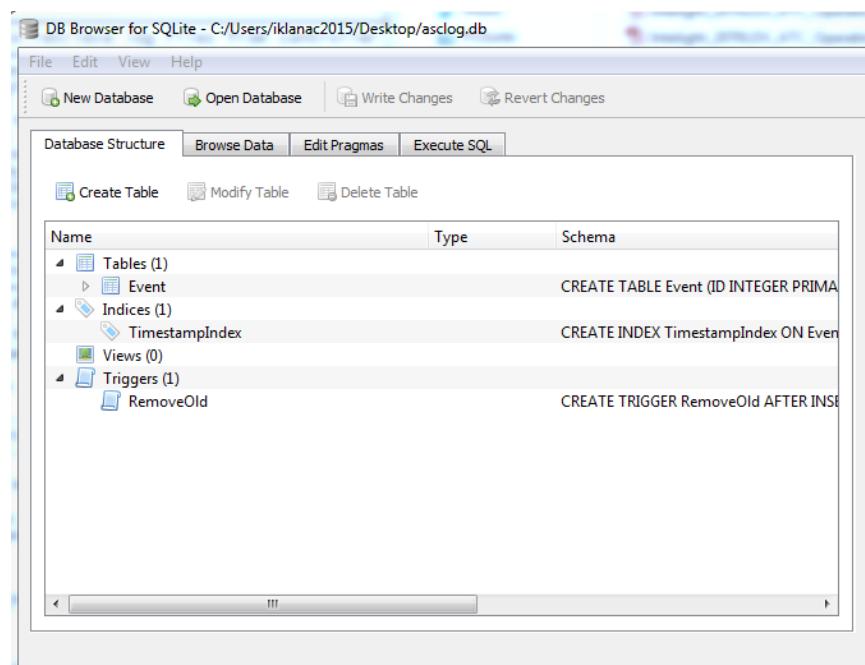


Figure 2-71. Asclog.dbfile opened in SqliteBrowser application

4. Open the tab “Execute SQL” in SqliteBrowser application

5. For exporting specific time of high resolution data to *.csv file use following command:
select date_time (Timestamp, "unixepoch") as Time, Tick, EventTypeId, Parameter from Event where Timestamp > strftime('%s','2015-09-21 21:00:00') and Timestamp < strftime('%s','2015-09-21 23:15:00')
6. Export selected data to *.csv file
7. Input the file name and save the *.csv file to computer

2.11 ASPMS High Resolution Data Download

In the document Chapter 5 describes how to set up the controller for manual data download and from that chapter the part with setting up the controllers IP addresses is used to prepare controller to communicate with ASPMS server. IP addresses for each controller need to be provided from the FL DOT staff, in this case for accessing the TERL network. To access TERL network, Firewall settings need to be adjusted so that controllers can communicate with ASPMS server. Testing can be done easily using CMD to “ping” each controller IP address, but even then it is necessary to make sure that access through FTP to the controllers root folder is possible. To do that we can use Chapter 5 part where we manually download data from the controller to ASPMS server. If that is working properly that means that it is possible to proceed with testing of ASPMS retrievability of High Resolution Data.

2.11.1 Run FTP/SCP and Decode and Import for Controllers

To run the software for FTP and Decode & Import controllers:

1. Go to the desktop which contains the folder named “FTP_DECODE_IMPORT_SOFTWARE”.
2. Click on “RunDecodeAndImport.exe” to run the application.

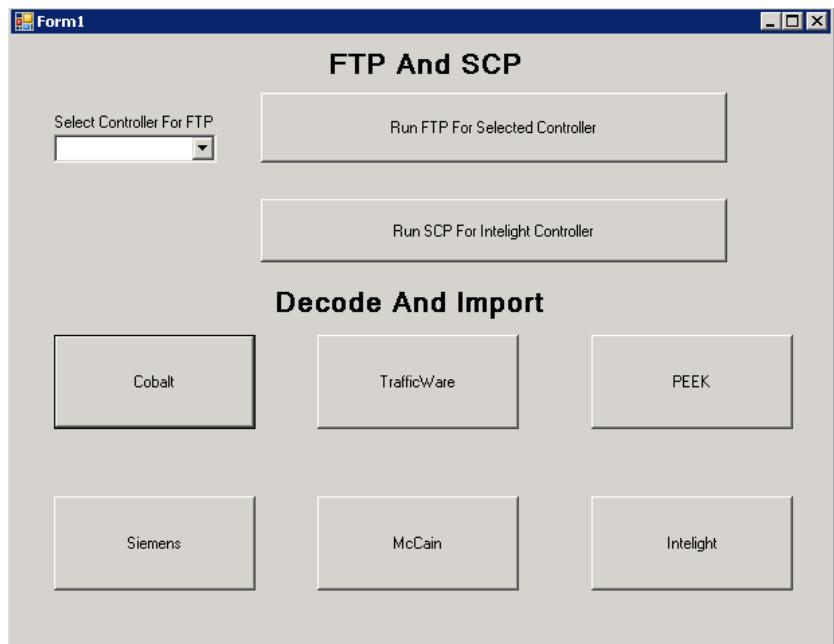


Figure 2-72. FTP and SCP high resolution data download

3. Select the drop down menu to select the controller or select “All” to run FTP for all controllers.
4. After selecting All or specific controller, click “Run FTP For Selected Controller” button to start FTP of data files for controllers.
5. For Intelight controller click “Run SCP For Intelight Controller”. Files are copied in directory “C:\temp\ControllerLogs\Logs” with respective signal id named folders for controllers set in the controller configuration step. Check for files in this directory. If FTP

runs without showing that files for a controller are being copied, ping the controller manually to see if it's responding, and try the FTP for the particular controller again.

6. Decode and Import data: Click the buttons with controller names to decode controller data files and import them to the database.

Data that are now located in the ASPMS database can produce high resolution graphs on FDOT Signal Performance Metrics site (<http://192.168.8.85/SignalPerformanceMetrics/>). Not all performance metrics are accessible through the site because the controller, might not be configured to store pedestrian data or preemption data, or there is no configuration in the controller for pedestrians or preemptions. Purdue Coordination Diagram is always accessible due to default setup where certain types of data are stored in the controller, like beginning of phase, end of phase, detector actuation, etc. Performance metrics graphs are shown in Appendix C.

2.11.2 Multipoint Simultaneous Access of ASPMSs from six Different Computers

FDOT Signal Performance Metrics site needs to be used by operators to perform evaluations of specific intersections and that is done by creating performance metrics graphs. In order to access the data from the controllers multiple operators might try to create metrics from same intersection or from different intersections at the same time. Tasks in the project required to test that possibility, which was tested from six different computers at the same time accessing data from the controllers. Figure 2-73 shows the interface of one FDOT Signal Performance Metrics site access from one computer station (operator). The following list explains the numbers in the figure:

1. Shows the computer name
2. Shows the accessed controller ID and name of the intersection
3. Shows the time of the accessing.

Appendix B contains all the FDOT Signal Performance Metrics site accesses from six different computers simultaneously accessing different controllers and intersections.

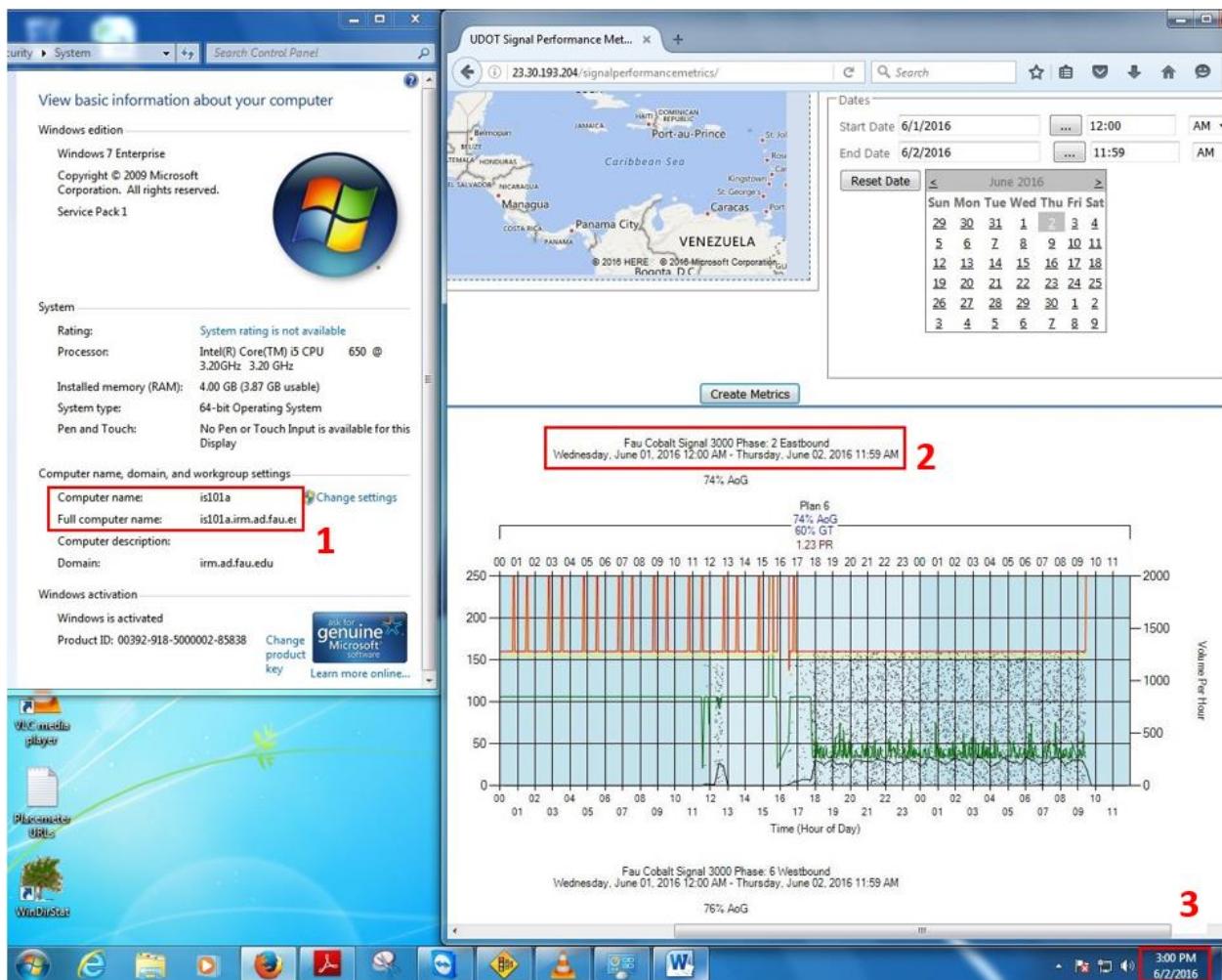


Figure 2-73. FDOT signal performance metrics site access from one computer

2.12 SPM Tool Configuration

SPM tool provides detector data, IP address of the controller, signalID and all the data that will later be used for creating signal performance measures graphs. SPM configuration needs to be done after the controller is installed and configured, which means that all the data must be known: detectors need to be configured as advanced, presence or stop bar detectors, phases need to be setup, detectors distance from the stop bar is also necessary, etc. After obtaining all the data from the controller and from the site we can start configuration in the SPM tool (each intersection). To configure one intersection (controller) in the SPM tool:

1. Open “SPMConfigurator” application

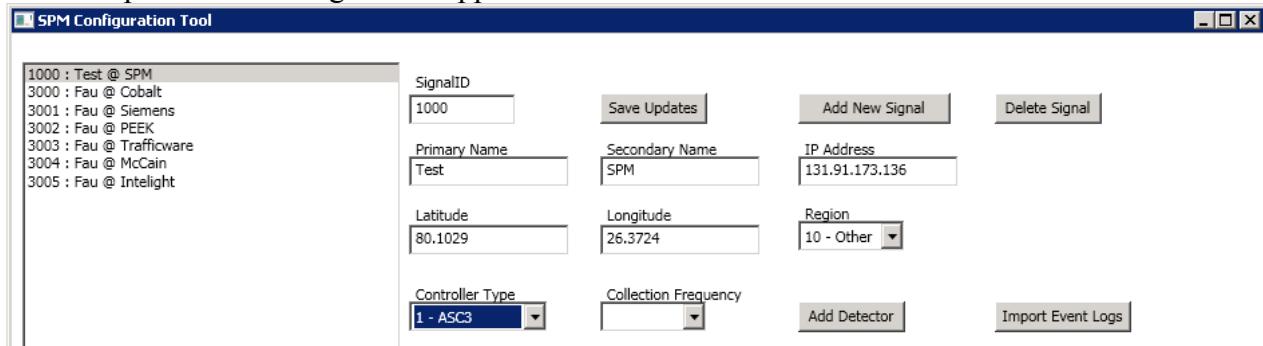


Figure 2-74. SPM Configurator Tool interface

2. Press “Add New Signal” button

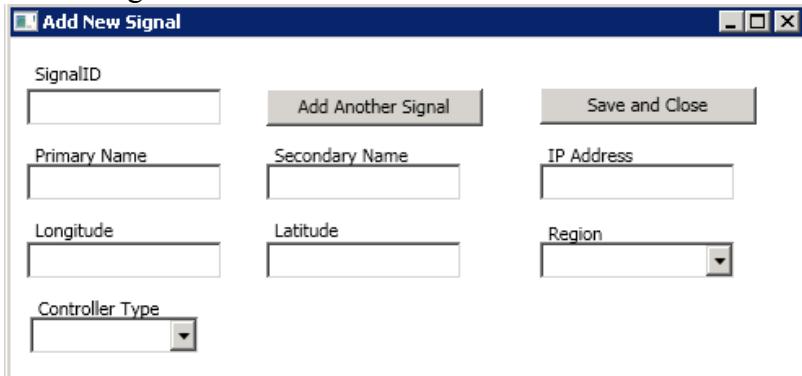


Figure 2-75. Add new signal interface

3. Input SignalID (number), Primary Name and Secondary Name (intersection name), IP Address (IP address of the controller), Longitude and Latitude (intersection coordinates), Region (where is intersection located) and Controller Type (controller – Cobalt, Siemens m50, etc.)

4. Press “Save and Close” button

Now, the installed new controller is also configured in the SPM tool, but it doesn't have any data on detectors that are necessary for Performance Metrics graphs that are later created on Performance Metrics site. To configure detector accordingly for specific performance metrics, follow these steps:

2.12.1 Purdue Coordination Diagram Detectors Configuration

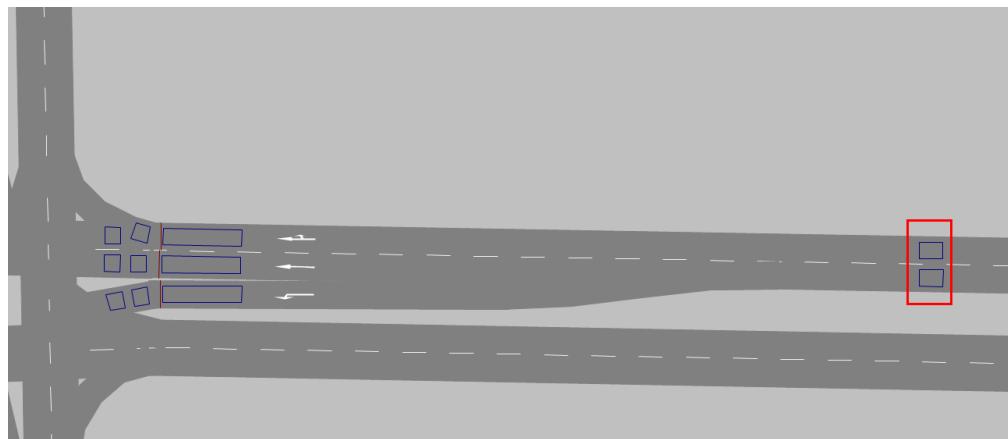


Figure 2-76. Purdue coordination diagram detectors

1. Press “Add Detector” button

New Detector for Signal 1000

1000	Detector ID:	[]		<input checked="" type="checkbox"/> Enabled	
Detector Channel	Protected Phase	Permitted Phase	Direction	<input type="checkbox"/> PCD	
[]	[]	[]	[]	<input type="checkbox"/> Speed	
IP Address	Port	Dist. From Stopbar	MPH	<input type="checkbox"/> Overlap	
[]	[]	[]	[]	<input type="checkbox"/> Split Fail	
Decision Point	Movement Delay	Region	Min Speed Filter	<input type="checkbox"/> TMC	Lane Type
[]	[]	[]	[]	<input type="checkbox"/> RLM	[]
Date Added	Monitor Date	Comments			
Select a date [15]	Select a date [15]				
<input type="button" value="Save"/>	<input type="button" value="Copy"/>	<input type="button" value="Delete"/>			

Figure 2-77. New detector configuration interface

2. Input Detector Channel (channel configured on the controller for advanced detectors), Protected Phase (corresponding phase for the configured detector), Direction (Eastbound, Westbound, etc. where phase and detectors are located), Distance From Stopbar (distance from stopbar in ft.), MPH (speed limitation on the approach), Movement Delay (delay from detector to stopbar) and Minimum Speed Filter (default - 5)
3. Enable “Enabled”
4. Enable “PDC”
5. Enable “Speed”
6. Press “Save” button

300001	300002	300003	300004	300005	300006	300007	300008
300009	300010	300011	300012	300013	300014	300015	300016

3000 Detector ID:

Detector Channel <input type="text" value="9"/>	Protected Phase <input type="text" value="6"/>	Permitted Phase <input type="text" value="0"/>	Direction <input type="text" value="Westbound"/>	<input checked="" type="checkbox"/> Enabled
IP Address <input type="text" value="0.0.0.0"/>	Port <input type="text" value="0"/>	Dist. From Stopbar <input type="text" value="300"/>	MPH <input type="text" value="40"/>	<input checked="" type="checkbox"/> PCD
Decision Point <input type="text" value="0"/>	Movement Delay <input type="text" value="15"/>	Region <input type="text" value="1"/>	Min Speed Filter <input type="text" value="5"/>	<input checked="" type="checkbox"/> Speed
				<input type="checkbox"/> Overlap
				<input type="checkbox"/> Split Fail
				<input type="checkbox"/> TMC
				<input type="checkbox"/> RLM
				Lane Type <input type="text" value="--"/>

Date Added

Monitor Date

Comments

Figure 2-78. Purdue coordination diagram detector configuration example

2.12.2 Turning Movement Counts Detectors Configuration

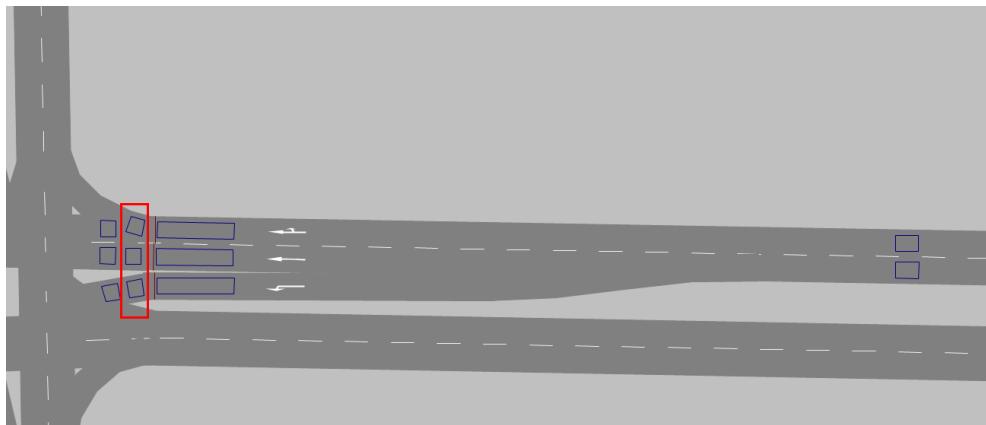


Figure 2-79. Turning movement count detectors

1. Press “Add Detector” button
2. Input - Detector Channel (channel configured on the controller for turning movement counts), Protected Phase (corresponding phase for the configured detector), Direction (Eastbound, Westbound, etc. where phase and detectors are located) and Lane Type (which lane corresponds to configured detector)
3. Enable “TMC”
4. Press “Save” button

300009	300010	300011	300012	300013	300014	300015	300016
300001	300002	300003	300004	300005	300006	300007	300008

3000 Detector ID:

Detector Channel <input type="text" value="1"/>	Protected Phase <input type="text" value="1"/>	Permitted Phase <input type="text" value="0"/>	Direction <input type="text" value="Westbound"/>	<input type="checkbox"/> Enabled
IP Address <input type="text" value="0.0.0.0"/>	Port <input type="text" value="0"/>	Dist. From Stopbar <input type="text" value=""/>	MPH <input type="text" value=""/>	<input type="checkbox"/> PCD
Decision Point <input type="text" value="0"/>	Movement Delay <input type="text" value="0"/>	Region <input type="text" value="1"/>	Min Speed Filter <input type="text" value="0"/>	<input type="checkbox"/> Speed
				<input type="checkbox"/> Overlap
				<input type="checkbox"/> Split Fail
				<input checked="" type="checkbox"/> TMC
				<input type="checkbox"/> RLM
				Lane Type <input type="text" value="L1"/>

Date Added

Monitor Date

Comments

Figure 2-80. Turning movement count detector configuration

2.12.3 Yellow & Red Actuations Detectors Configuration

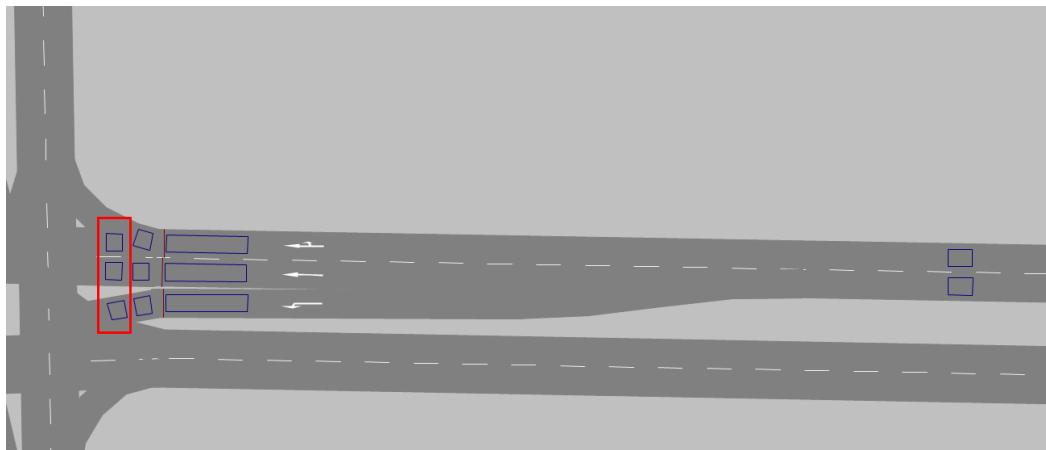


Figure 2-81. Yellow & red actuation detectors

1. Press “Add Detector” button
2. Input - Detector Channel (channel configured on the controller for turning movement counts), Protected Phase (corresponding phase for the configured detector), Direction (Eastbound, Westbound, etc. where phase and detectors are located) and Lane Type (which lane corresponds to configured detector)
3. Enable “Enabled”
4. Enable “TMC”

5. Press “Save” button

300009	300010	300011	300012	300013	300014	300015	300016
300001	300002	300003	300004	300005	300006	300007	300008

3000	Detector ID: <input type="text" value="300001"/>	<input checked="" type="checkbox"/> Enabled				
Detector Channel <input type="text" value="1"/>	Protected Phase <input type="text" value="1"/>	Permitted Phase <input type="text" value="0"/>	Direction <input type="text" value="Westbound"/>	<input type="checkbox"/> PCD		
IP Address <input type="text" value="0.0.0.0"/>	Port <input type="text" value="0"/>	Dist. From Stopbar <input type="text"/>	MPH <input type="text"/>	<input type="checkbox"/> Speed		
Decision Point <input type="text" value="0"/>	Movement Delay <input type="text" value="0"/>	Region <input type="text" value="1"/>	Min Speed Filter <input type="text" value="0"/>	<input checked="" type="checkbox"/> TMC	Lane Type <input type="text" value="L1"/>	
Date Added <input type="text" value="2/17/2016"/> <input type="button" value="15"/>	Monitor Date <input type="text" value="2/17/2016"/> <input type="button" value="15"/>	<input type="text"/>				
<input type="button" value="Save"/>		<input type="button" value="Copy"/>	<input type="button" value="Delete"/>	Comments		

Figure 2-82. Turning movement count detector configuration

2.12.4 Purdue Split Failure Detectors Configuration

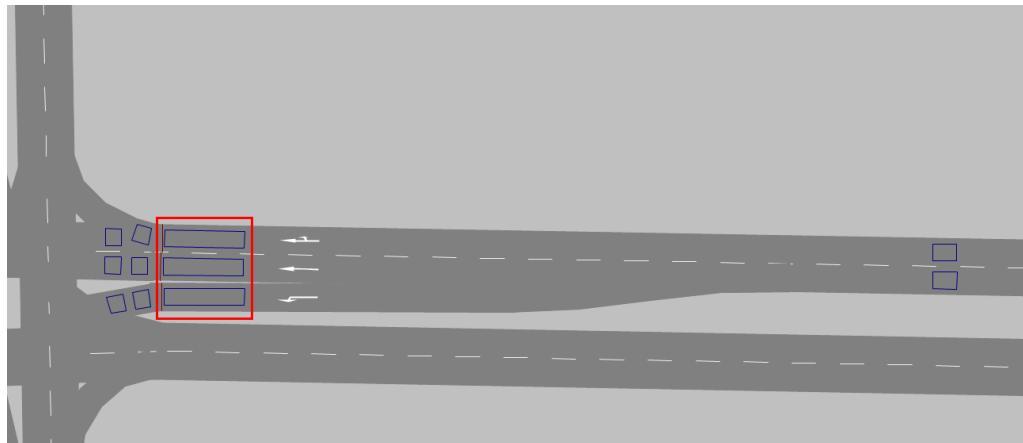


Figure 2-83. Purdue split failure detectors

1. Press “Add Detector” button
2. Input - Detector Channel (channel configured on the controller for presence detectors), Protected Phase (corresponding phase for the configured detector), Permitted Phase (phase that can be green at same time as Protected Phase), Direction (Eastbound, Westbound, etc. where phase and detectors are located) and Lane Type (which lane corresponds to configured detector)
3. Enable “Enabled”
4. Enable “Split Fail”

5. Press “Save” button

300009	300010	300011	300012	300013	300014	300015	300016
300001	300002	300003	300004	300005	300006	300007	300008

3000 Detector ID:

Detector Channel <input type="text" value="3"/>	Protected Phase <input type="text" value="3"/>	Permitted Phase <input type="text" value="3"/>	Direction <input type="text" value="Southbound"/>	<input checked="" type="checkbox"/> Enabled
IP Address <input type="text" value="0.0.0.0"/>	Port <input type="text" value="0"/>	Dist. From Stopbar <input type="text" value="0"/>	MPH <input type="text" value="0"/>	<input type="checkbox"/> PCD
Descision Point <input type="text" value="0"/>	Movement Delay <input type="text" value="0"/>	Region <input type="text" value="1"/>	Min Speed Filter <input type="text" value="0"/>	<input type="checkbox"/> Speed
				<input type="checkbox"/> Overlap
				<input checked="" type="checkbox"/> Split Fail
				<input type="checkbox"/> TMC
				<input type="checkbox"/> RLM
				Lane Type <input type="text" value="L1"/>

Date Added

Monitor Date

Comments

Figure 2-84. Purdue split failure detector configuration

3 Development of Minimum Standards for Event-based High-Resolution Data

Many options for collecting data and interpreting the set of new performance measures became possible with the introduction of high-resolution data logging capabilities into modern traffic signal controllers. The benefits that this new feature can offer are highly valuable, so researchers, practitioners, consultants and employees in public agencies can use it to improve the current state of practice. Therefore, the companies that build traffic signal controllers, depending on the characteristics of their traffic signal controller devices, integrated high-resolution data logging into some of their devices.

All events that occur in the field or in hardware-in-the-loop simulation setup are stored using event codes and timestamps when the subject event happened. The events that various controllers can collect and store vary for different vendors and different devices. Mentioned devices do not have identical data storage capacity or frequency nor are all event types that are being collected the same. For this reason, all the event types that all six controllers used in this study can collect had to be listed and compared in order to determine the minimal and optional requirements for the new controllers that are to be used in Florida. The list is provided in the following chapter of this report.

3.1 Event-based Data Elements

All six controllers that were part of this study were investigated both theoretically and practically to document the events that are being stored during the operation of the controller. All events are stored in the controller's database by using the codes assigned to them. Beside the code that represents the type of event, also timestamps are saved with each code so it is known when each event exactly happened.

Table 3-1 shows the different formats that controllers use to display timestamps and the explanations (legend) for the table with the event codes. After compiling the full list of the events stored by the controllers, the event codes were marked with colors According to whether the events were recorded by all controllers ("mandatory"), recorded by some of the controllers ("optional"), or recorded by none of the controllers ("deprecated"). ().

Table 3-1. Legend for the Table 3.2

Controller	Time Format (Timestamp)
Econolite	1/21/2016 3:00:40 PM (00:40.1 - Column A)
Siemens	11/3/2015 7:00:00 AM (00:00.5 - Column A)
PEEK	03/28/2016 06:00:00.5 - Column A
Trafficware	3/16/2016 3:00:09 PM (00:08.7 - Column A)
McCain	2016-03-21 09:45:23.9 - Column A
Intelight	Column A (11/24/2015 - Date) Column B (12:30:21 PM - Time) Column C (1 - Tick)

Legend	
X	Enumeration CAPTURED - not present in all controllers' outputs.
X	Enumeration CAPTURED - present in all controllers' outputs.
X	Enumeration not CAPTURED.
Abbreviation	Description
M	Mandatory (Operation and command shall be implemented)
O	Optional (Operation and command may be implemented)
D	Deprecated

Table 3.2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Phase On	Phase # (1-16)	0		X	O	
Phase Begin Green	Phase # (1-16)	1	X		M	
Phase Check	Phase # (1-16)	2	X		M	
Phase Min Complete	Phase # (1-16)	3		X	O	
Phase Gap Out	Phase # (1-16)	4	X		M	
Phase Max Out	Phase # (1-16)	5	X		M	
Phase Force Off	Phase # (1-16)	6		X	O	
Phase Green Termination	Phase # (1-16)	7		X	O	
Phase Begin Yellow Clearance	Phase # (1-16)	8	X		M	
Phase End Yellow Clearance	Phase # (1-16)	9	X		M	
Phase Begin Red Clearance	Phase # (1-16)	10	X		M	
Phase End Red Clearance	Phase # (1-16)	11	X		M	
Phase Inactive	Phase # (1-16)	12	X		M	

Table 3.2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Phase events reserved for future use.	Phase # (1-16)	13-20		X	O	
Pedestrian Begin Walk	Phase # (1-16)	21		X	O	
Pedestrian Begin Clearance	Phase # (1-16)	22		X	O	
Pedestrian Begin Solid Don't Walk	Phase # (1-16)	23		X	O	
Pedestrian Dark	Phase # (1-16)	24		X	O	
Pedestrian events reserved for future use.		25-30			O	
Barrier Termination	Barrier #(1-8)	31		X	O	
FYA – Begin Permissive	FYA # (1-4)	32		X	O	
FYA – End Permissive	FYA # (1-4)	33		X	O	
Barrier events reserve for future use.		34-40		X	O	
Phase Hold Active	Phase # (1-16)	41		X	O	
Phase Hold Released	Phase # (1-16)	42		X	O	
Phase Call Registered	Phase # (1-16)	43	X		M	
Phase Call Dropped	Phase # (1-16)	44	X		M	
Pedestrian Call Registered	Phase # (1-16)	45		X	O	
Phase Omit On	Phase # (1-16)	46		X	O	
Phase Omit Off	Phase # (1-16)	47		X	O	
Pedestrian Omit On	Phase # (1-16)	48	X		M	
Pedestrian Omit Off	Phase # (1-16)	49		X	O	
Phase Control Events reserved for future use.		50-60		X	O	
Overlap Begin Green	Overlap # (as number A=1 B=2, etc.)	61		X	O	

Table 3 2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Overlap Begin Trailing Green (Extension)	Overlap # (as number A=1 B=2, etc.)	62		X	O	
Overlap Begin Yellow	Overlap # (as number A=1 B=2, etc.)	63		X	O	
Overlap Begin Red Clearance	Overlap # (as number A=1 B=2, etc.)	64		X	O	
Overlap Off (Inactive with red indication)	Overlap # (as number A=1 B=2, etc.)	65		X	O	
Overlap Dark	Overlap # (as number A=1 B=2, etc.)	66		X	O	
Pedestrian Overlap Begin Walk	Overlap # (as number A=1 B=2, etc.)	67		X	O	
Pedestrian Overlap Begin Clearance	Overlap # (as number A=1 B=2, etc.)	68		X	O	
Pedestrian Overlap Begin Solid Don't Walk	Overlap # (as number A=1 B=2, etc.)	69		X	O	
Pedestrian Overlap Dark	Overlap # (as number A=1 B=2, etc.)	70		X	O	
Overlap events reserved for future use.	Overlap # (as number A=1 B=2, etc.)	71-80		X	O	
Detector Off	DET Channel # (1- 64)	81	X		M	
Detector On	DET Channel # (1- 64)	82	X		M	
Detector Restored	DET Channel # (1- 64)	83		X	O	
Detector Fault-Other	DET Channel # (1- 64)	84		X	O	
Detector Fault-Watchdog Fault	DET Channel # (1- 64)	85		X	O	
Detector Fault-Open Loop Fault	DET Channel # (1- 64)	86		X	O	

Table 3 2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Detector Fault-Shorted Loop Fault	DET Channel # (1- 64)	87		X	O	
Detector Fault-Excessive Change Fault	DET Channel # (1- 64)	88		X	O	
PedDetector Off	DET Channel # (1- 64)	89		X	O	
PedDetector On	DET Channel # (1- 64)	90		X	O	
Pedestrian Detector Failed	DET Channel # (1- 64)	91		X	O	
Pedestrian Detector Restored	DET Channel # (1- 64)	92		X	O	
Detector events reserved for future use.		93-100		X	O	
Preempt Advance Warning Input	Preempt # (1-10)	101		X	O	
Preempt (Call) Input On	Preempt # (1-10)	102		X	O	
Preempt Gate Down Input Received	Preempt # (1-10)	103		X	O	
Preempt (Call) Input Off	Preempt # (1-10)	104		X	O	
Preempt Entry Started	Preempt # (1-10)	105		X	O	
Preemption Begin Track Clearance	Preempt # (1-10)	106		X	O	
Preemption Begin Dwell Service	Preempt # (1-10)	107		X	O	
Preemption Link Active On	Preempt # (1-10)	108		X	O	
Preemption Link Active Off	Preempt # (1-10)	109		X	O	
Preemption Max Presence Exceeded	Preempt # (1-10)	110		X	O	
Preemption Begin Exit Interval	Preempt # (1-10)	111		X	O	
TSP Check In	TSP #(1-10)	112		X	O	
TSP Adjustment to Early Green	TSP #(1-10)	113		X	O	

Table 3 2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
TSP Adjustment to Extend Green	TSP #(1-10)	114		X	O	
TSP Check Out	TSP #(1-10)	115		X	O	
Preemption Events reserved for future use		116-130		X	O	
Coord Pattern Change	Pattern # (0-255)	131	X		M	
Cycle Length Change	Pattern # (0-255)	132	X		M	
Offset Length Change	Pattern # (0-255)	133	X		M	
Split 1 Change	New Split Time in Seconds (0-255)	134	X		M	
Split 2 Change	New Split Time in Seconds (0-255)	135	X		M	
Split 3 Change	New Split Time in Seconds (0-255)	136	X		M	
Split 4 Change	New Split Time in Seconds (0-255)	137	X		M	
Split 5 Change	New Split Time in Seconds (0-255)	138	X		M	
Split 6 Change	New Split Time in Seconds (0-255)	139	X		M	
Split 7 Change	New Split Time in Seconds (0-255)	140	X		M	
Split 8 Change	New Split Time in Seconds (0-255)	141	X		M	

Table 3 2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Split 9 Change	New Split Time in Seconds (0-255)	142		X	O	
Split 10 Change	New Split Time in Seconds (0-255)	143		X	O	
Split 11 Change	New Split Time in Seconds (0-255)	144		X	O	
Split 12 Change	New Split Time in Seconds (0-255)	145		X	O	
Split 13 Change	New Split Time in Seconds (0-255)	146		X	O	
Split 14 Change	New Split Time in Seconds (0-255)	147		X	O	
Split 15 Change	New Split Time in Seconds (0-255)	148		X	O	
Split 16 Change	New Split Time in Seconds (0-255)	149		X	O	
Coord cycle state change	Parameter (0-6) defined as: 0 = Free 1 = In Step 2 = Transition - Add 3 = Transition - Subtract 4 = Transition - Dwell 5 = Local Zero 6 = Begin Pickup	150		X	O	

Table 3 2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Coordinated phase yield point	Phase # (1-16)	151		X	O	
Coordination events reserved for future use.		162-170		X	O	
Test Input on	Test Input # (as number A=1 B=2, etc.)	171		X	O	
Test Input off	Test Input # (as number A=1 B=2, etc.)	172		X	O	
Unit Flash Status change	NTCIP Flash state # (0-255)	173	X		M	
Unit Alarm Status 1 Change	NTCIP Flash state # (0-255)	174	X		M	
Alarm Group State Change	NTCIP Flash state # (0-255)	175		X	O	
Special Function Output on	Special Function # (0-255)	176		X	O	
Special Function Output off	Special Function # (0-255)	177		X	O	
Manual control enable off/on	Manual control enable off/on # (0,1)	178		X	O	
Interval Advance off/on	Interval Advance off/on # (0,1)	179		X	O	
Stop Time Input off/on	Stop Time Input Advance off/on # (0,1)	180		X	O	
Controller Clock Updated	Optional parameter: Time correction in Seconds (0-255)	181		X	O	
Power Failure Detected	True (1)	182		X	O	
Contact PEEK		183				
Power Restored		184		X	O	
Vendor Specific Alarm	Vendor defined parameter	185		X	O	

Table 3 2. Standards for generating SPMs from TERL-approved signal controllers (continued)

Code explanation	Parameter	Code	Mandatory	Optional	FDOT Requirement	Additional Notes and Requirements
Cabinet/System events reserved for future use.		186-199		X	O	
Reserved for future use.		200-255		X	O	
ACTUAL_SPLIT 1		300				
ACTUAL_SPLIT 2		301				
ACTUAL_SPLIT 3		302				
ACTUAL_SPLIT 4		303				
ACTUAL_SPLIT 5		304				
ACTUAL_SPLIT 6		305				
ACTUAL_SPLIT 7		306				
ACTUAL_SPLIT 8		307				
ACTUAL_SPLIT 9		308				
ACTUAL_SPLIT 10		309				
ACTUAL_SPLIT 11		310				
ACTUAL_SPLIT 12		311				
ACTUAL_SPLIT 13		312				
ACTUAL_SPLIT 14		313				
ACTUAL_SPLIT 15		314				
ACTUAL_SPLIT 16		315				
ACTUAL_NATURAL_CYCLE		317				
ACTUAL_OFFSET		318				
BARRIER_ENTR_Y_RING1		501				
BARRIER_ENTR_Y_RING2		502				

The stored event logs in the controllers are used to calculate various performance measures that help in determining of traffic signal operations performance. Table 3-3 shows the event codes used for calculation of the corresponding performance measure. Please note that it is possible for one event to be used in calculation of more than one performance measure.

Table 3-3. Performance measures and event codes used for their derivation

Performance Measures	Event Code Found related to Performance Measures in Code	Provided By UDOT
Approach Delay - functional	1, 8, 10, 64, 82, 131	
Approach Volume - functional	1, 8, 10, 64, 82, 131	
Arrivals On Red - functional	1, 8, 10, 64, 82, 131	
Purdue Coordination Diagram - functional	1, 8, 10, 82, 131	
Purdue Split Failure - No graphs – Needs to be configured in the SPM Tool. To be accomplished later.	1,4,5,6,11,21,23	1, 4, 5, 6, 8, 9 11, 81, 82, 131
Pedestrian Delay - No graphs – Needs to be configured in the controller. To be accomplished later.	21,45,90,23,131	21, 22, 43, 131
Preemption Details - No graphs – Needs to be configured in the controller. To be accomplished later.	1, 8 , 10	
Purdue Phase Termination	1,11,4,5,6,21,23, 131	4, 5, 6, 131
Speed - The graphs are given below, but without data from the controller because speed detectors need to be configured in the controller. To be accomplished later.	1, 8, 10, 82, 131	
Split Monitor -	1,4,5,6,8,9,10,11,21,23, 82, >130 to <150	1, 4, 5, 6, 8, 9, 11, 23, 131
Turning Movement Counts - No graphs – Need to add new detectors after the stop bar. To be accomplished later.	82, 131	81, 82, 131
Yellow and Red Actuations - No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.		8, 9, 11, 81, 82, 131

3.2 Minimum Standard Specification for Future Controllers

The specification of minimum standards for the events that future controllers have to collect and store are based on the events that are declared mandatory in the . Those mandatory events (codes) are being stored in all six types of tested controllers, and all future controllers that will be installed in Florida, unrelated to the vendor name, will have to comply with that minimum requirements (marked with blue fields and red symbols in the).

All other events that are being collected by some of the tested controllers or none of them but known from the literature are declared optional. Naturally, it would be preferable if the controller has as many of the events that can collect and store as possible. However, due to the differences in the approach and the technology that each vendor uses, the operations, interface, capabilities and finally the events that can be collected vary from vendor to vendor.

3.3 High resolution Data Logging Quality Test

To test the quality of high-resolution data logging, a comparison was conducted between the logged event-based data elements in the controller and the VISSIM's corresponding event-based data elements. The data from VISSIM was considered to be the “ground-truth” and if the outputs from the HILS were similar, the data logging quality is good.

Purdue Coordination Diagram (PCD) is selected as a medium for investigating the data logging quality. To perform the data logging quality test, PCDs were created by using the SMP web server, which relies on the data that controllers store in their database and the new tool developed by FAU. This new tool creates the PCD diagrams by using the data from LDP output files from VISSIM which represented the reference output. If both diagrams are similar, then detector and signal phase loggings are accurate.

For this task, the comparison for three signal controllers is performed (McCain, Trafficware and Econolite). The VISSIM file was set up to store .ldp files for all signal phases and the advanced detectors in frequency of 0.1 s which is the same frequency that controllers use to store the events data. The same VISSIM file with six intersections is set up to work with all six controllers in HILS setup, but three are compared in this report. The simulation was running for approximately one hour and afterwards, the data from the controllers were transferred from the controllers to the SPM FDOT server, decoded, imported and PCDs were created for each approach of every controller in the network of six intersections. On the other hand, the created .ldp files from VISSIM were imported into software “PCD tool” created by FAU research team. Those .ldp files contain data about activity of signal phases and advanced detectors in the resolution of 0.1 s. In this way, the compatibility between data from controller and VISSIM is ensured. The created PCDs were compared for the percentages of Arrivals on Green, percentage of Green time, Platoon ratio, shape of lines representing the Change to Green, Change to Yellow and Change to Red events. Finally, the advanced detector actuations are provided by black dots in PCDs. Those measures are compared on the PCDs provided below.

Econolite Cobalt controller

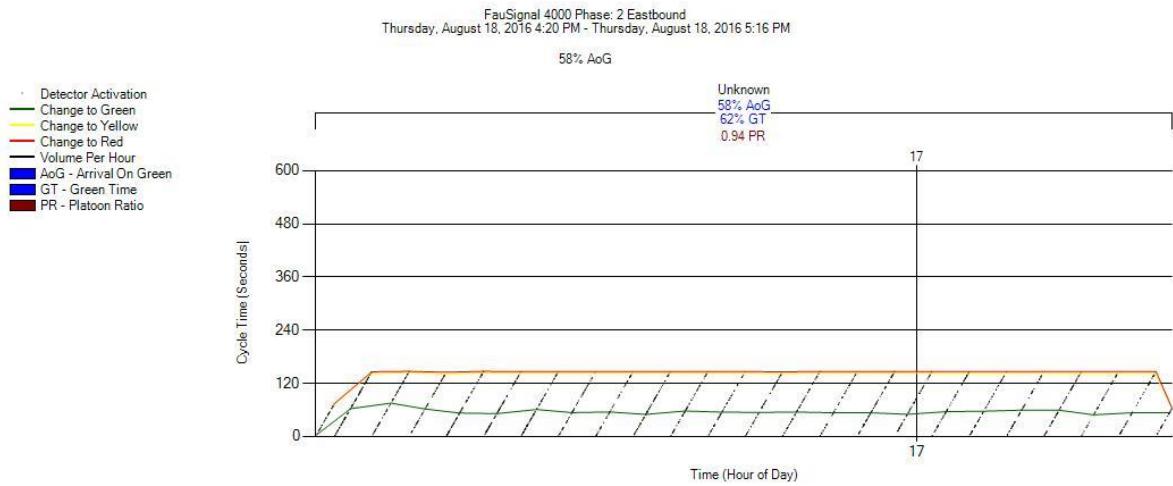


Figure 3-1. PCD for phase 2, EB on controller 4000 (Cobalt) from VISSIM .ldp file

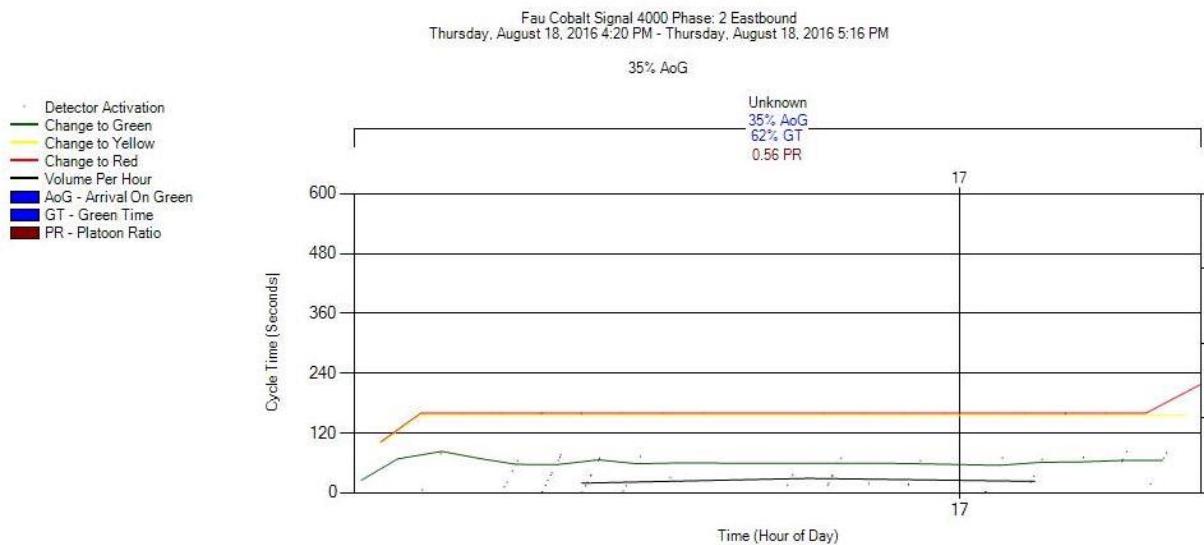


Figure 3-2. PCD for phase 2, EB on controller 4000 (Cobalt) from HILS setup

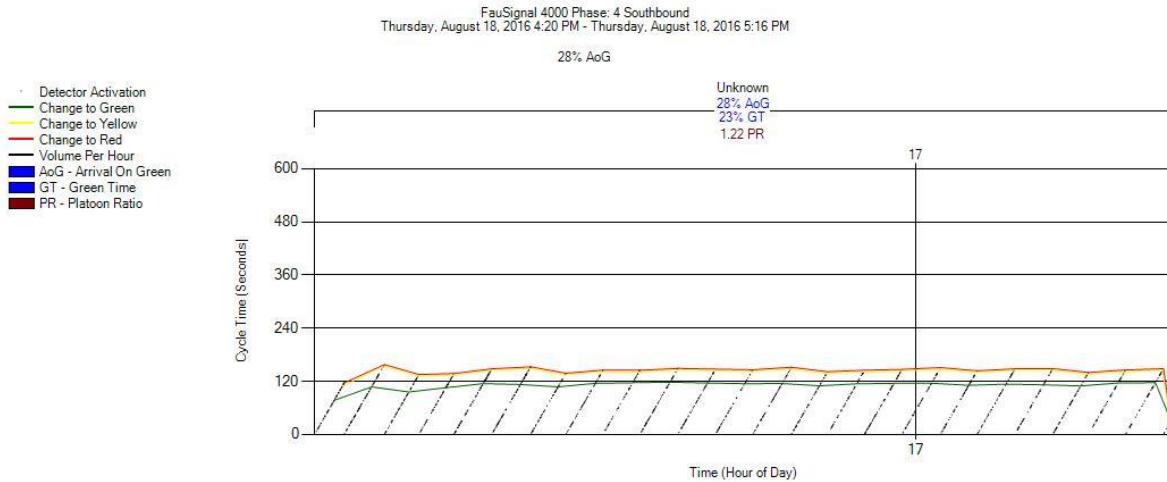


Figure 3-3. PCD for phase 4, SB on controller 4000 (Cobalt) from VISSIM .ldp file

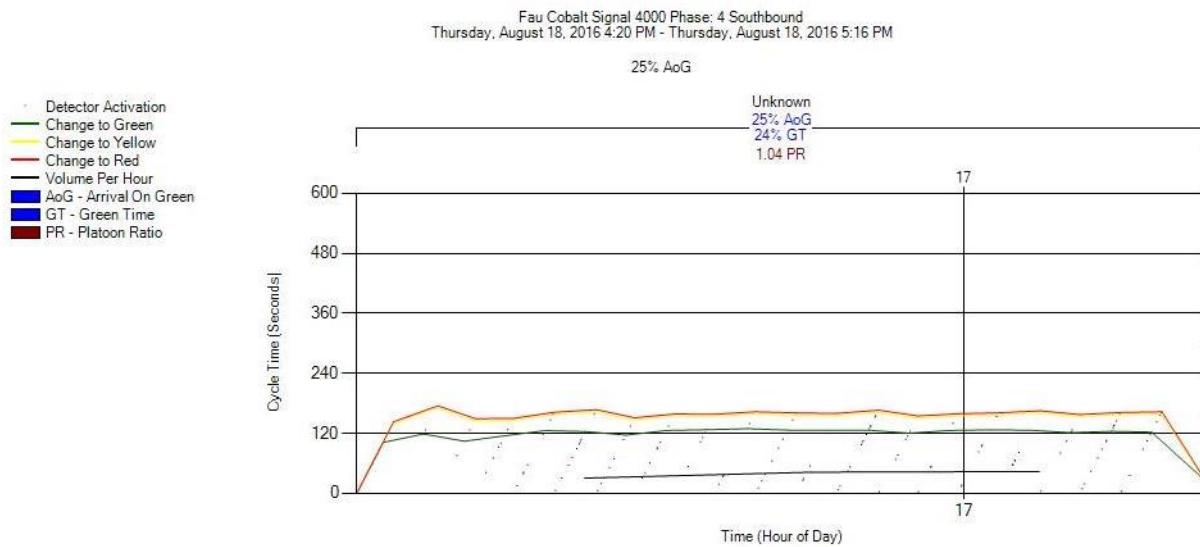


Figure 3-4. PCD for phase 4, SB on controller 4000 (Cobalt) from HILS setup

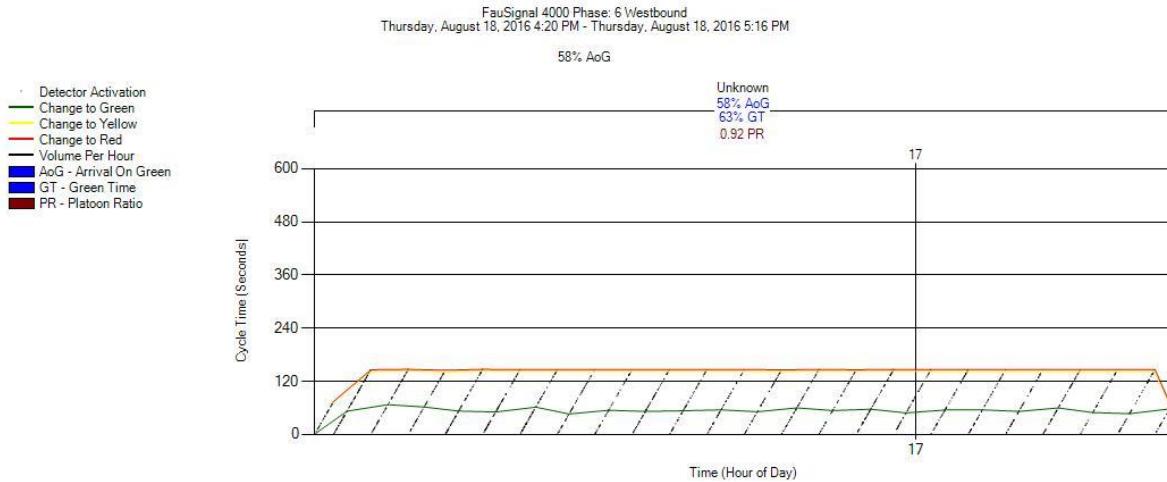


Figure 3-5. PCD for phase 6, WB on controller 4000 (Cobalt) from VISSIM .ldp file

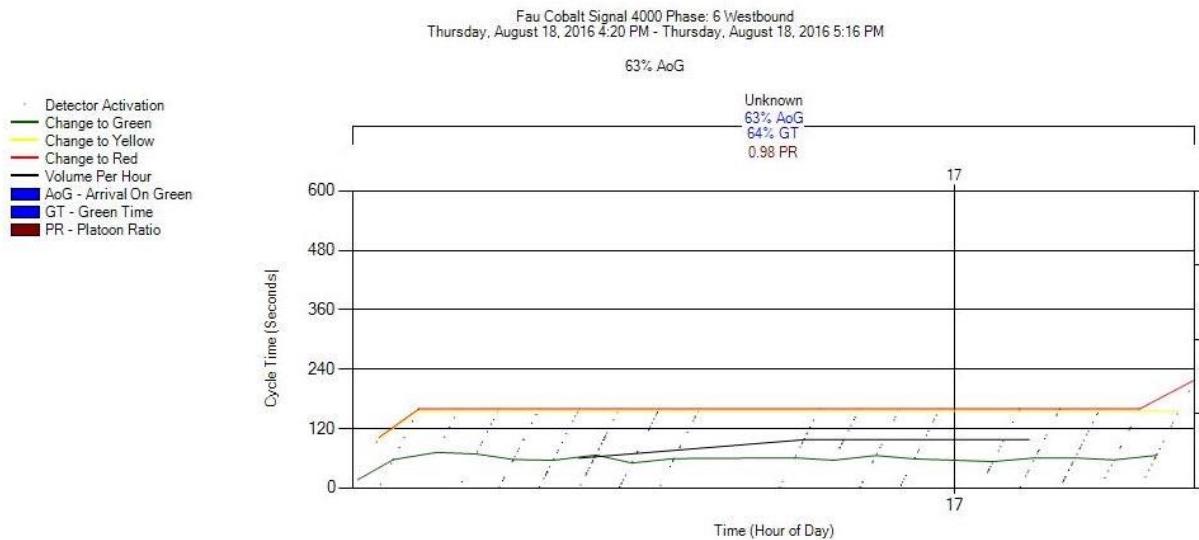


Figure 3-6. PCD for phase 6, WB on controller 4000 (Cobalt) from HILS setup

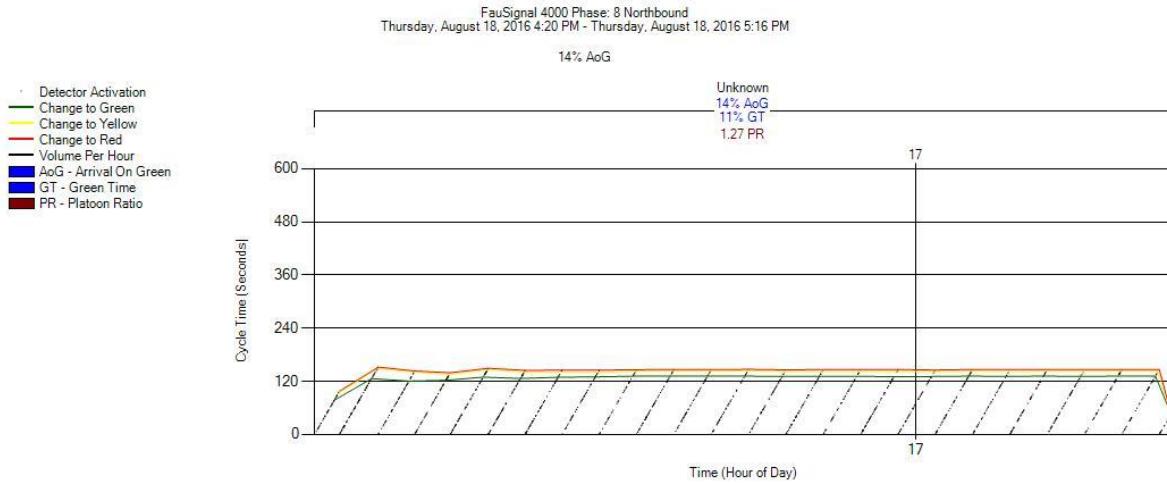


Figure 3-7. PCD for phase 8, NB on controller 4000 (Cobalt) from VISSIM .ldp file

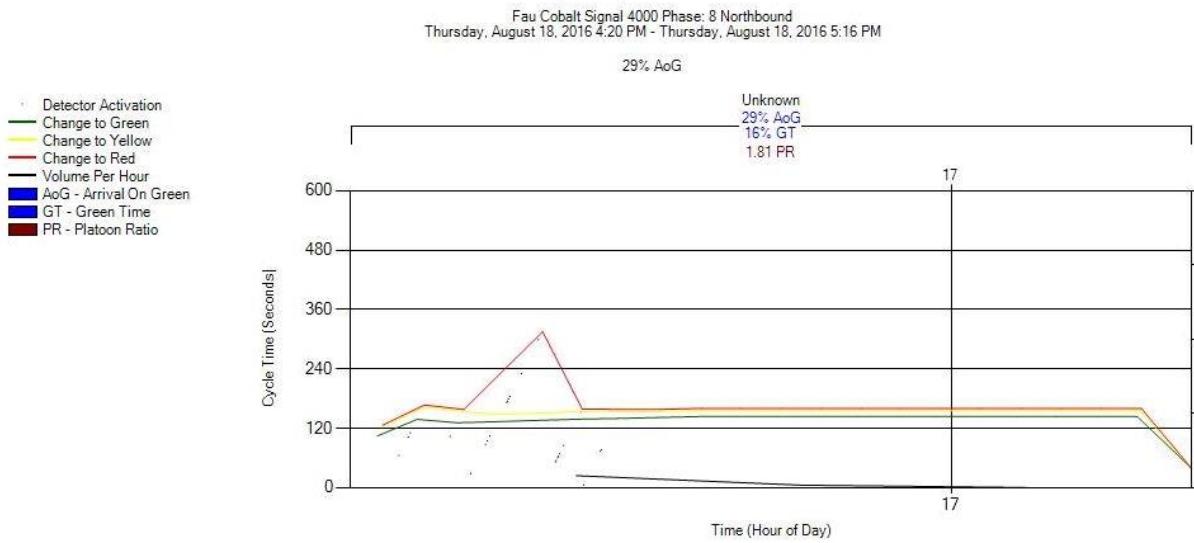


Figure 3-8. PCD for phase 8, NB on controller 4000 (Cobalt) from HILS setup

Trafficware Series 900 ATC controller

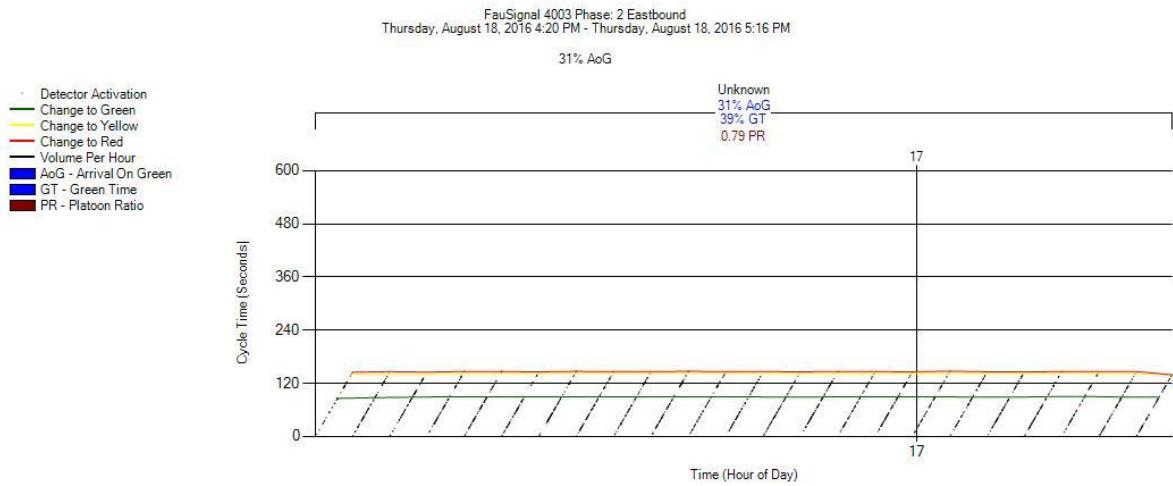


Figure 3-9. PCD for phase 2, EB on controller 4003 (Trafficware) from VISSIM .ldp file

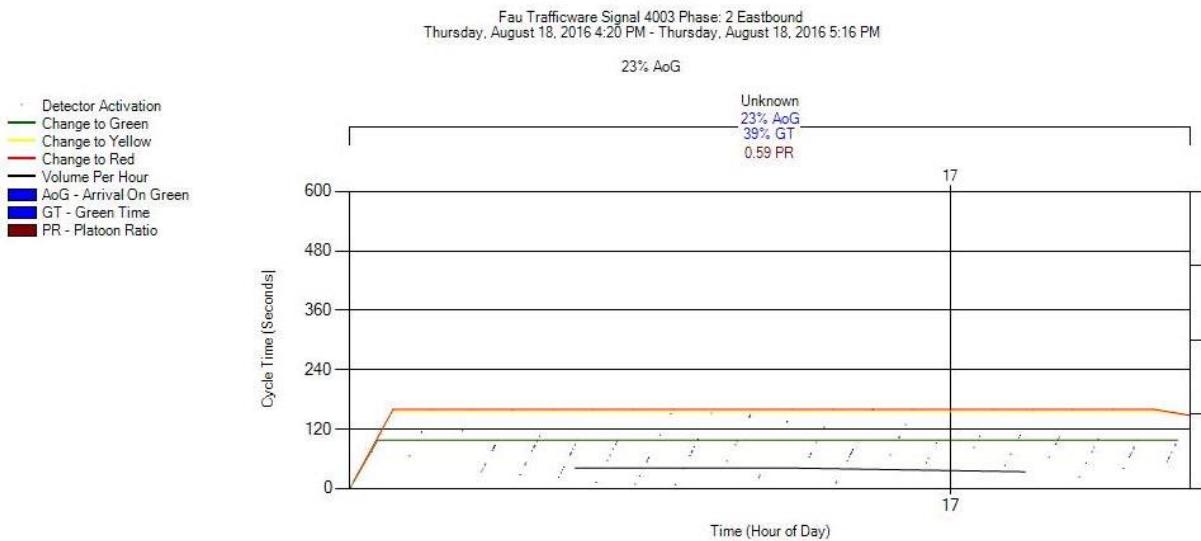


Figure 3-10. PCD for phase 2, EB on controller 4003 (Trafficware) from HILS setup

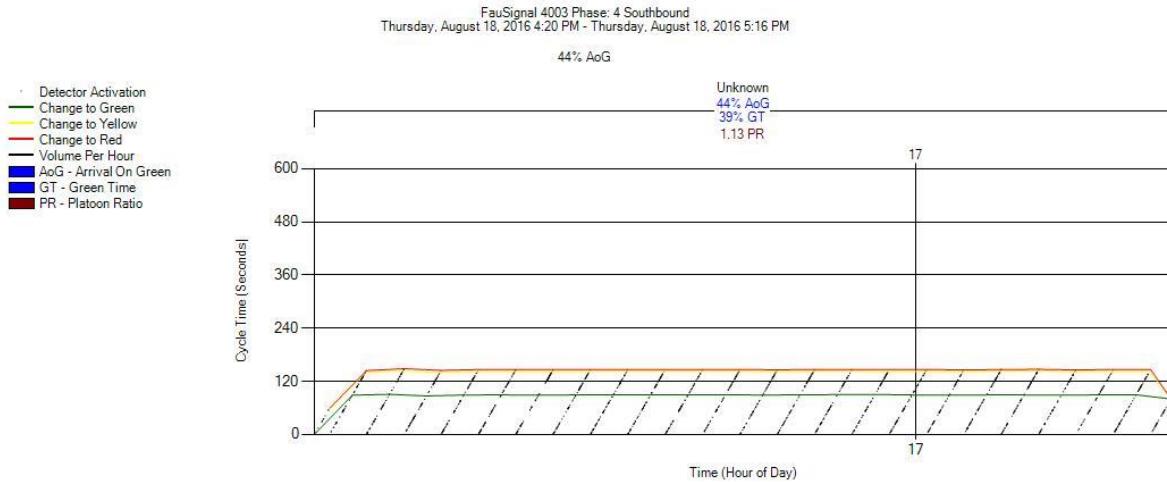


Figure 3-11. PCD for phase 4, SB on controller 4003 (Trafficware) from VISSIM .ldp file

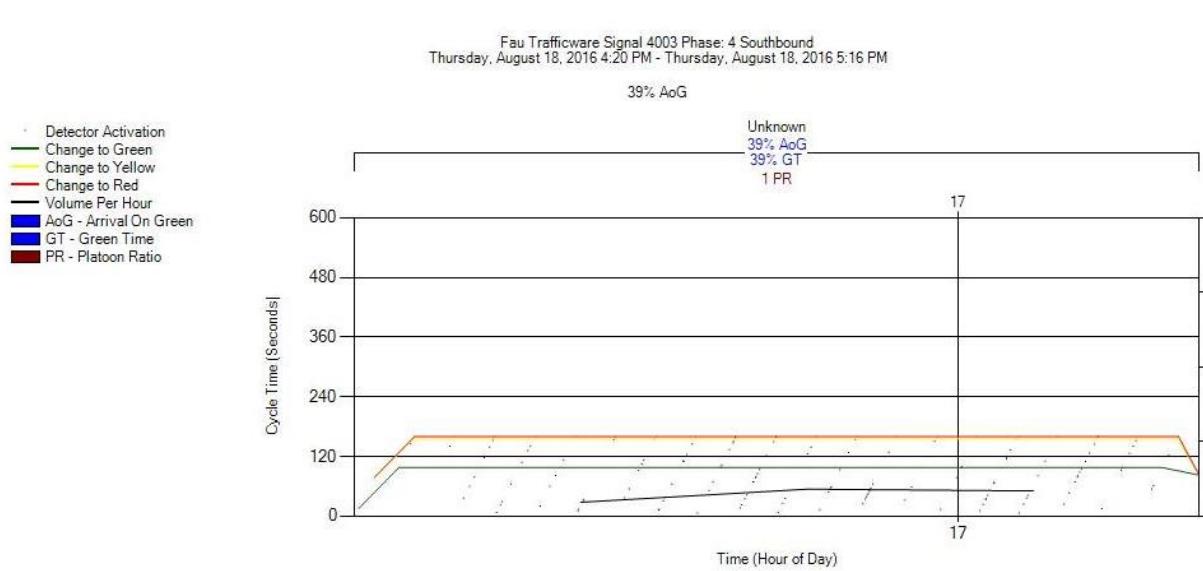


Figure 3-12. PCD for phase 4, SB on controller 4003 (Trafficware) from HILS setup

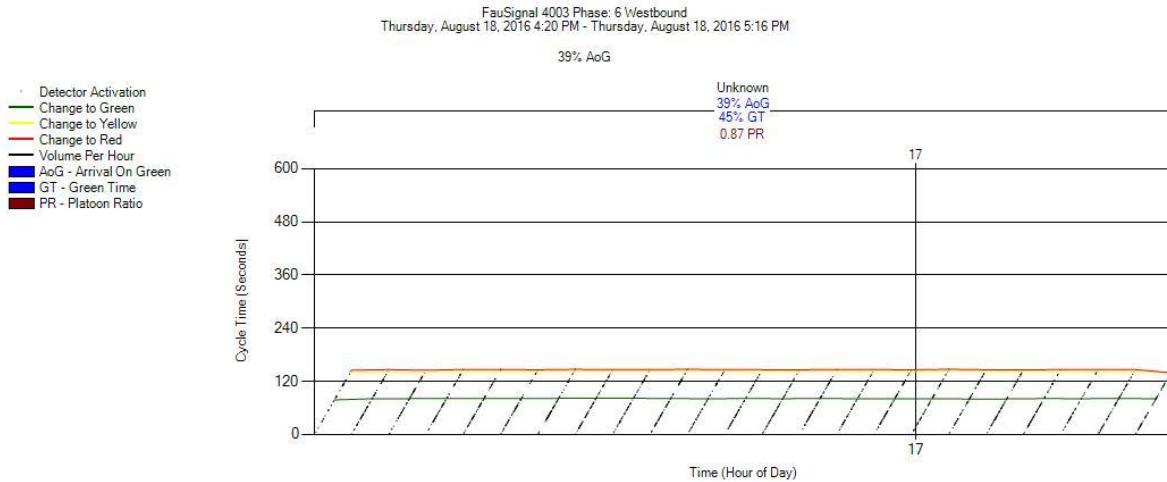


Figure 3-13. PCD for phase 6, WB on controller 4003 (Trafficware) from VISSIM .ldp file

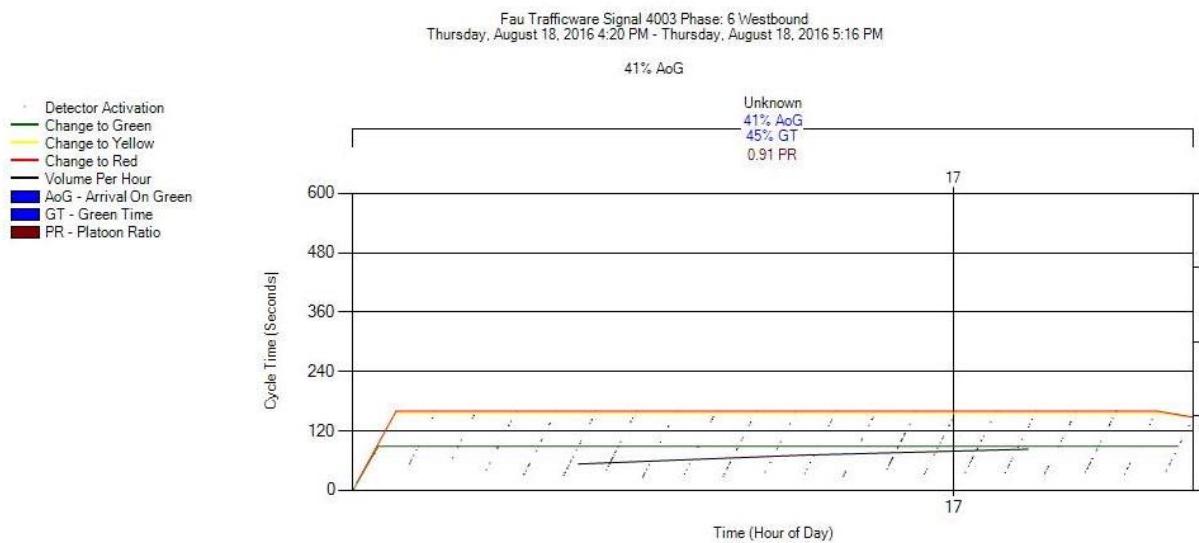


Figure 3-14. PCD for phase 6, WB on controller 4003 (Trafficware) from HILS setup

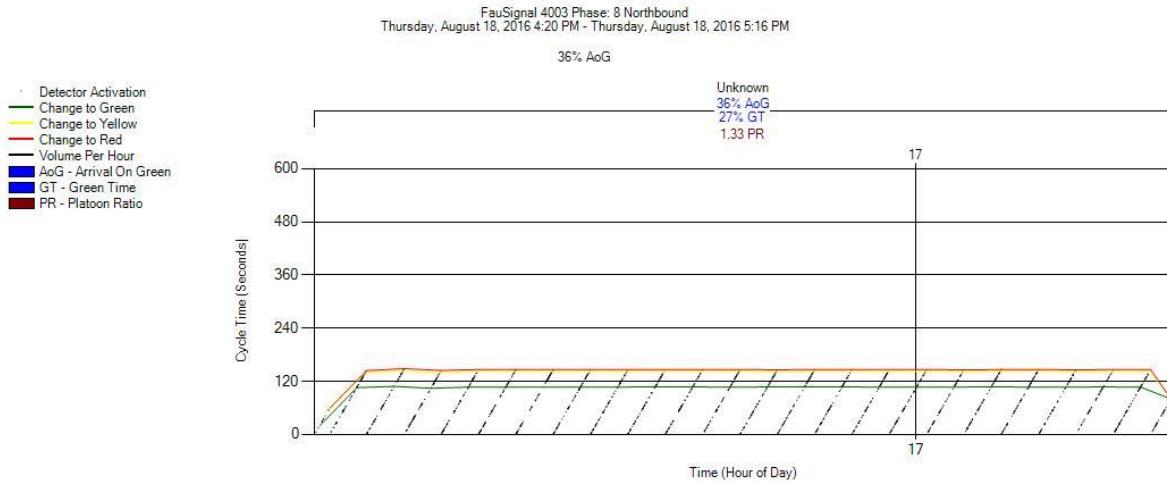


Figure 3-15. PCD for phase 8, NB on controller 4003 (Trafficware) from VISSIM .ldp file

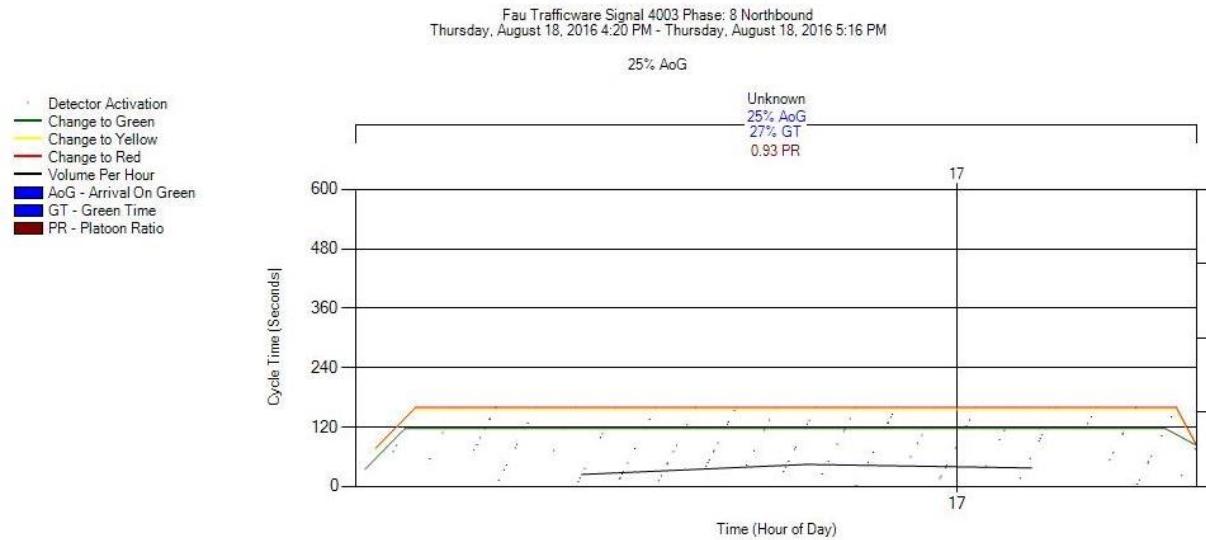


Figure 3-16. PCD for phase 8, NB on controller 4003 (Trafficware) from HILS setup

McCain ATC eX controller

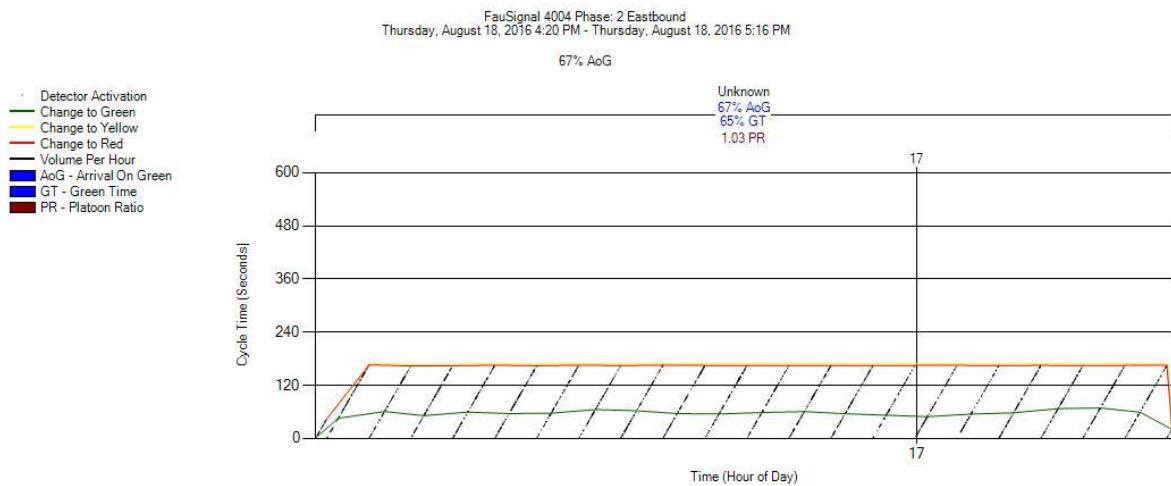


Figure 3-17. PCD for phase 2, EB on controller 4004 (McCain) from VISSIM .ldp file

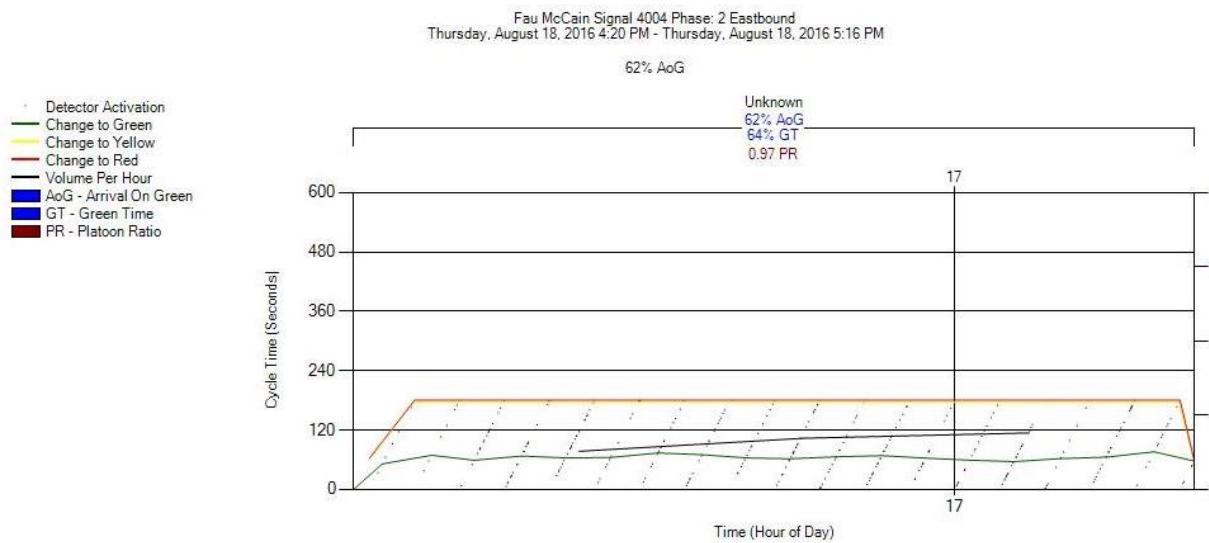


Figure 3-18. PCD for phase 2, EB on controller 4004 (McCain) from HILS setup

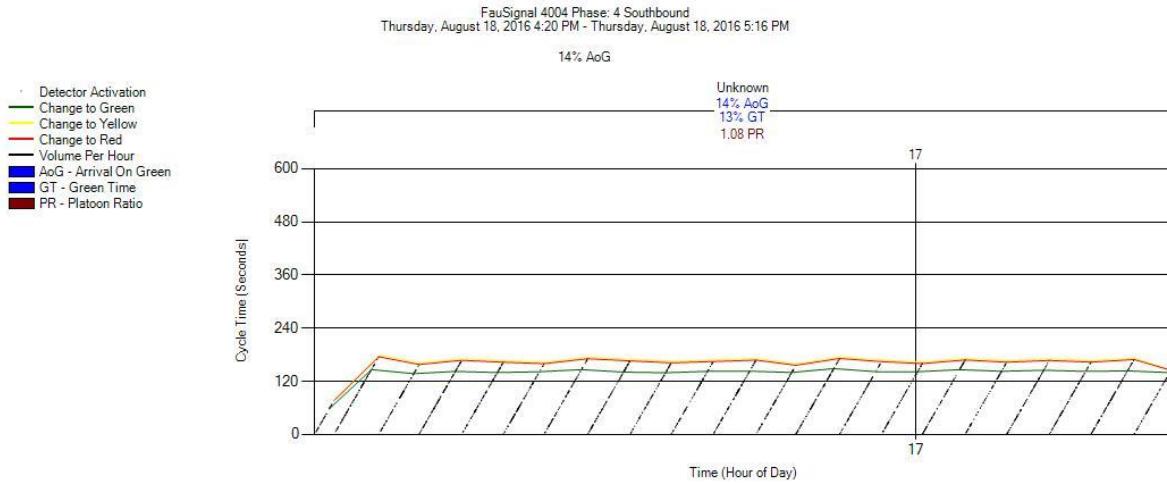


Figure 3-19. PCD for phase 4, SB on controller 4004 (McCain) from VISSIM .ldp file

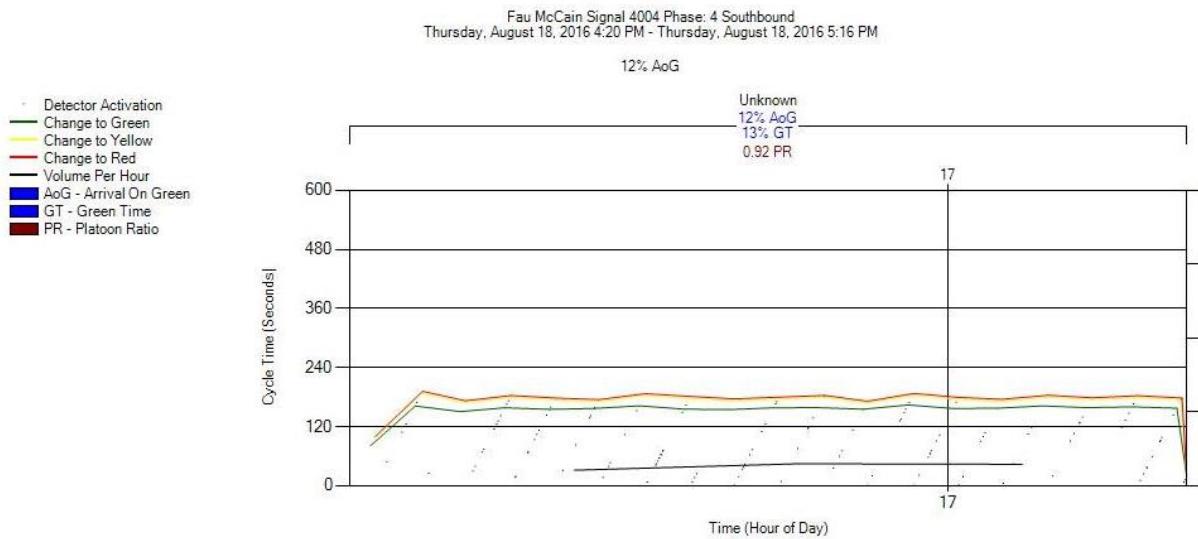


Figure 3-20. PCD for phase 4, SB on controller 4004 (McCain) from HILS setup

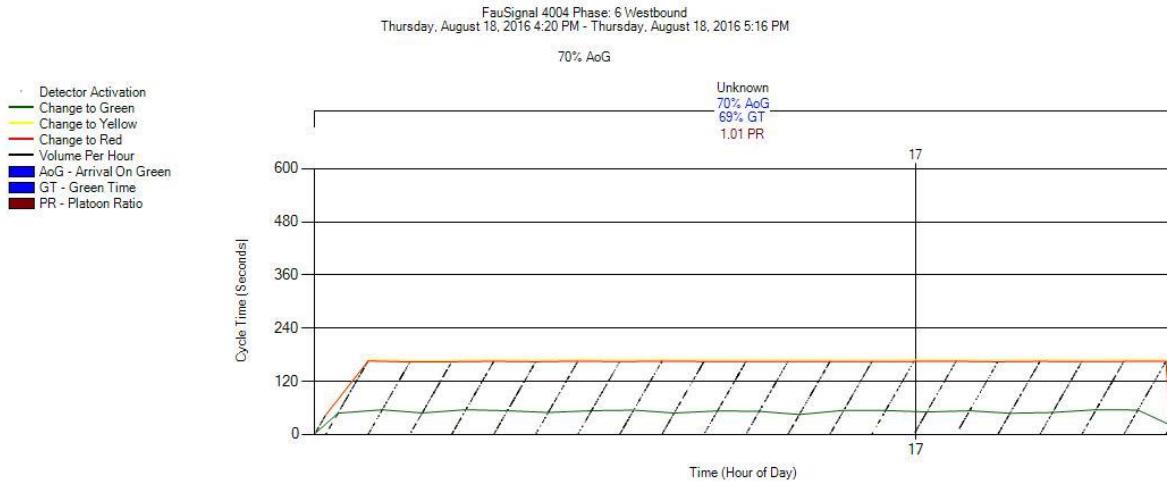


Figure 3-21. PCD for phase 6, WB on controller 4004 (McCain) from VISSIM .ldp file

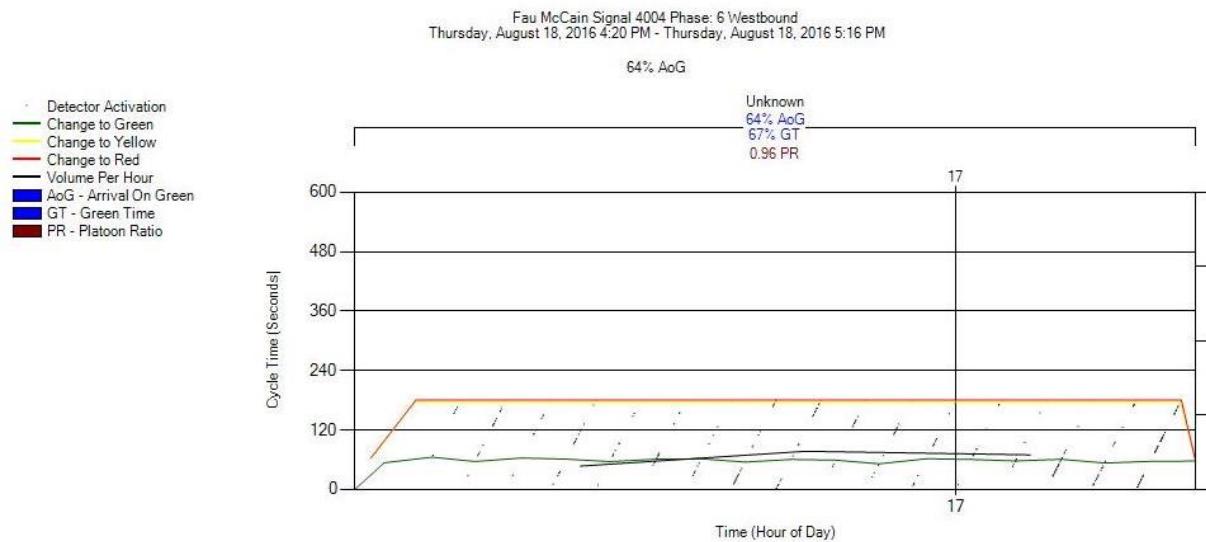


Figure 3-22. PCD for phase 6, WB on controller 4004 (McCain) from HILS setup

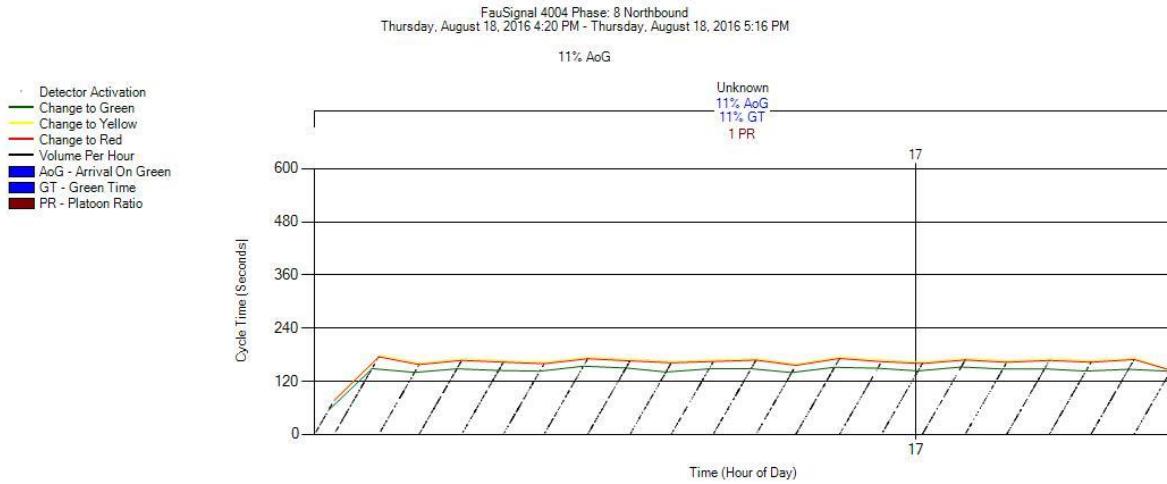


Figure 3-23. PCD for phase 8, NB on controller 4004 (McCain) from VISSIM .ldp file

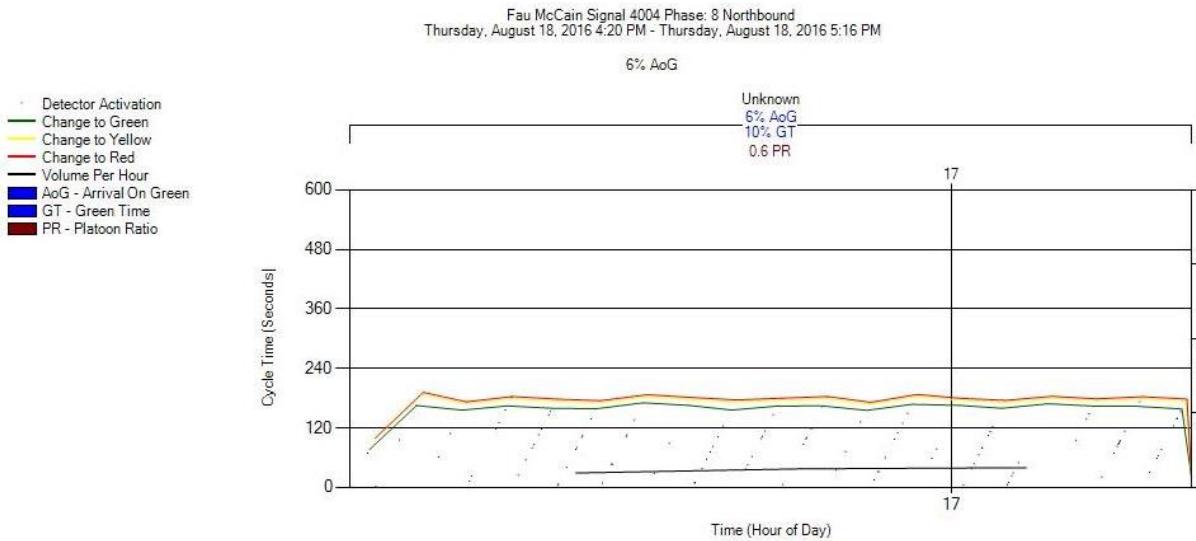


Figure 3-24. PCD for phase 8, NB on controller 4004 (McCain) from HILS setup

By examining the groups of PCD files from VISSIM and HILS setup it is obvious that the difference in data logging exists between the two methods. It looks like not all detector actuations are logged if the HILS setup is used for creating the PCDs. That can be noted by smaller number of dots on PCDs below red, yellow and green lines compared to the PCDs created from VISSIM .ldp files. Consequently, percentage of Arrivals on Green and platoon ratios are different for the same movement and the same controller if different methods are used. Also, the percentages of Green time are slightly different.

Most probable reason for the differences shown above is the different number of detector actuations for the same simulation run depending of the input file. The hypothesis is made that amount of data the system needs to process for six intersections, all their phases and detectors simultaneously is too large and that causes the omissions of vehicle detections. Therefore, the FAU research team decided to execute one more simulation experiment, but this time by using

only one intersection. For this test the Econolite Cobalt controller device was used. For showing if the difference in the logged data exist when only one controller is used on one intersection network, Southbound and Westbound approaches are selected. The obtained PCDs are given below.

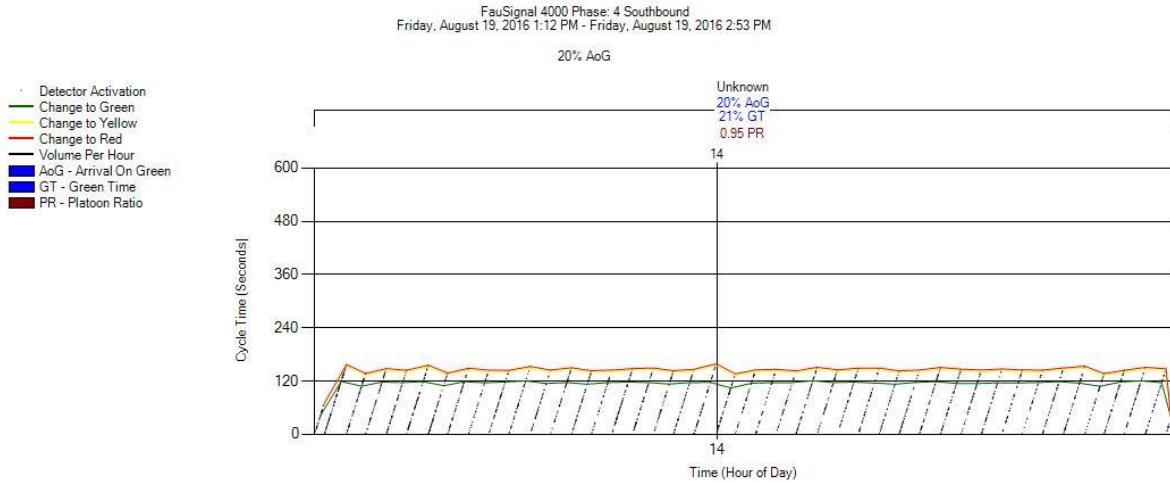


Figure 3-25. PCD for phase 4, SB on Econolite controller from VISSIM (one intersection)

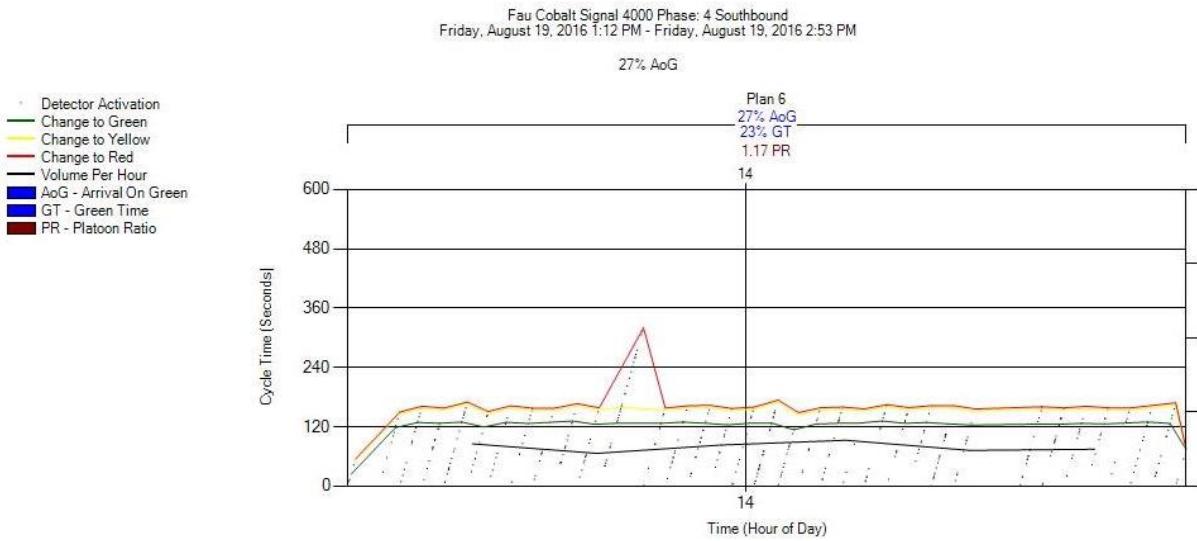


Figure 3-26. PCD for phase 4, SB on Econolite controller from HILS (one intersection)

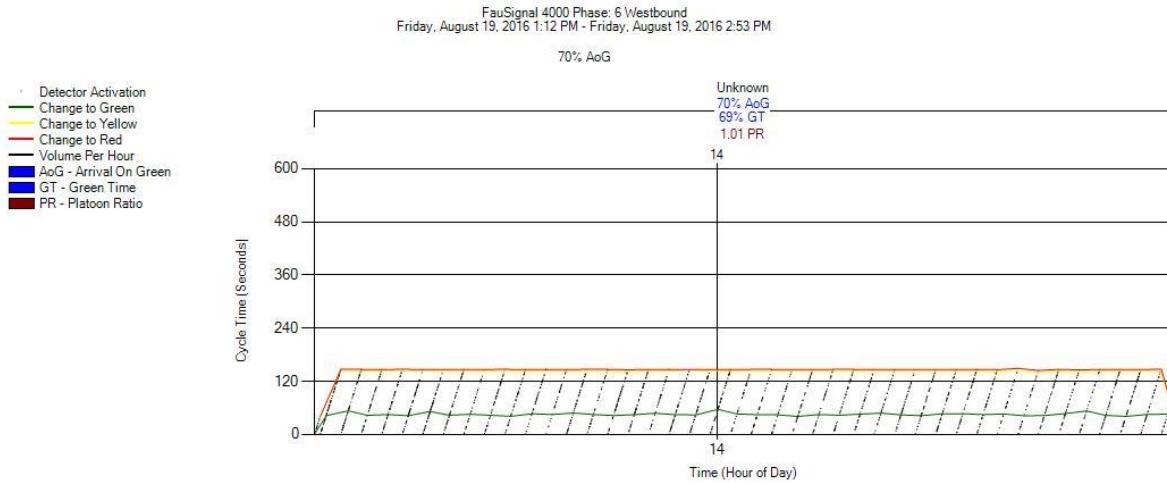


Figure 3-27. PCD for phase 6, WB on Econolite controller from VISSIM (one intersection)

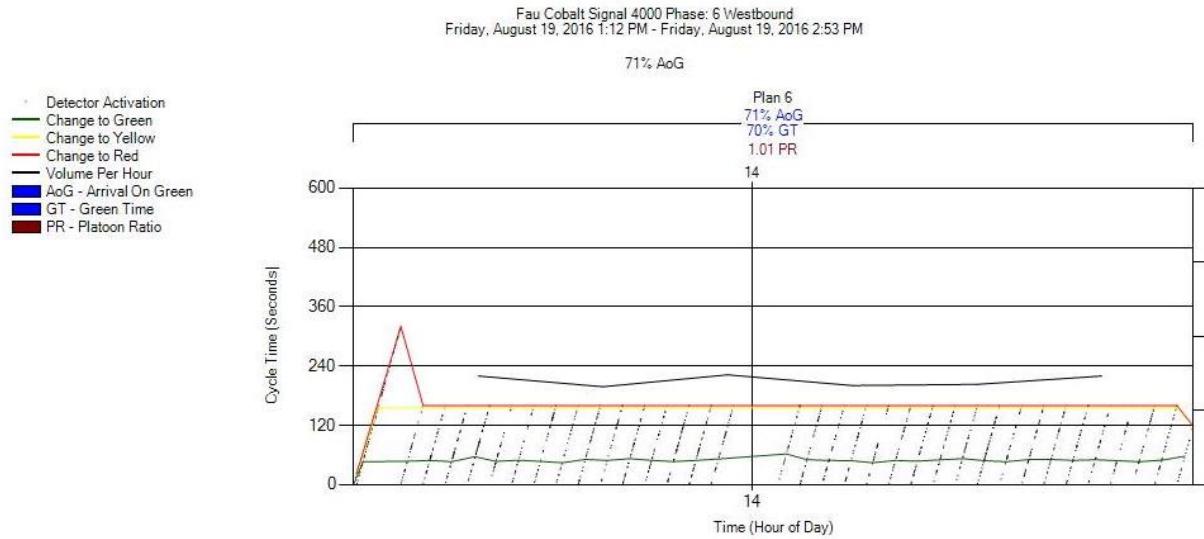


Figure 3-28. PCD for phase 6, WB on Econolite controller from HILS (one intersection)

Even in case when only one controller is active on one intersection network, still the measures from PCDs are not similar when using HILS setup and .ldp files from VISSIM. Percentage of arrivals on green, green time and platoon ratios are different in that two cases. That fact suggests that the quantity of the data that HILS setup needs to process is not the one and only reason for differences in the logged events. Even some deviations about logging the beginning of the red light are noted (Figure 3-26 and Figure 3-28). All this issues require further investigation in order to isolate the cause and obtain acceptable level of accuracy.

3.4 Testing Detector and Other Faults

In order to make sure if all detectors work properly, the procedure for testing faulty detectors is developed. The procedures will differ in accordance with the controller type, which means that six procedures are made with small differences depending of the controller type.

First step in testing the detector faults is investigating if controllers report any detector faults. Next, if there are no reported faults, the functionality of the detectors is checked while the simulation is running. When vehicle passes over a detector, the actuation can be confirmed on the appropriate controller screen. Few additional tests can also be done. The situation if the detector that is not operational still can report the actuations, is checked by changing the detector type from vehicle to pedestrian detector for example. If there are no actuations in that case, it means that there are no false detections that can be reported. Second testing scenario could be the constant call on a detector. If the call is present in the controller, not interrupted, and if controller reports an error, that means the detection is working properly.

3.4.1 Testing for False Detections

To exclude the possibility of the false detections for all detectors on one intersection a simple test will be used. The goal of this test is to change the detector setup so vehicles cannot activate the detectors in VISSIM. When all detectors are changed, and if everything is set up correctly, the screen for showing the detector activations on the controllers will not show any activation when vehicles cross the detectors. If any detection is noted, that detection is false and the setup has to be checked for the subject detector. To perform this type of test, it is necessary to change the Activation options for all detectors in the subject network from All Vehicle Types to Pedestrian. Steps for performing the test are provided below:

1. When VISSIM file, CIDs and controllers are completely ready for starting HILS, find the folder that contains the VISSIM file and other accompanying files for one intersection for HILS
2. Copy the entire folder to another location and give it an appropriate name, for example “Testing for false detections”. There the testing configuration will be set up.
3. Open the VISSIM file from the copied folder, which is to be tested
4. Double left-click on the first detector
5. Select the Activation card
6. Under the column Vehicle classes select “50 Pedestrian”
7. Click “OK”
8. Repeat for all the detectors in the subject network.
9. Save the VISSIM file
10. Run the simulation from “VirtualCID.exe” application like when starting the HILS simulation
11. Observe the controller display and beware for actuations

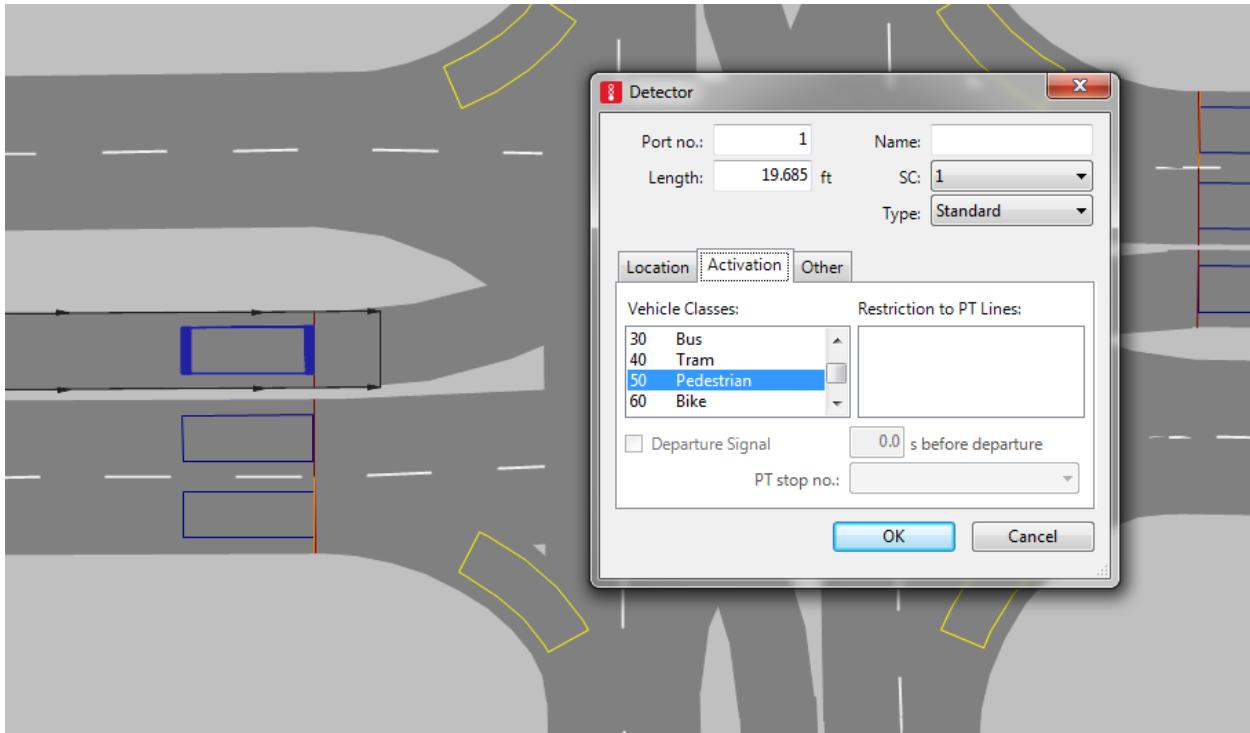


Figure 3-29. Changing the detectors activation setup in VISSIM

The HILS simulation should be started from VirtualCID.exe by selecting the three files (.inp, .layx and .txt) from the copied folder (e.g. “Testing for false detections”), and start observing the actuations noted by the controller on the controller display.

3.4.2 Testing for Actuation Interruptions – Stop Bar Detectors

To test if the detection from the VISSIM is recorded properly and constantly, a simple test is created. The goal is to check if there are interruptions of a detection in VISSIM noted by the controller in HILS testing setup. In other words, if the vehicle is constantly above the detector that will create constant call that should not have any pauses. In order to create that scenario, an additional signal controller (Type: Fixed time) should be made and it should have only one signal group that will constantly have only red signal. All signal heads on the intersection should be edited to follow the commands from the new Signal Controller inside VISSIM (labeled as number 2) that should provide constant red signal. Steps for performing the test are provided below:

1. When VISSIM file, CIDs and controllers are completely ready for starting HILS, find the folder that contains the VISSIM file and other accompanying files for one intersection for HILS
2. Copy the entire folder to another location and give it an appropriate name, for example “Testing for stop-bar detection interruptions”. There the testing configuration will be set up.
3. Open the VISSIM file from the copied folder, which is to be tested
4. Create the new Signal Controller by selecting the Signal Control tab in the menu bar
5. In the bottom part of the screen there will be only one Signal controller of type External

6. Right click on the white surface and click “Add”.
7. Set the Number of Signal Controller (e.g. 2)
8. For type select Fixed time from drop down menu
9. Set the constant red signal by clicking the Edit Signal Control button and make the signal plan with only one signal group and the constant red signal
10. Double left-click on the first signal head
11. Under SC drop-down menu select the number you have inserted for the “constant red) signal controller (by default the next available number – probably 2)

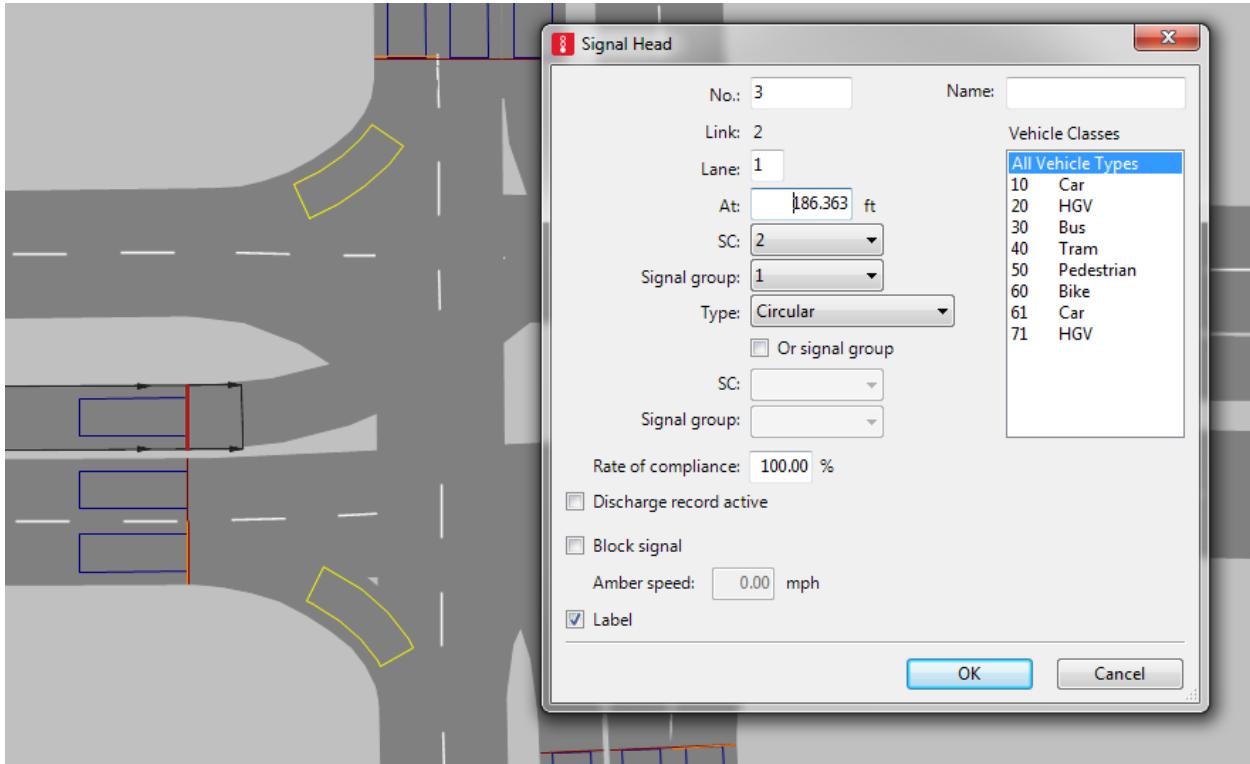


Figure 3-30. Changing the signal heads to newly created constant red signal plan in VISSIM

12. Click OK
13. Repeat for all the signal heads on the intersection
14. Save the VISSIM file
15. Run the simulation from “VirtualCID.exe” application like when starting the HILS simulation
16. Observe the controller display and monitor the actuations for stop line detectors (in the provided file, the stop bar detectors are numerated from 1 to 8). When vehicles arrive and place above the stop bar detectors then the call shall be noted in the controller. That call should be constant and uninterrupted if the setup is done correctly.
17. If one waits long enough, even the advanced detectors (in the submitted files numeration from 9 to 16) will be constantly occupied. The same observation like in the previous step can be performed.

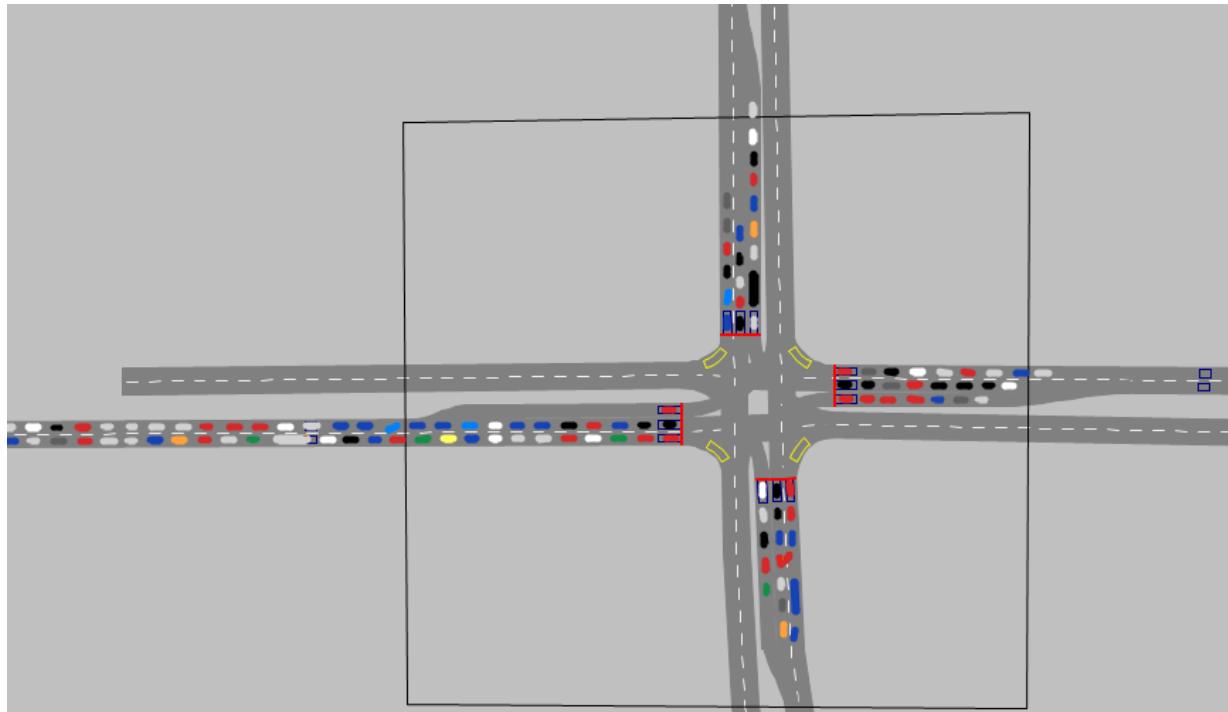


Figure 3-31. Testing for actuation interruptions – stop bar detectors (constant red signal)

The HILS simulation should be started from VirtualCID.exe by selecting the three files (.inp, .layx and .txt) from the copied folder (e.g. “Testing for stop-bar detection interruptions”), and start observing the actuations noted by the controller on the controller display.

3.4.3 Testing for Actuation Interruptions – Advanced Detectors

If the examiner does not want to test stop-bar detectors but only advanced detectors or does not want to wait until the queues of vehicles back up enough to cover all advanced detectors on all approaches, an alternative method can be applied. Steps for performing the test are provided below:

1. When VISSIM file, CIDs and controllers are completely ready for starting HILS, find the folder that contains the VISSIM file and other accompanying files for one intersection for HILS
2. Copy the entire folder to another location and give it an appropriate name, for example “Testing for advance detection interruptions”. There the testing configuration will be set up.
3. Open the VISSIM file from the copied folder, which is to be tested
4. Create the new Signal Controller by selecting the Signal Control tab in the menu bar
5. In the bottom part of the screen there will be only one Signal controller of type External
6. Right click on the white surface and click “Add”.
7. Set the Number of Signal Controller (e.g. 2)
8. For type select Fixed time from drop down menu
9. Set the constant red signal by clicking the Edit Signal Control button and make the signal plan with only one signal group and the constant red signal
10. Create new signal heads immediately downstream of all the advanced detectors

11. When creating each new signal head, select 2 (or other assigned number of “constant red” signal plan) and click “OK”.
12. Repeat for all the advanced detectors on all approaches to the intersection
13. Save the VISSIM file
14. Run the simulation from “VirtualCID.exe” application like when starting the HILS simulation
15. Observe the controller display and monitor the actuations for advanced detectors (in the provided file, the stop bar detectors are numerated from 9 to 16). When vehicles arrive and place above the stop bar detectors then the call shall be noted in the controller. That call should be constant and uninterrupted if the setup is done correctly.

The HILS simulation from VirtualCID.exe should be started by selecting the three files (.inp, .layx and .txt) from the copied folder (e.g. “Testing for advance detectors detection interruptions”), and start observing the actuations noted by the controller on the controller display.

3.4.4 Intelight – Detectors Status Screen

In order to activate the screen needed for general check-up of the alarms and actuations mentioned in all three tests, one must execute the following steps:

1. Press the keyboard button “2” - to enter Maxtime on Intelight controller
2. Press number “1” – Status
3. Press number “4” – Detectors
4. Press number “1” – to enter the vehicle detectors. If the alarm is active for some of the detectors, the operator can check the type of alarm by pressing the “Esc” to go back to the previous menu, and then press “2” to enter Vehicle detector alarms where type of Alarm can be determined.
5. On the other hand, if there are no alarms active, stay in the step 4 (menu Vehicle detectors with three rows: number of detector, active and Alarm).
6. If the current display is Vehicle detectors (path 1.4.1 described above), then the simulation can be started.
7. While the simulation is running, observe the actuations in the row with the label Active. When the detector detects the actuation, the number of the detector will appear (be repeated) in the middle row right below the subject detection number.

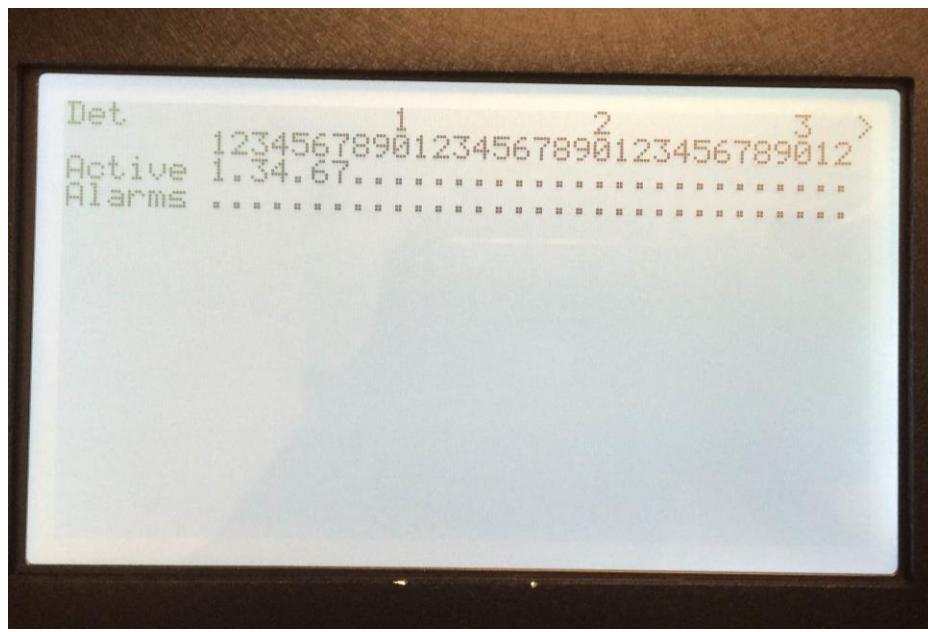


Figure 3-32. Intelight detector status screen

3.4.5 McCain – Detectors Status Screen

To activate the screen needed for general check-up of the alarms and actuations mentioned in all three tests, one must execute the following steps:

1. Go back to the basic menu
2. Press number “4” – DETECTORS
3. Press number “3” – VEHICLE DETECTOR DIAGNOSTICS
4. Press the number of detector set to perform diagnostics (e.g. “1”) – Detector numbers are provided in the first row and the alarms are provided in the following four rows.
5. Press the “ESC” three times to go back to the basic menu if no alarms are active.
6. Press “0” – STATUS
7. Press “4” – DETECTORS
8. Press “1” – VEHICLE DETECTORS
9. While the simulation is running, observe the actuations in the row with the label ACTIVE. ‘X’ mark in the row ACTIVE represents the actuation of the detector of the number above (first row DET# contains numbers assigned to detectors)

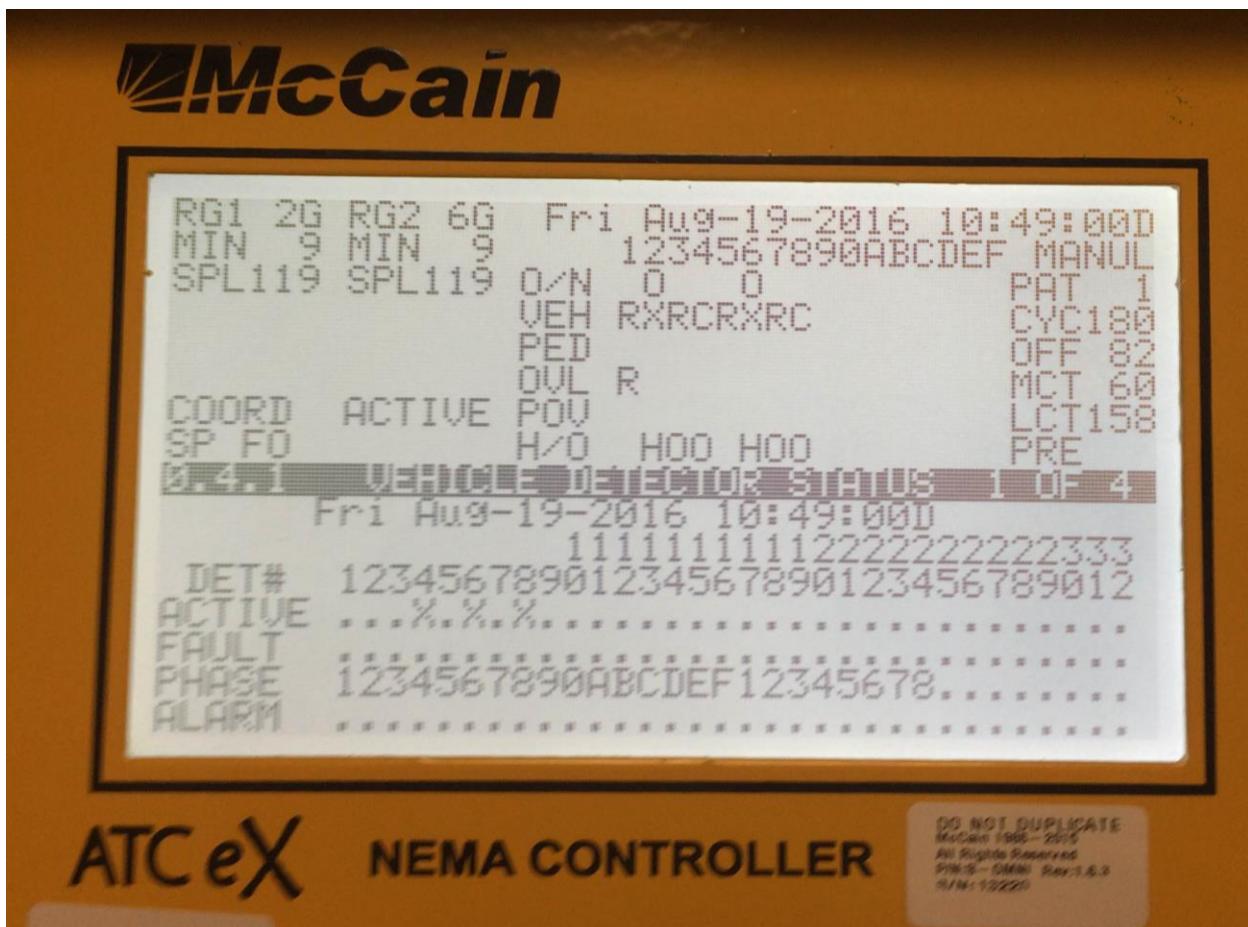


Figure 3-33. McCain detector status screen

3.4.6 Trafficware – Detectors Status Screen

To activate the screen needed for general check-up of the alarms and actuations mentioned in all three tests, one must execute the following steps:

1. Go back to the basic menu
 2. Press the button “MAIN MENU” twice – to enter the Main menu
 3. Press number “5” – Detectors
 4. Press “7” – Status
 5. Press “1” – VehDets 1-32 for accessing the display for the set of first 32 detectors (16 detectors in the files used for HILS testing)
 6. If the third row “Veh Alarm” contains only dash lines “-“ there are no active alarms for detectors
 7. While the simulation is running, observe the actuations in the rows with the labels Veh Field Call and Veh Call. “*” mark in that rows represents the actuation of the detector. Position of the mark “*” denotes which detector is active.

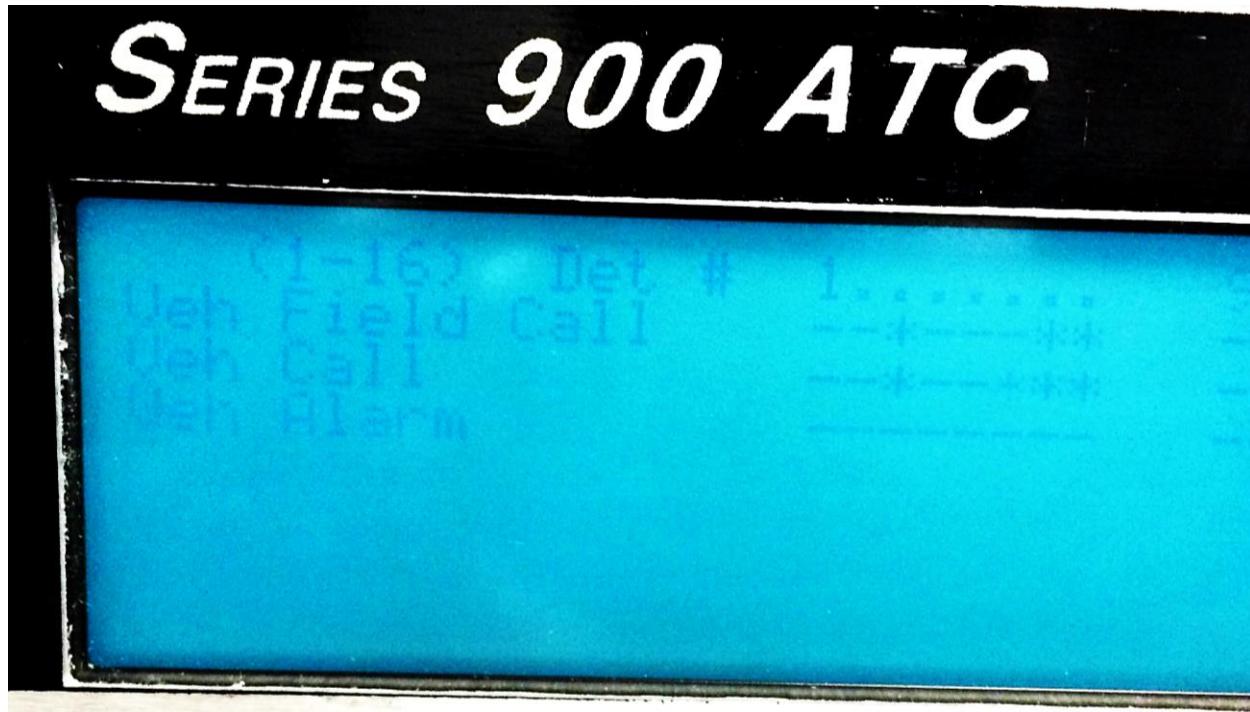


Figure 3-34. Trafficware detector status screen

3.4.7 PEEK – Detectors Status Screen

To activate the screen needed for general check-up of the alarms and actuations mentioned in all three tests, one must execute the following steps:

1. Press “HME” - to go to the Home menu
2. Press the button “MNU” – to enter the Main menu
3. Press number “1” – STATUS
4. Press “1” – CONTROLLER
5. Press “5” – DETECTORS
6. Press “1” – VEHICLE DETECTOR STATUS
7. The Vehicle Detectors Status screens show the current state of all 64 vehicle detector and 8 pedestrian detector inputs. It also shows if any detectors that have been placed into a “failed” state by the detection input diagnostics. An “X” under any detector number indicates that that detector is either active or has been judged to have failed.
8. The number at the top of each column indicates the detector channel number. Use the DWN key to see the status of detector inputs 33 through 64.
9. ACTIVE – An “X” means the controller is receiving a valid input on this Detector channel.
10. FAILED – An “X” means that a failed condition has been detected on this channel. This could mean that the detector has exceeded the time set for Max Presence (M), exceeded the set counts per minute (E), and/or there is negative Channel Status reporting (E, S, L, W or O).

11. ALARM – A letter code here indicates a Detector Diagnostics Failure which can be any of the following: exceeded the set counts per minute (E), exceeded the time set for Max Presence (M), exceeded set minute limit of no detector activity (N), or Negative Channel Status reporting from the Detector for one or more of the following conditions: O=Other (Report of an undefined error; the detector has an error code different than industry standard errors).
12. While the simulation is running, observe the actuations in the rows with the label ACTIVE and. ‘X’ mark in that rows represents the actuation of the detector. Position of the mark “X” denotes which detector is active.

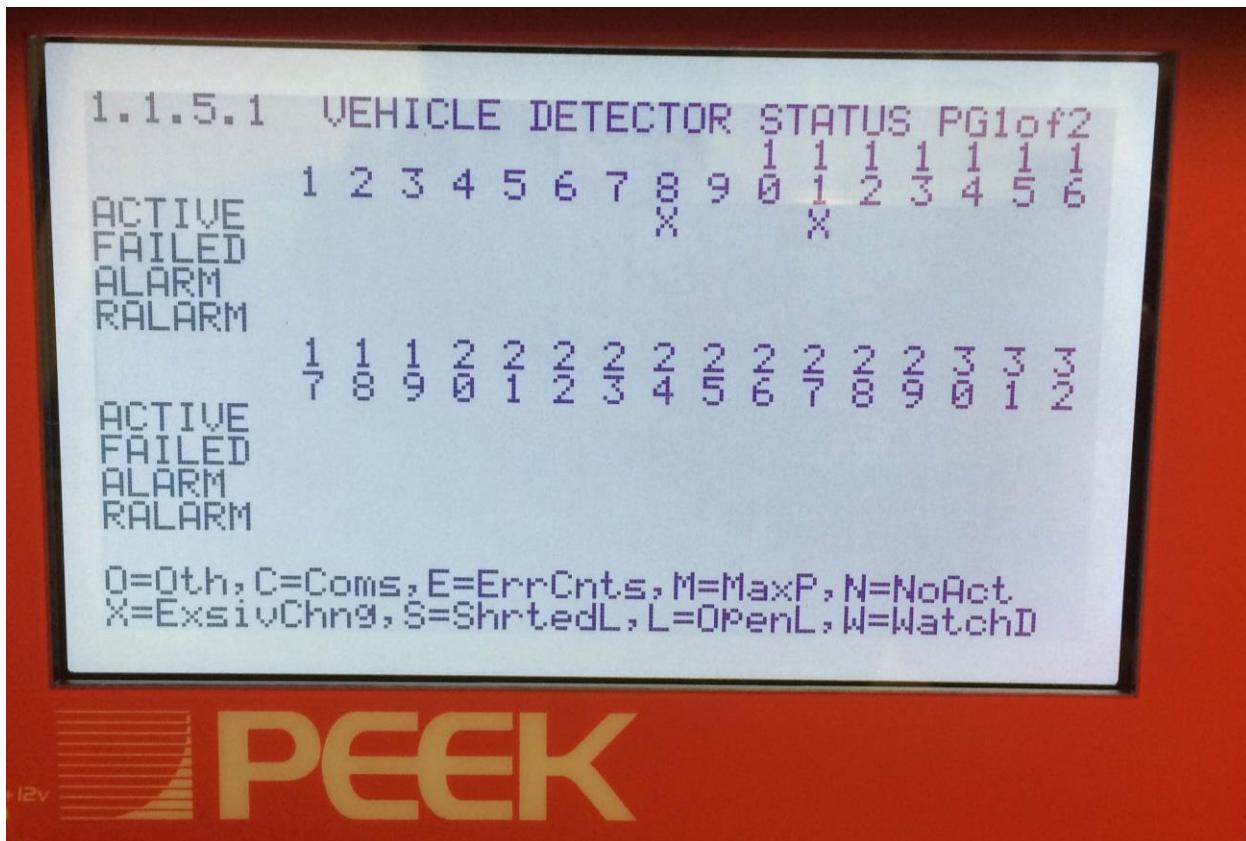


Figure 3-35. PEEK detector status screen

3.4.8 Econolite – Detectors Status Screen

To activate the screen needed for general check-up of the alarms and actuations mentioned in all three tests, one must execute the following steps:

1. Press the button with the symbol of a house - Go back to the basic menu
2. Select Event Logs in the Status Bar – second icon from the left in the Status Bar (EKG graph)
3. Press “Detector Events” on the right side – to view possible Detector alarms
4. Press Two Arrows icon right from the Event Logs in the Status Bar – Hardware

5. Press “Detector” on the left side – Status for detectors 1-64 (16 detectors in the files used for HILS testing)
6. While the simulation is running, observe the circular fields. “C” mark in that rows represents the actuation of the detector. Numbers of the detectors are given on the left.

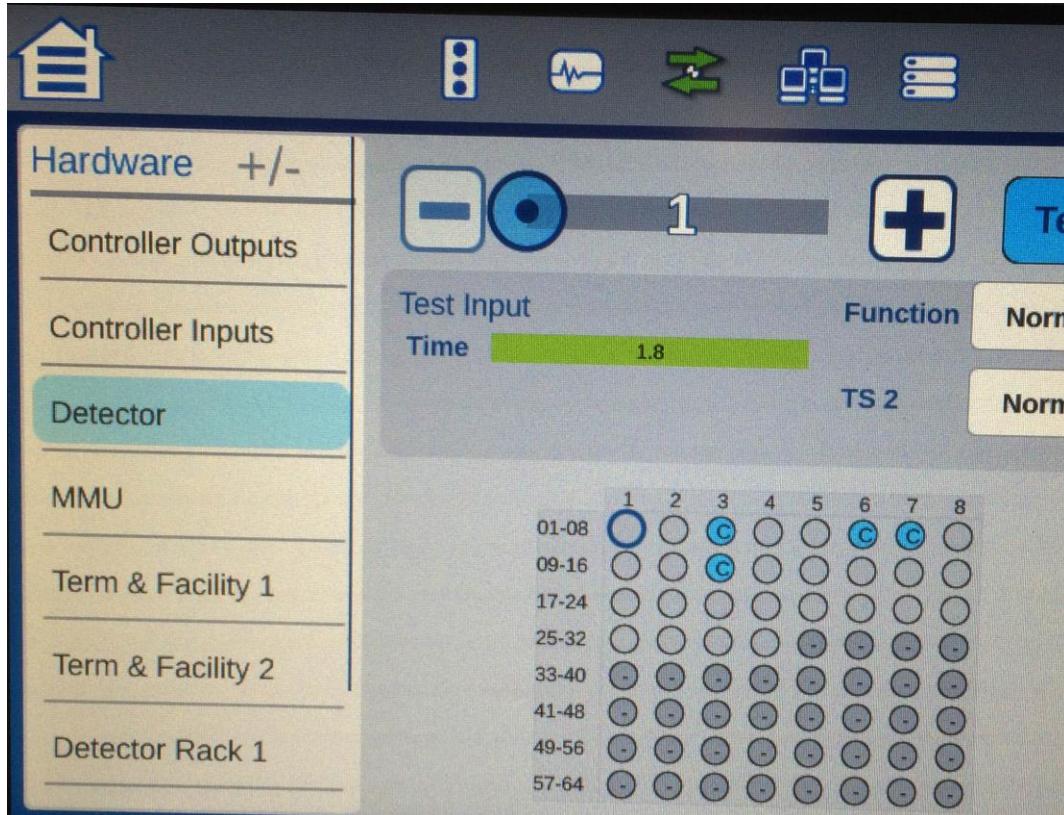


Figure 3-36. Econolite detector status screen

3.4.9 Siemens – Detectors Status Screen

To activate the screen needed for general check-up of the alarms and actuations mentioned in all three tests, one must execute the following steps:

1. Press the “esc” button - to go to the Main Menu
2. Press “1” – ACTIVE STATUS
3. Press ‘6’ – DETECTORS to enter the DETECTOR STATUS
4. The Detector Status display allows the user to view the current detector status as determined by the detector diagnostics. To view the status for Vehicle Detectors 17 and higher, press button “b”
5. The status codes used on the Detector Status display include the following:
 - Code 0 (ON LINE) - Denotes that the detector is operating within the parameters established for diagnostic faults.
 - Code 1 (MP) - Denotes that the detector failed the CU Maximum Presence diagnostic.

- Code 2 (NA) - Denotes that the detector failed the CU No Activity diagnostic.
 - Code 3 (EC) - Denotes that the detector failed the CU Erratic Counts diagnostic.
 - Code 4 (NS) - Denotes that the detector is assigned but: Detector Bus Interface Unit (BIU) is enabled and Port 1 hardware is not installed. BIU is enabled, Port 1 hardware is installed and Port 1 is disabled. BIU is not enabled and a hardware input is not available
 - Code 5 (BIU) - Denotes that a response frame fault occurred for the BIU.
 - Code 6 (LWD) - Denotes that the detector BIU channel status input for the detector is OFF. This may indicate: The detector is NOT a TS 2 detector, a detector failure occurred, a detector watchdog time-out occurred. Code 7 (LO). Denotes that the detector reported an open loop fault to the detector BIU.
 - Code 8 (LS) – Denotes that the detector reported a shorted loop fault to the detector BIU.
 - Code 9 (LC) – Denotes that the detector reported an excessive inductance change fault to the detector BIU.
6. If none of the faults is active, press “esc” to go one step back
 7. Press “7” – INTERSECTION to enter the dialog screen for monitoring the detector activations in real time
 8. While the simulation is running, observe the row “V CALL”. “C” mark in that rows represents the actuation of the detector.

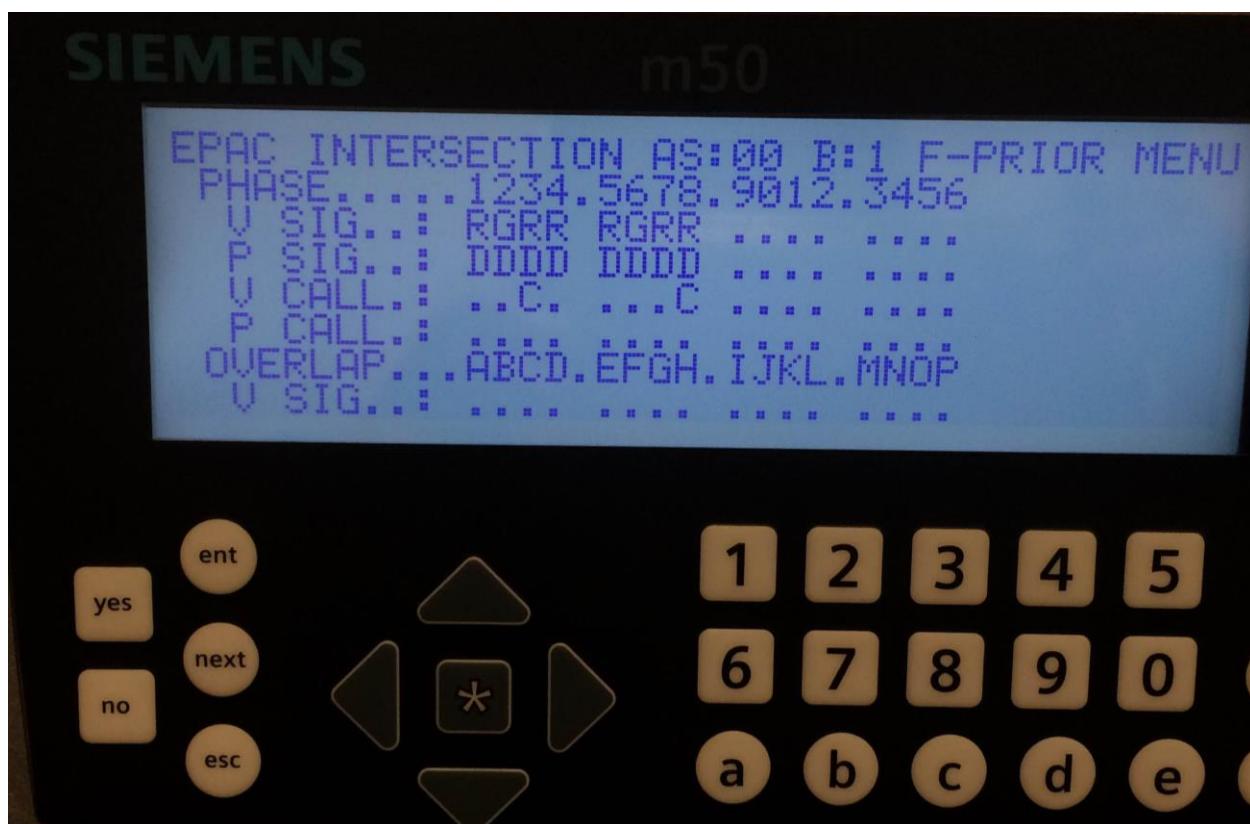


Figure 3-37. Siemens detector status screen

3.5 User Manual for HILS Setup and Retrieval of High Resolution Data

3.5.1 Software Interface (Virtual CID) Between the Controllers and the VISSIM

VirtualCID software needs to be installed on the computer before any configuration of VISSIM is done. After VirtualCID is installed, VISSIM needs to be adjusted to work with Trafficware CID. To configure VISSIM to communicate with signal controller, one needs to make changes of both VISSIM and VirtualCID files.

In VISSIM it is needed to set the controller Type to “External”. In order to do that:

1. Open Signal Control menu in VISSIM
2. Select Signal Controllers
3. Under Type select “External”

If all of the necessary detectors and signal heads, that will be used in the simulation runs, are already set up in VISSIM, it is time to create a CID file. The CID file is created in Notepad and it has to be placed in the same folder where the VISSIM input file (*.inpx) is located. Those VISSIM files can be found in the folder Virtual CID FDOT Networks. Choose the folder “1 intersection FDOT” for experiments with only one intersection or folder “6 Intersections FDOT” for the experiments with a (hypothetical) network of six intersections. The layout for CID files is shown in the Figure 3-38 below:

```
1  VISSIM setting [SC, SG, Phase]
2  1,1,1
3  1,2,2
4  1,3,3
5  1,4,4
6  1,5,5
7  1,6,6
8  1,7,7
9  1,8,8
10
11 Detector setting [Detector, SC, Phase]
12 1,1,9
13 2,1,15
14 3,1,12
15 4,1,14
16 5,1,13
17 6,1,10
18 7,1,11
19 8,1,16
20 9,1,2
21 10,1,6
22 11,1,4
23 12,1,8
24
25 Port setting [SC, Port] 3
26 1,6
27
28 Ethernet setting [SC, Port]
```

Figure 3-38. Virtual CID file example

4. Controller/Group/Phase Settings in VISSIM
 - a. **SC** - Signal controller (Intersection used in VISSIM to correspond to a controller)
 - b. **SG** - Signal Group in VISSIM
 - c. **Phase** - Phase used in the controller (Configured controller – Cobalt, Siemens, PEEK, McCain, Trafficware or Intelight)

5. Detector Settings in VISSIM

- a. **Detector** -

Count: 32	PortNo	Name	Lane	Pos	Length	SC	Type
1	1		5 - 3	89.873	3.000	1	Standard
2	2		5 - 2	90.498	3.000	1	Standard
3	3		2 - 3	154.856	3.000	1	Standard
4	4		2 - 2	157.049	3.000	1	Standard
5	5		7 - 3	85.303	3.000	1	Standard
6	6		7 - 2	85.535	3.000	1	Standard

Figure 3-39. Detector number assigned to a phase of the same number

- b. **SC** - Signal controller (Intersection used in VISSIM to correspond to a controller)
- c. **Phase** - Phase used in controller (Configured controller – Cobalt, Siemens, PEEK, McCain, Trafficware or Intelight)

6. Port Settings in VISSIM

- a. **SC** - Signal controller (Intersection used in VISSIM to correspond to a controller)
- b. **Port** - Communication port (Serial port RS232) on computer that is connected to a controller over Trafficware CID.

Each controller is connected with the computer by using a separate serial port. To find out which serial port is used for which controller, a user needs to connect Naztec TS2 Test Box software and test each port by changing its number in testbox configuration file (“testbox.ini”).

In order to accomplish this open a testbox.ini file in Notepad and change the number of port in the second row (shown in Figure 3-40 below). Disregard what is written in the first line, (e.g. numbers of ports can take values higher than 8, this would just need to be set up when the port numbers are assigned). The numbers of assigned ports can be found in Control Panel/Device Manager under the Ports (COM & LPT) drop down menu. Numbers at the end of the USB Serial Port names will be used for input into testbox.ini configuration file.

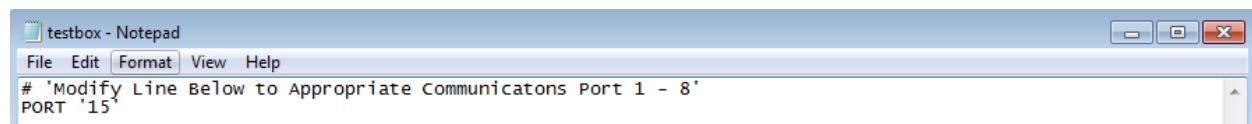


Figure 3-40. Testbox configuration file

If the CID's RS232 and SDLC indicators (on the Naztec TS2 Test Box) connected to the selected controller, are flashing, the connection has been established. Every time a person wants to connect to a different controller, he/she needs to change the port number and use the number

which is assigned to that particular controller. The changes need to be made in the Testbox.ini file (shown in Figure 3-40, row 2), but also in the Virtual CID file (the .txt document in the same folder where VISSIM input file is stored), Figure 3-38, row 26, the second digit.

3.5.2 Checking the Connection with the Controller(s) – Test Box TS2

After establishing physical connection between the Trafficware CID and controller on one side and a computer on the other side, a user can run communications between controller and Trafficware CID. This is done by selecting the Communication tab, and choosing “TS2” under the option Connect. If the communication works properly, green lights (RX & TX) will start flashing on the front panel of the Trafficware CID hardware box, indicating that the communication is established both through SDLC and RS 232 cables. In addition to the lights on the hardware box, the Trafficware TS2 Test Box software will also show red, yellow and green lights to acknowledge proper communications. After verifying that the communication between CID and controller and computer works properly, the Trafficware TS2 Test Box software (C:/Naztec TS2 Test Box) needs to be closed in order to enable the Virtual CID software to establish a new connection between CID and controller and computer/VISSIM software.

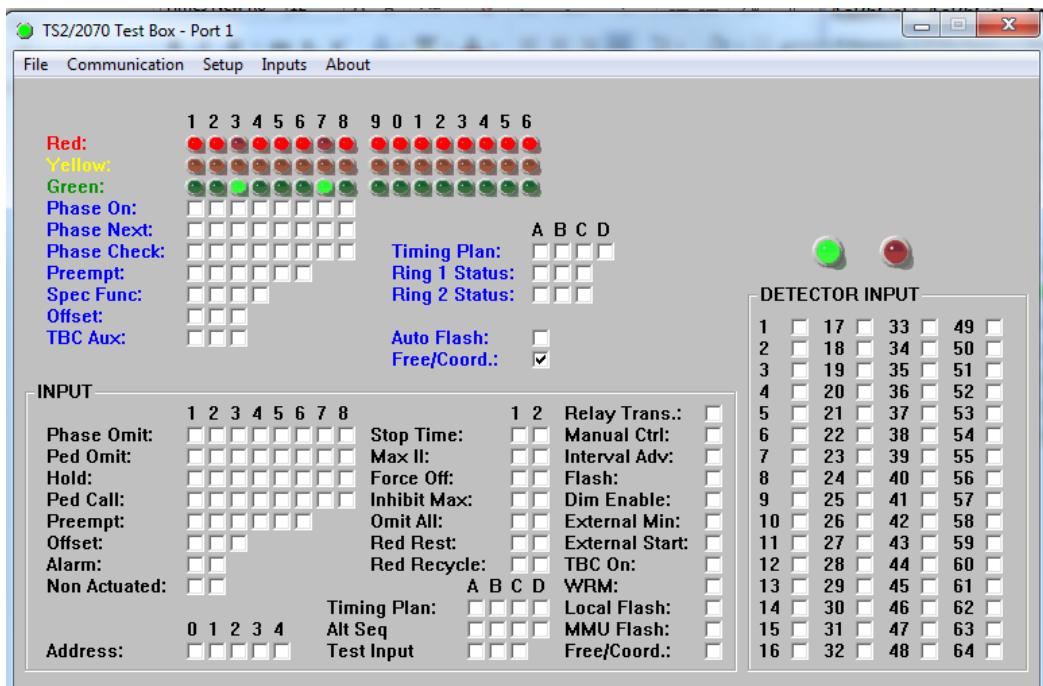


Figure 3-41. Trafficware TS2 Test Box software

3.5.3 Starting Up HILS

When both VISSIM file and CID file are configured, a user should open the “Virtual CID” application (shown in Figure 3-42) on the Desktop with a double click or a right click and selecting an option “Run as administrator”.

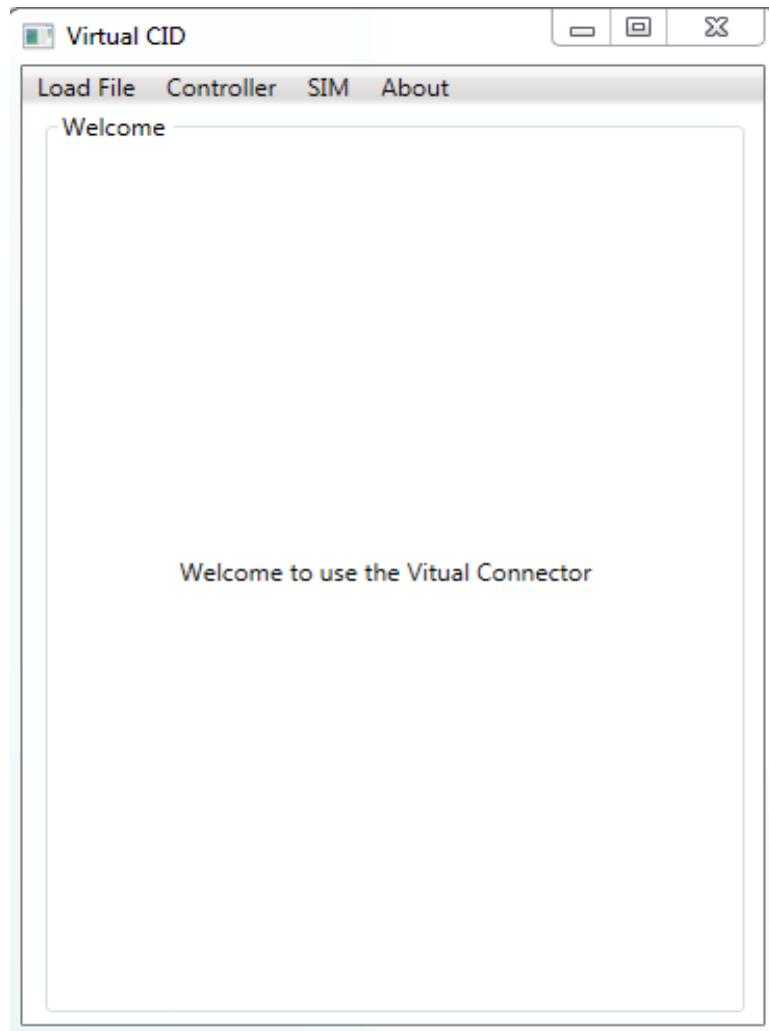


Figure 3-42. Virtual CID interface

After Virtual CID application is open:

6. Select “Load file” from VirtualCID tab menu, then select “VISSIM” to open a network (shown in Figure 3-43).

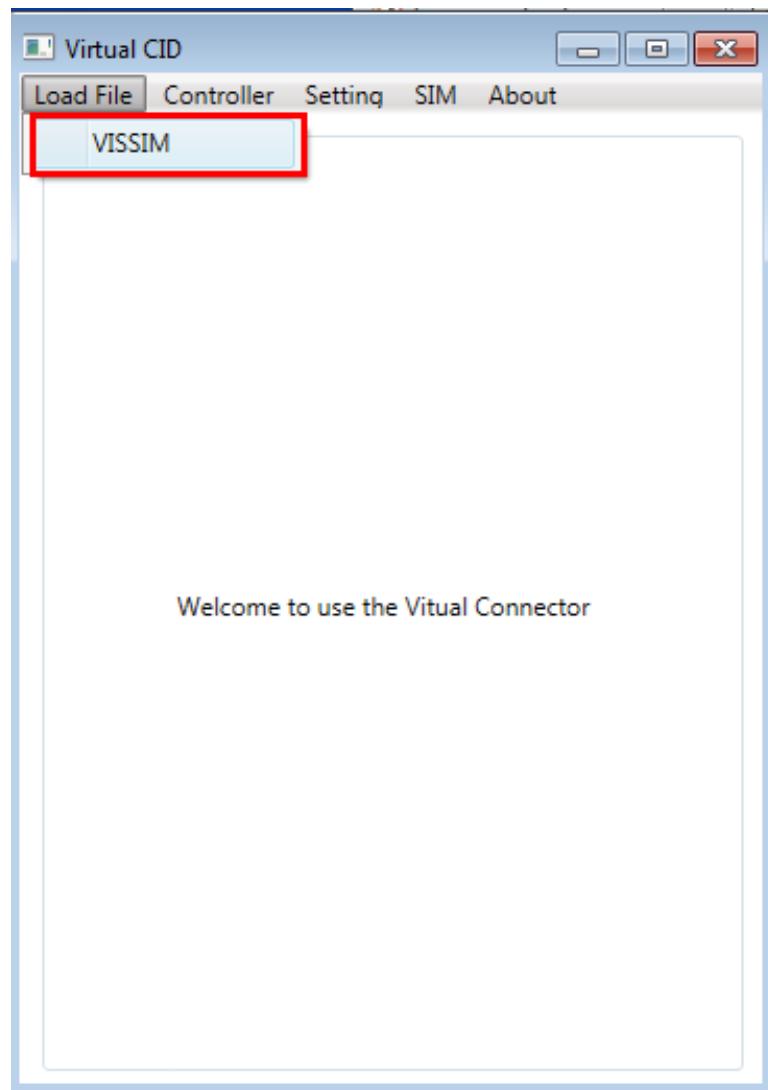


Figure 3-43. Virtual CID “Load file” menu

7. Select multiple appropriate files for a network that you want to test. One needs to select a *.txt containing Virtual CID configuration, an *.inx file (VISSIM’s input file) and *.layx file (VISSIM’s file with extension .layx). Then click on “Open” (see Figure 3-44).

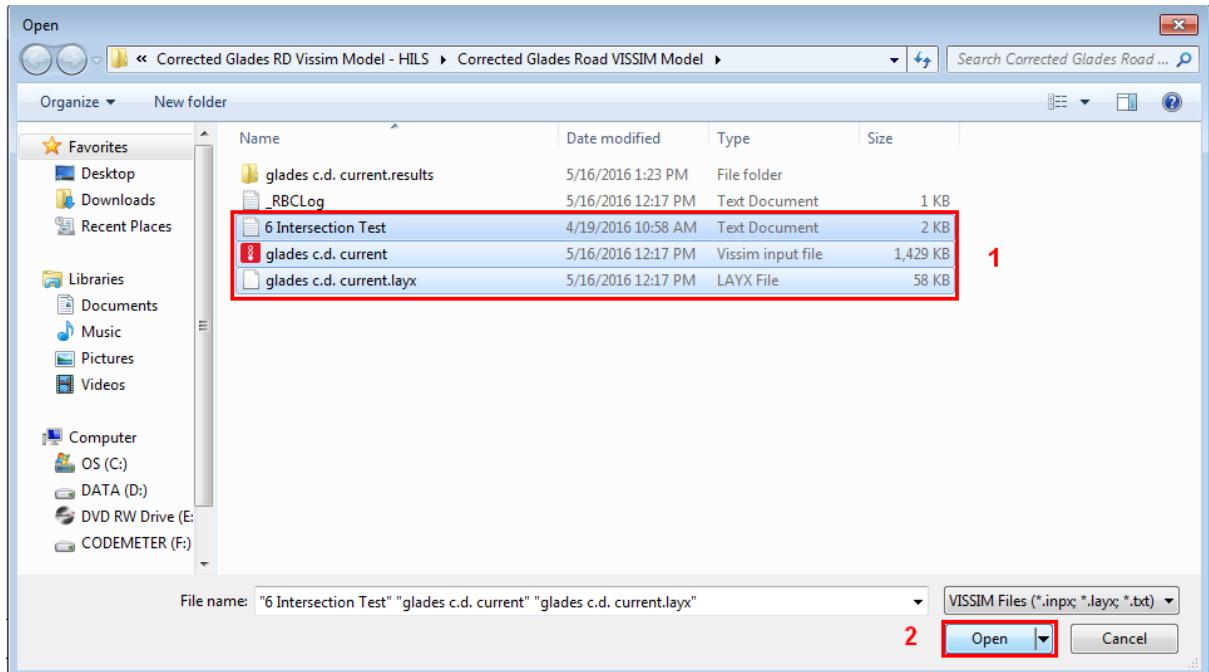


Figure 3-44. Multiple CID file selection

8. Go back to the VirtualCID application and click on the “Controller” tab, then select “Naztec Test Box” (shown in Figure 3-45).

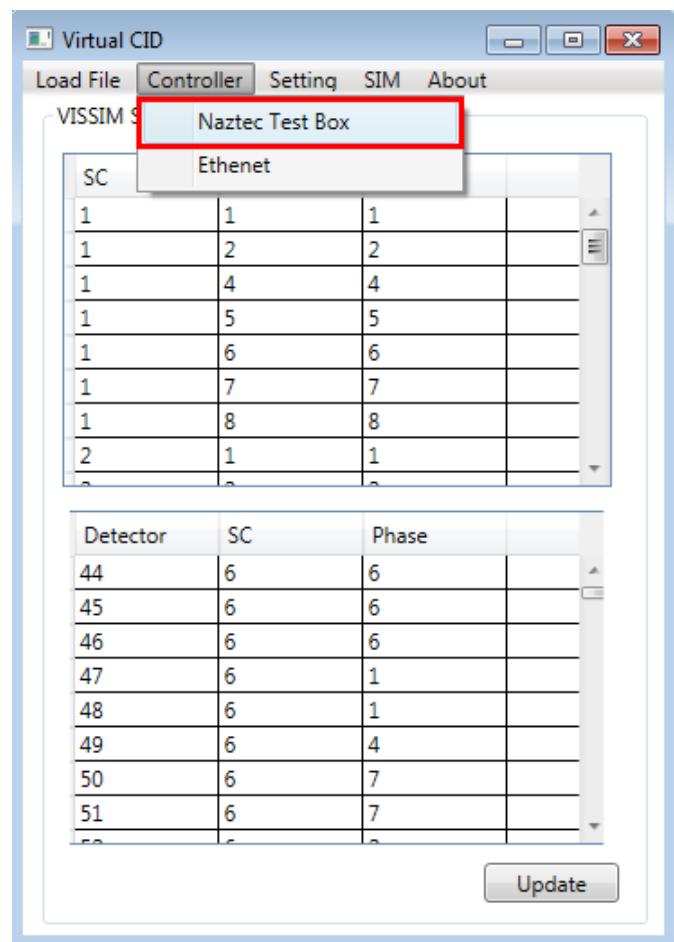


Figure 3-45. Virtual CID “Controller” menu

9. Click on the button “Open” (shown in Figure 3-46)

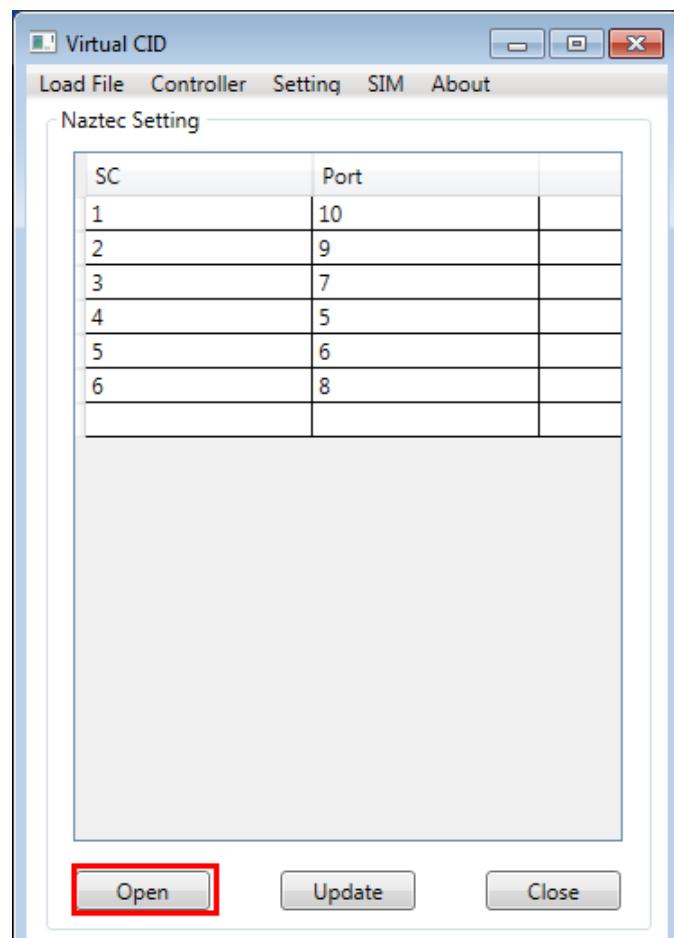


Figure 3-46. Virtual CID “Controller” menu

10. Select tab “SIM” from VirtualCID tab menu, then select “Start” to start the simulation (shown in Figure 3-47).

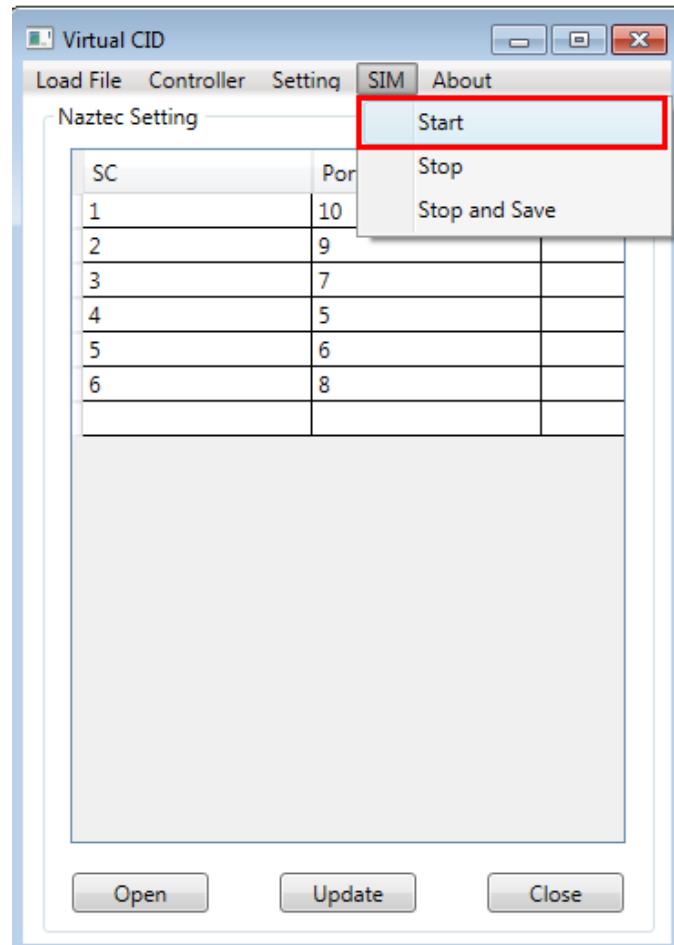


Figure 3-47. Virtual CID “SIM” menu

In order to proceed with the next steps, all of the controllers need to be configured and set up for download of the logged data. Detailed explanations on how to set up six controllers from the TERL approved-controller list can be found in the document “Manual for testing and verifying retrieval of Signal Performance Measures” (delivered to TERL).

3.5.4 Run FTP/SCP Decode and Import for Controllers

To run the software for FTP and Decode & Import controllers:

1. Go to the computer Desktop of the FDOT server and find a folder named “FTP_DECODE_IMPORT_SOFTWARE”.
2. Open the folder and double click on “RunDecodeAndImport.exe” to run the application.

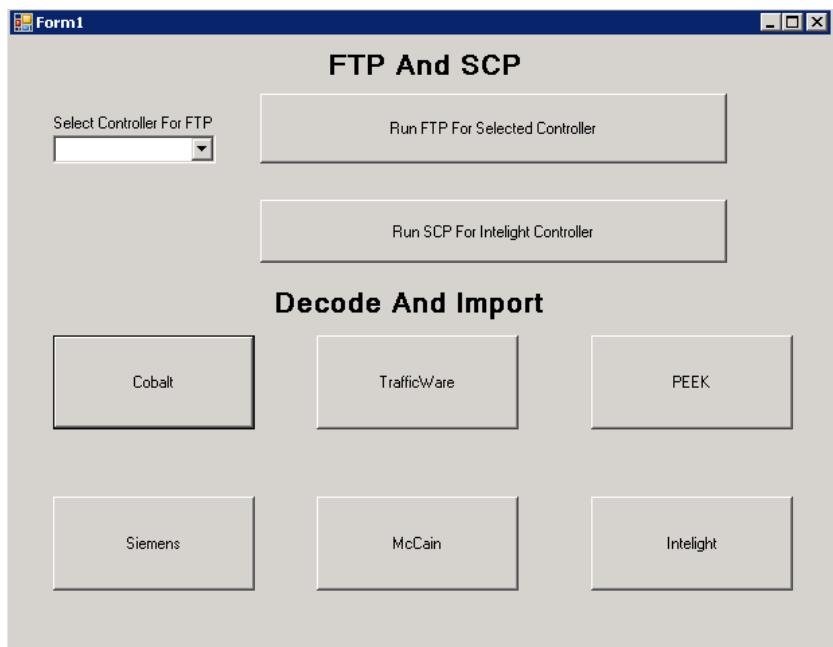


Figure 3-48. FTP and SCP high resolution data download

3. Select the drop down menu to select a particular controller or select “All” to run FTP processes for all of the controllers.
4. After selecting desired controller(s), click “Run FTP For Selected Controller” button to start FTP transfer of data files from the controller(s) to the server.
5. For Intelight controller click “Run SCP For Intelight Controller”.

Once the FTP process is finished, all of the high-resolution logs are copied in directory “C:\temp\ControllerLogs\Logs” within a subfolder which is named after the controller ID (e.g. 3000). Each controller will have a unique ID, which is specified in the controller configuration step within Signal Performance Measure (SPM) configuration tool. After the FTP process is finished one should check the files in this directory to ensure that the FTP transfer was successful. If FTP transfer results in no files (or the files are very old; a rare outcome but possible) one should check the communication between server and controller by pinging the controller manually from the Command prompt window.

6. Decode and Import of Logged Data: Click on the button with a controller name to decode controller’s logged data and import them into the SQL ASPMS database on the FDOT server.

Once the data are decoded and imported to the ASPMS database they can be used to produce High-Resolution Performance Measures on the FDOT Signal Performance Metrics website (<http://192.168.8.85/SignalPerformanceMetrics/>). Currently, not all of the performance measures (provided by the latest update from UDOT) can be accessed because VISSIM simulations and/or controllers have not been configured to store all of the pedestrian, preemption and similar events. However, such performance measures will be retrievable once those events are simulated in VISSIM and transferred to the controllers’ logs. Basic performance measures, such as those presented by Purdue Coordination Diagrams etc., are always accessible because they use logs of

the basic signal operations events such as beginning of phases, end of phases, detector actuations, etc. All of the available Performance metrics graphs are shown in the Appendix C of the “Manual for testing and verifying retrieval of Signal Performance Measures”.

3.5.5 Configuration of the SPM Tool

SPM tool is used to configure detector data, IP address of the controller, signal ID and all the other data that are used for creating signal performance measures/graphs. SPM configuration needs to be done after the controller is installed and configured, which means that all the information necessary for SPM configuration must be known: detectors need to be configured as advanced, presence or stop bar detectors (with defined distance from the stop bars), phases need to be set up, etc. After all the controller data are available one can start configuring each intersection in the SPM tool. To configure an intersection (controller) in the SPM tool (Figure 3-49):

1. Open “SPMConfigurator” application

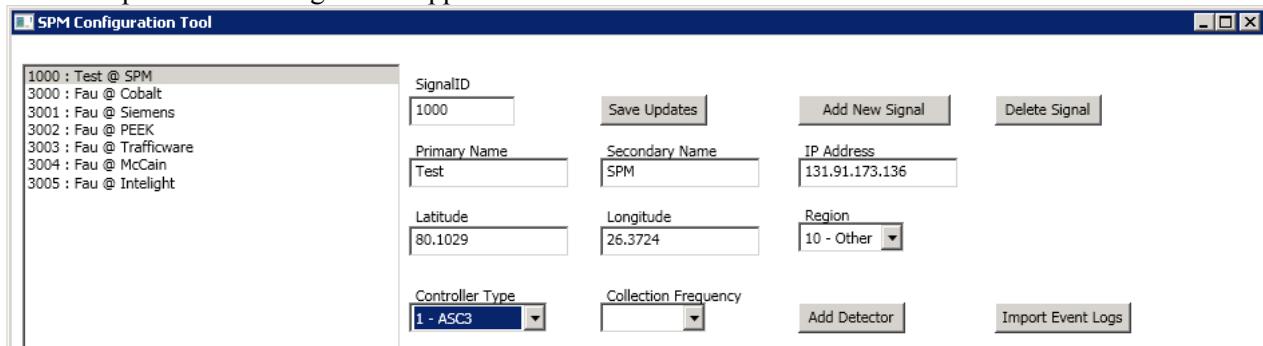


Figure 3-49. SPM Configurator Tool interface

2. Press “Add New Signal” button

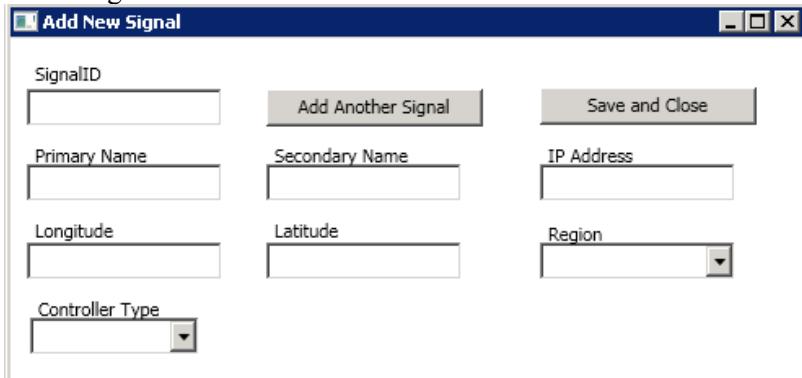


Figure 3-50. Add New Signal interface

3. Input Signal ID (number), Primary Name and Secondary Name (intersection name), IP Address (IP address of the controller), Longitude and Latitude (intersection coordinates), Region (where the intersection is located) and Controller Type (controller – Cobalt, Siemens m50, etc.)
4. Press “Save and Close” button

Once these four steps are done a new controller is configured in the SPM tool and it should be able to report various signal performance measures. If this is not the case, it should be checked that detectors are configured properly in the controllers to support development of the Purdue Coordination Diagrams. In order to configure detectors in the controller one needs to follow instructions in the “Manual for testing and Verifying retrieval of Signal Performance Measures”, which is already delivered to TERL.

3.6 Validation of Operations and Training in HILS Testing System

After the installation of the HILS testing system with all the components of hardware and software necessary for successful testing, the FAU research team held the presentation and the first training for the FDOT staff. Training and the validation of operations of HILS system are continued after the initial installation. The FAU research team has already organized few online meetings with the FDOT TERL staff in order to help the FDOT staff to go through all steps of the procedure for HILS setup and high-resolution data retrieval. All the issues that appear during that process are being addressed and the help is provided to the FDOT staff. Several more online meetings are planned until the entire procedure is completed successfully.

4 Definitions of Measures of Effectiveness Based on High-Resolution Controller

Many options for collecting data and interpreting the set of new performance measures became possible with the introduction of high-resolution data logging capabilities into modern traffic signal controllers. The benefits that this new feature can offer are highly valuable, so researchers, practitioners, consultants and employees in public agencies can use it to improve the current state of practice. Therefore, the companies that build traffic signal controllers, depending on the characteristics of their traffic signal controller devices, integrated high-resolution data logging into some of their devices.

Chapter 2 explains the existing signal performance measures already available in FDOT ASPMS software. The following chapter presents the review of previous work conducted in this field. Then, some additional performance measures and the modifications of the existing, together with the necessary changes in the ASPMS software are presented in the Chapters 4 and 5.

Readiness for statewide implementation is elaborated in the Chapter 6, and the report is concluded with a calibrated and validated VISSIM model. Corridor location, geometry and signal timings are given together with the detailed instructions how to setup each controller for creating Purdue Coordination Diagrams, to connect each of them with VISSIM by using controller interface devices and how to manually setup the coordination in the controllers.

4.1 Existing Signal Performance Measures Available Through FDOT ASPMS Software

Currently it is possible to select among 12 performance measures in the FDOT ASPMS software. Those performance measures can have various uses

Approach Delay

Displays the delay by showing the time between activations of a detector during the red and when the phase turns green for the coordinated movements. This performance measure does not include start-up delay, deceleration or queue lengths that surpass the detectors position. This performance measure is useful delay per vehicle and delay per hour for each coordinated approach. The values for approach volumes can be used for identification of the directional splits and for determining what is the most appropriate time to close certain lanes for performing the construction or maintenance.

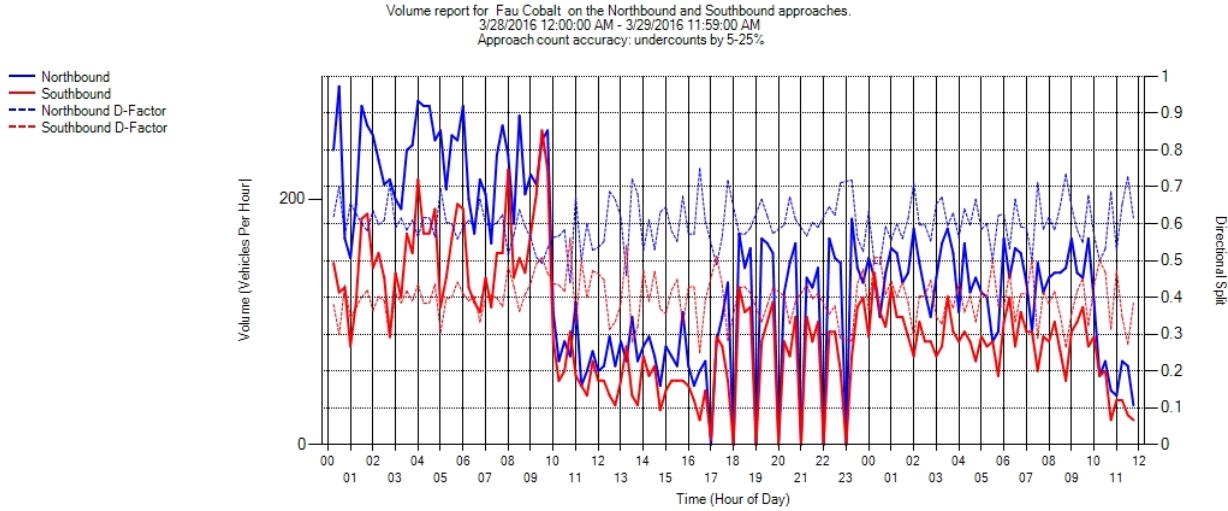


Figure 4-1. Approach volume

Approach Volume

Counts of the approaching vehicles obtained by detectors placed 350 ft to 400 ft. The detectors' location before the beginning of the turning lanes makes turning movements counting unavailable. The measured values of the volume per approach tends to be under the real values under heavy traffic and in case when approaches have multiple lanes.

Metric	Value
Total Volume	8,397
Peak Hour	4:00 AM - 5:00 AM
Peak Hour Volume	458
PHF	0.923
Peak-Hour K-factor	NA
Northbound Total Volume	5,036
Northbound Peak Hour	4:00 AM - 5:00 AM
Northbound Peak Hour Volume	270
Northbound PHF	0.964
Northbound Peak-Hour K-factor	NA
Northbound Peak-Hour D-factor	0.696
Southbound Total Volume	3,361
Southbound Peak Hour	9:00 AM - 10:00 AM
Southbound Peak Hour Volume	214
Southbound PHF	1
Southbound Peak-Hour K-factor	NA
Southbound Peak-Hour D-factor	1.09

Metric	Value
Total Volume	10,251
Peak Hour	1:30 AM - 2:30 AM
Peak Hour Volume	534
PHF	0.829
Peak-Hour K-factor	NA
Westbound Total Volume	7,745
Westbound Peak Hour	1:30 AM - 2:30 AM
Westbound Peak Hour Volume	408
Westbound PHF	0.879
Westbound Peak-Hour K-factor	NA
Westbound Peak-Hour D-factor	0.309
Eastbound Total Volume	2,506
Eastbound Peak Hour	3:45 AM - 4:45 AM
Eastbound Peak Hour Volume	130
Eastbound PHF	1
Eastbound Peak-Hour K-factor	NA
Eastbound Peak-Hour D-factor	2.86

Figure 4-2. Approach volume (tabular)

Arrivals on Red

This performance measure shows the percent of vehicles that arrived during the red signal and the percentage of red time for each coordination pattern. On the graph, Y-axis is displaying the volume in vehicles per hour, and the secondary Y-axis shows the percent of vehicles that arrive on red. This metrics can help in isolating areas where the progression is not good enough.

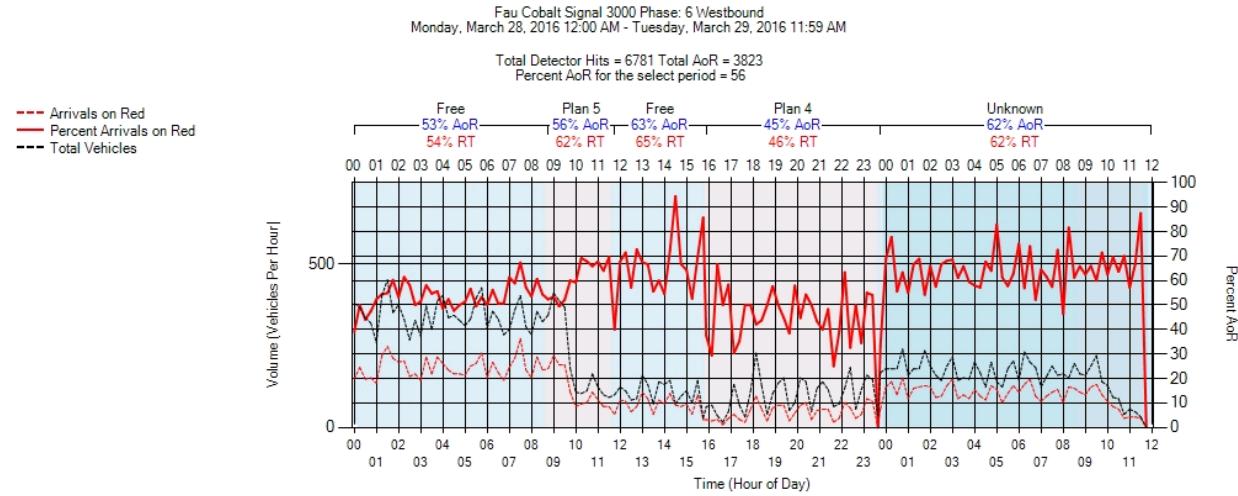


Figure 4-3. Arrivals on red

Purdue Coordination Diagram (PCD)

PCD is a diagram used to visualize the relation between the signal indications of the coordinated phases and vehicle arrivals on cycle-by-cycle basis. For understanding the PCD it is necessary to explain how the PCD is supposed to be read. Between the green and yellow lines, the phase is green. Between the yellow and red lines, the phase is yellow, and below the green line the phase is red. The long vertical red lines during the night hours when the main street is sitting in green while side streets and left turns are being omitted. The short vertical red lines show skipping of the side street, left turns or a late start of green for either of them.

Also few measures are included in the PCD diagram created by the ASPMS tool. Brief explanation for each of them is provided below.

Arrivals on Green (AoG) – Shows the percent of vehicles arrived during the green signal duration on the subject approach.

Green Time (GT) – the percent of green split time for the phase.

Platoon Ratio (PR) – numerical value that quantifies the quality of progression on an approach. In fact, it is the ratio of the number of vehicles arriving during the green phase to the proportion of the green interval of the total cycle.

$$PR = \frac{C}{g_i} \times AoG = \frac{AoG}{GT} \quad (I)$$

HCM 2000 defines six types of arrival types based on the platoon ratio. Those types are given in the Table 4-1 below:

Table 4-1. Arrival types based on platoon ratio

Arrival Type	Range of Platoon Ratio	Default Value of PR	Progression Quality
1	$PR \leq 0.50$	0.333	Very poor
2	$0.50 < PR \leq 0.85$	0.667	Unfavorable
3	$0.85 < PR \leq 1.15$	1.000	Random arrivals
4	$1.15 < PR \leq 1.50$	1.333	Favorable
5	$1.50 < PR \leq 2.00$	1.667	Highly favorable
6	$PR > 2.00$	2.000	Exceptional

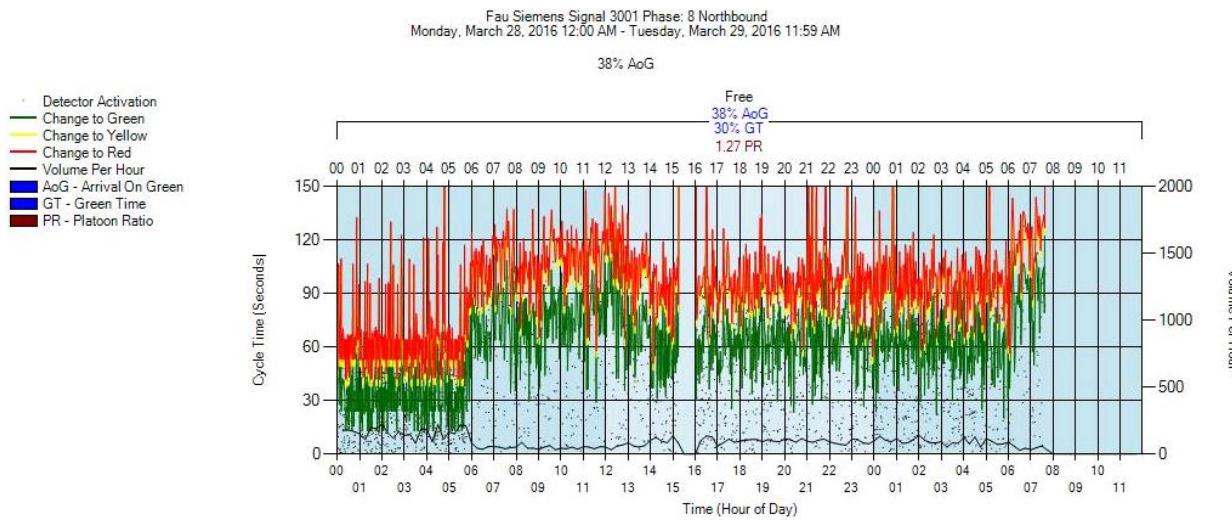


Figure 4-4. Purdue coordination diagram

Purdue Split Failure

A split failure is defined as termination of phase with a v/c ratio greater than 1.0, or in other words terminating the green indication before all demand is serviced.

Pedestrian Delay

This measure represents time from a received pedestrian call to the start of the walk indication. It uses controller high-resolution data to check when a pedestrian actuation event happens. Pedestrian pushbuttons are not directly connected with ASPMS tool.

Preemption Details

This measure shows the preemption activations using controller high-resolution data. No detectors are directly connected to ASPMS tool. The detectors are used just to trigger the preemption activity in the controller and the adequate event number is logged.

Purdue Phase Termination

These charts show how each phase is terminated when going from green to red indication. The metrics will show if a gap-out, max-out, force-off or skip were the actual types of phase termination. Gap-out indicates that not all programmed time is used by the subject phase. Max-out and force-off both indicate that all programmed time was used, however force-off occurs during the coordination while max-out occurs during the free operations. A skip means that the phase was not activated. This performance measure helps to isolate the movements where split times need to be adjusted. Additionally, this measure can help in identifying the issues with the detectors (faulty detector cause constant max-outs for a certain phase).

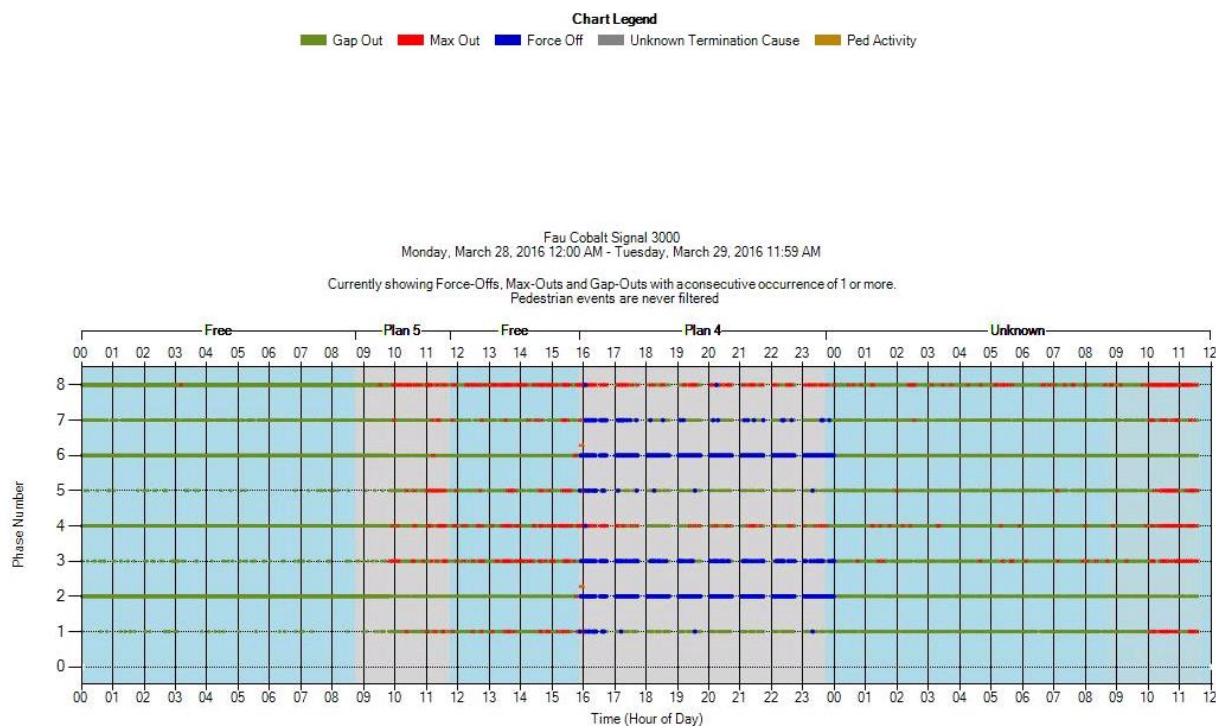


Figure 4-5. Purdue phase termination

Speed

The speeds are captured using the 10-foot wide Wavetronics radar detector placed 350 feet to 400 feet upstream of the intersection, then they are recorded and time-stamped. First 15 seconds (or different time period is defined by user) after the initial green indication is not taken into account due to the unrepresentative speeds at the beginning of green. The goal is to collect free flow speed which are not affected by traffic signal timing, and therefore the initial period is excluded. This performance measure is useful for modelling of coordination or special event plans, to set yellow and all red durations, and also to identify when the speed is degraded to the level when a retiming is necessary.

Split Monitor

This metrics shows the durations of green, yellow and red indications for various phases on the intersection. The green color represents gap-outs, red color max-outs, blue is for force-offs and

yellow show pedestrian activations. This metrics is helpful in determining the amount of time each phase uses.

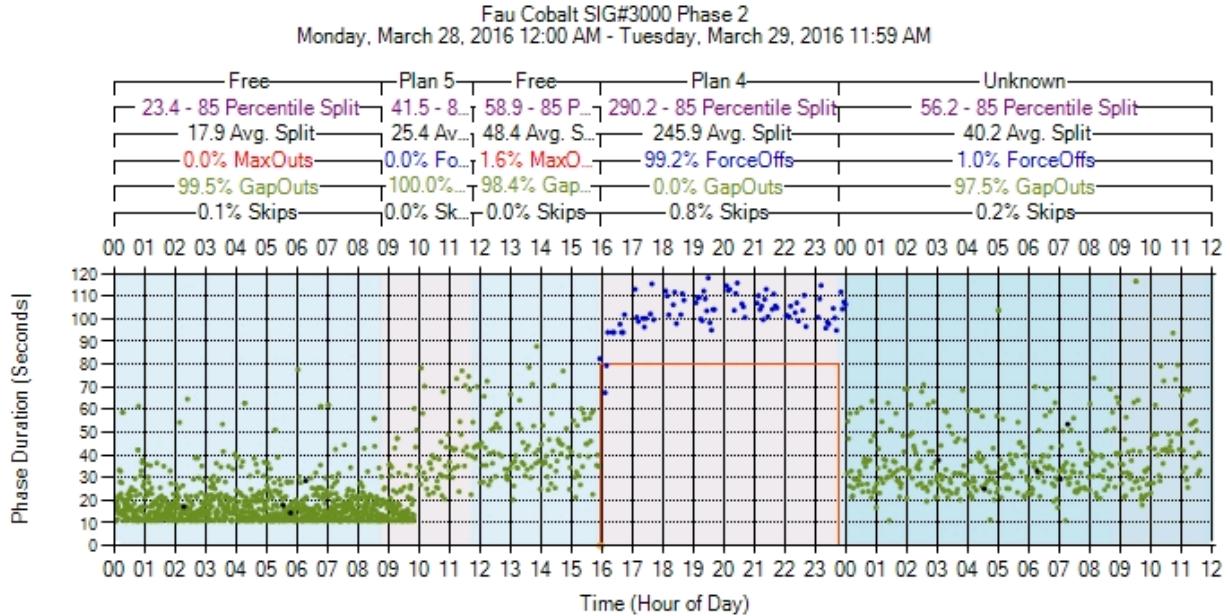


Figure 4-6. Split monitor

Turning Movement Counts

This measure displays lane-by-lane volume per hour and total volume for each movement. Also total volume, peak hour volume, peak hour factor and lane utilization factor are potential outputs for this metrics. Lane-by-lane counts are necessary for this metrics.

Yellow and Red Actuations

Displays the events when vehicles crossed the intersection during the yellow or red indication for the phase serving their movement. Like in the case of Turning Movement Counts, for this measure Lane-by-lane count detection is necessary. For this and the previous measure, the detectors after the stop bar need to be added.

4.2 Literature Review of Previous Work

Real traffic signal control hardware is replacing the software control component of the simulation platform and enhances the advantages of the hardware-in-the-loop traffic simulation compared to software-only traffic simulation (Engelbrecht, 1999). A real time bus priority algorithm was evaluated and tested during the development. System performed well, also providing the researchers to identify problems that were not available during the design of the algorithm. Hardware-in-the-loop simulation (HILS) would be beneficial to organizations, universities, and all organizations who provide traffic solutions and design.

Analyze the application of hardware-in-the-loop simulation at diamond interchange is research goal. Study showed that accuracy of traffic operations is improved using hardware-in the-loop simulation by removing the inherent differences between emulated controllers and the actual hardware (Koonce, 1999). PASSER III-98, CORSIM simulation platform, and hardware-in-the-loop simulation is used to evaluate traffic operations on diamond interchange. Three procedures for interchange analysis was conducted and comparison of simulation and field result was presented, showing that hardware-in-the loop simulation accurately estimated interchange performance.

Extensive public and private sector efforts have been underway to try to develop traffic responsive and adaptive control procedures (Bullock, 2000). SCATS (Sydney Coordinated Adaptive Traffic System) and SCOOT (Split Cycle Offset Optimization Technique) are systems that are internationally implemented. Vehicle detection setup is according to prescribed logic to optimize Measure of Efficiency (MOEs). Even though computer power has reached a point where network simulations can be performed on entire network, there is still no application that will allow quantitative evaluation of the system performance so that system parameters can be changed before field implementation. Bullock (2000) shows development of hardware-in-the-loop simulation procedures, while presenting the possibilities that this type of equipment can be used to help traffic engineering professionals. Controller Interface Devices (CID) allow hardware-in-the-loop simulation to be feasible. Some of the features of hardware-in-the-loop simulation are:

- Field equipment can be evaluated so that even before implementing in the field we know is the equipment functional.
- Some of traditional simulation models do not have MOEs, but MOEs provided with hardware-in-the-loop simulation can be used to evaluate adaptive signal control performance.
- Experiments can be performed in laboratory which means that testing in live traffic conditions can be avoided.
- Training of the traffic engineers can be done through hardware-in-the-loop simulation so that engineers can have experience even before working in real life conditions.
- Hardware-in-the-loop simulation can help technician to resolve the issue with the equipment.

Complex problems can be studied with digital computer simulations, especially when complexity of the problem is large. Simulation is the best option to test operation and configuration of the system before field implementation (Wells, 2001). Generic models can be used to represent

controller simulations that can produce significant differences when compared with field results. Hardware-in-the-loop simulations provide real-time communication between traffic controllers and simulation, receiving the inputs from simulation, making decisions based on the inputs and sending commands to activate device models in simulation. Wells presented an overview of the hardware-in-the-loop simulation as well as software constraints for real-time hardware-in-the-loop simulation. The importance of real-time hardware-in-the-loop simulation is that this system allows traffic signal controller to interact with the computer simulation giving the opportunity to improve the accuracy of simulations.

HILS consist from three modules: (1) detector emulation module, (2) internal controller emulation module, and (3) micro-simulation module. Lee (2001) develop a microscopic simulation model to evaluate proposed model, link by link with NETSIM. Conclusion was that proposed model appropriately simulate traffic flows of the test network. Based on the detector data, signal timings, cycle lengths and turning movement green times are procured.

Advanced features of traffic control signals are not present in macroscopic and microscopic simulation packages which brought the need for developing cost effective procedure to evaluate traffic signal control equipment (Bullock, 2004). Bullock (2004) presents motivation for using hardware-in-the-loop simulation. Traffic engineers will have the possibility to test traffic signal equipment in real time in laboratory, as opposed to testing the traffic signal controller or adaptive controller algorithms on the street. The main goal is to extend the state of the practice, improve fundamental technologies for implementing HILS systems and test real-time errors in the simulation model. The framework and future practice can be concluded based on Bullock (2004) study. Hardware-in-the-loop simulation applications references and development of standardized Controller Interface Devices will be introduced. The issue could be the intellectual property and real-time software and hardware engineering that are developed and used by different controller vendors.

Nontraditional technologies as well as adaptive signal control are implemented in an effort to reduce congestion, vehicle delays, and reduce signal-retiming cost. Hunter (2010) conducted the comparison of adaptive signal control implementation and optimized time-of-day (TOD) controls. Based on the implementation of adaptive signal control on an 11-intersection section of Cobb Parkway in Cobb County, Georgia. Hunter (2010) showed different behavior than the adaptive signal control system installed in the field during the AM period. Overall, findings for the tested adaptive system showed faster responsiveness to changes in traffic demand. Adaptive system and TOD controls had similar results when looking on peak period of traffic demand, while adaptive system showed better adaptability to off-peak traffic demand periods.

Day (2010) discussed two tools for assisting engineer in obtaining arterial offsets. First tool is Purdue Coordination Diagram (PCD) and second is arterial travel time measurement by vehicle reidentification via address matching by Bluetooth media access control (Day, 2010). Evaluation of tools is based on obtaining offsets for before-and-after comparison of an offset tuning. Over the PCDs changes after the implementation were used to evaluate impact on arterial. Prediction was that improvements will be from 52% of Percent On Green (POG) to 62% while actual was 64% - 65%. Travel time improved 30% on NB while SB were not affected by offset changes.

Microscopic and macroscopic simulations are important for evaluating and analyzing new traffic signal methods. Methods for configuring traffic signals are different because of vendor privacy and algorithms, thus it is hard to use software simulations to perform evaluations. The hardware-

in-the-loop simulation platform is used to perform microscopic simulations to efficiently evaluate performance of various signal controllers. Also, compatibility issue with different controllers is present when talking about hardware-in-the-loop simulation. Method for setting up multi-intersection traffic signal control is presented by Ren (2014). His conclusion is that hardware-in-the-loop simulation can operate with different signal controllers, but also can be implemented and evaluated for multi-intersection setup.

4.3 Additional Performance Measures Based on Existing High Resolution Enumerations

Part of this study is also an investigation about potential performance measures that could be added to the group of the existing ones with the goal of depicting the quality of signal performance. The condition that must be met is that the existing high-resolution event logs and their enumeration needs to be used.

Previous studies (Stevanovic et al., 2015) showed that AoG should not be used as a sole performance measure to compare different traffic signal strategies because it does not provide the information how efficiently is the assigned green time being used. To provide a more comprehensive overview of the traffic progression, AoG should be combined with GT and cycle length. Also a simplified version of Approach delay calculated by current methodology using high-resolution data, underestimates the true average approach delay.

With that in mind, the development of a new high-resolution performance measure named Average Arrivals on Green Ratio (AAOGR) and the modification of the Approach delay (AD) calculation are suggested.

Average Arrivals on Green Ratio

AAOGR is a relation similar to the PR because it takes into account the variability of the cycle length and duration of green time on a cycle-by-cycle basis. That makes it practical for using when cycle lengths are often changing (for example adaptive traffic control). AAOGR actually denotes an average percentage of vehicles arriving during green signal indication per second of average green time.

How the AAOGR is calculated? Number of vehicles passing on green (V_{gi}) is calculated for each cycle C_i , and was divided by the number of vehicles during each cycle on the same approach (V_{ci}). In such a way, cyclical values were averaged for the entire peak period ($T = \sum_{i=1}^N C_i$). In addition, the variability of green time (g_i) and cycle length (C_i) were also taken into account.

$$AAOGR = \frac{\sum_{i=1}^N \frac{V_{gi}}{V_{ci}} \times C_i}{\sum_{i=1}^N g_i \times C_i}$$

$\sum_{i=1}^N \frac{V_{gi}}{V_{ci}} \times C_i$

$\sum_{i=1}^N g_i \times C_i$

Cycle-by-Cycle Averaged Arrivals on Green

Arrivals on Green during the cycle

Cycle-by-Cycle Averaged Green Time

Green time during the cycle C_i

$$PR = \frac{AoG}{GT} = \frac{\frac{\sum_{i=1}^{V_c} V_{gi}}{V_c}}{\frac{\sum_{i=1}^N g_i}{\sum_{i=1}^N C_i}}$$

Arrivals on Green during the entire period (T)

Averaged Green Time for the entire period (T)

Figure 4-7. Calculation of AAOGR and PR

AAOGR is computed similarly to Platoon Ratio (PR), whose mathematical derivation is also shown in Figure 4-7 above. In order to compare AAOGR and PR in the most simplistic/basic case, these two PMs are derived for a fixed-time signal control strategy, where cycle length and green times were constant. Derivation of AAOGR and PR in such a case shows that the PR actually represents a product of AAOGR and cycle length. In a more complex case, when cycle length and green time vary per cycle (as in the case when adaptive traffic control is used), the AAOGR represents much better measure of progression compared to PR, because PR does not take in consideration cycle length. To sum up, the AAOGR represents a percentage of vehicles (out of total number) that have passed through the intersection per a second of green time.

$$AAOGR = \frac{\frac{\sum_{i=1}^N \frac{V_{gi}}{V_{ci}} * C_i}{\sum_{i=1}^N C_i}}{\frac{\sum_{i=1}^N g_i * C_i}{\sum_{i=1}^N C_i}} = \frac{\sum_{i=1}^N \frac{V_{gi}}{V_{ci}} * C_i}{\sum_{i=1}^N g_i * C_i} \quad (1)$$

$$\left\{ \begin{array}{l} C_i \text{ is const. } (C_i = C) \\ g_i \text{ is const. } (g_i = g) \end{array} \right\} \xrightarrow{\text{yields}} AAOGR = \frac{C * \sum_{i=1}^N \frac{V_{gi}}{V_{ci}}}{N * g * C} = \frac{\sum_{i=1}^N \frac{V_{gi}}{V_{ci}}}{N * g} * 100 \quad [\frac{\%}{\text{sec of green}}]$$

$$PR = \frac{AOG}{GT} = \frac{\sum_{i=1}^N \frac{\frac{V_{gi}}{V_{ci}} * C_i}{\frac{g_i}{C_i}}}{\sum_{i=1}^N C_i} = \frac{\sum_{i=1}^N \frac{C_i^2 * V_{gi}}{g_i * V_{ci}}}{\sum_{i=1}^N C_i} \quad (2)$$

$$\left\{ \begin{array}{l} C_i \text{ is const. } (C_i = C) \\ g_i \text{ is const. } (g_i = g) \end{array} \right\} \xrightarrow{\text{yields}} PR = \frac{\sum_{i=1}^N \frac{C^2 * V_{gi}}{g * V_{ci}}}{\sum_{i=1}^N C} = \frac{C^2 * \sum_{i=1}^N \frac{V_{gi}}{V_{ci}}}{N * g * C} = \frac{C}{N * g} * \sum_{i=1}^N \frac{V_{gi}}{V_{ci}} \quad [\emptyset]$$

$$\Rightarrow PR = AAOGR * C$$

Figure 4-8. Derivation of the AAOGR and PR on the example of fixed-time traffic control

Finally, AoG as a performance measure cannot be straightforwardly used to compare various traffic signal alternatives, because it does not offer the information how efficiently is the assigned green time used by an arriving platoon. PR is a better measure, but it also does not consider duration of a cycle length. A signal operating at a higher cycle, could be less efficient than the one with lower cycle and the same GT and AoG. AAOGR includes the needed parameters (percentage of green time and cycle length), and displays an unambiguous picture of how efficient is the progression of a platoon through the intersection. Such a measure can be used for comparison of adaptive and non-adaptive systems but also for comparison of efficiency of traffic platoons at signals from various network partitions or corridors. That enables the staff to use a common measure of traffic progression.

Approach Delay modification

Why a modification in the approach delay calculation is suggested? Average delay times computed by the current methodology did not show good match with average delay results obtained from simulation. A delay for a vehicle arriving on red is calculated as the difference between the departure time during the next green and the time when a vehicle arrived at the stop line. The modification for the calculation of the AD is that an approximate position of the vehicle in the queue and the queue discharge rate are used in that process. If a vehicle is on the first place in the queue, it would leave at the beginning of green indication (plus two seconds of startup delay). Otherwise, if there were vehicles in the queue, the delay is increased by the time needed to discharge the queue, once the signal turns green. Discharge rate is based on the

recommendations from Greenshields et al., (1947), according to whom the first five headways are: 3.8, 3.1, 2.7, 2.4 and 2.2 seconds. After the fifth vehicle, the headways level out at 2.1 seconds. The following symbols were used in algorithm applied in the microsimulation environment:

R - Number of Random Seeds

P - Number of Cycles for the given Random Seed and approach

V_n - Number of vehicles for the given Random Seed

r - Duration of red time for Cycle for the given Random Seed and approach

g - Duration of green time for Cycle for the given Random Seed and approach

a - Duration of amber time for Cycle for the given Random Seed and approach

t^g - Beginning of green time within Cycle for the given Random Seed and approach

t^a - Beginning of amber time within Cycle for the given Random Seed and approach

t^r - Beginning of red time within Cycle for the given Random Seed and approach

C - Duration of Cycle for the given Random Seed and approach

L - Distance from detector to the stop line for the given approach

S - Speed limit at for the given approach

t - Simulation time when vehicle is detected on detector for the given Random Seed and approach

t' - Simulation time when vehicle is projected to be at the stop line for the given Random Seed and approach

z - Number of vehicles in queue for the given approach

D - Delay for given Random Seed and approach

V_g - Number of vehicles arriving on green during the cycle for the given Random Seed and approach

V_c - Total number of vehicles during the cycle for the given Random Seed and approach

AAOGR - Average Arrivals on Green Ratio

```

FOR j = 1 TO R
FOR k = 1 TO Pnj
FOR i = 1 TO Vckj
    tgnkj = rnkj
    tankj = rnkj + gnkj
    trnkj = rnkj + gnkj + ankj
    Cnkj = trnkj
    Pnj
    Vnj =  $\sum_{k=1}^{P_{nj}} V_{ckj}$ 
    t'nij = t(ny)ij + Lny / Sn

    IF t'nij ≥ gnkj AND t'nij < rnkj
        Dnij = 0
        Vngikj = 1
    ELSE IF t'nij ≥ rnkj AND t'nij < gn(k+1)j
        Vngikj = 0
        z = z + 1
    IF z = 1
        Dnij = 2 + 3.8 + gn(k+1)j - t'nij
    ELSE IF z = 2
        Dnij = 2 + 3.8 + 3.1 + gn(k+1)j - t'nij
    ELSE IF z = 3
        Dnij = 2 + 3.8 + 3.1 + 2.7 + gn(k+1)j - t'nij
    ELSE IF z = 4
        Dnij = 2 + 3.8 + 3.1 + 2.7 + 2.4 + gn(k+1)j - t'nij
    ELSE IF z = 5
        Dnij = 2 + 3.8 + 3.1 + 2.7 + 2.4 + 2.2 + gn(k+1)j - t'nij
    ELSE IF z ≥ 6
        Dnij = 2 + 3.8 + 3.1 + 2.7 + 2.4 + 2.2 + (z - 5) * 2.1 + gn(k+1)j - t'nij
    END IF
END IF

END FOR
END FOR
END FOR

```

$$AAOGR = \frac{\sum_{j=1}^R \frac{\sum_{i=1}^{V_{ckj}} V_{ngikj} * C_{nkj}}{V_{ckj}} * V_{n_j}}{\sum_{k=1}^{P_{nj}} g_{nkj} * C_{nkj}} * V_{n_j}$$

$$D_n = \frac{\sum_{j=1}^R \sum_{i=1}^{V_{n_j}} D_{nij}}{\sum_{j=1}^R V_{n_j}}$$

Figure 4-9. The pseudo code for calculation of AAOG and modified approach delay (D_n)

This method for calculating approach delay that considers the potential queues that can form during the red signal indication provides better match to the values of delays provided by microsimulation software (Dakic et al. 2015). When derived approach delays were compared to those from a simulation model, the results were similar enough. AD derived from high-resolution simulation data matches VISSIM's own approach delay pretty well. The model is quite reliable (R^2 is around 90%) and accurate (less than 4% error). The currently used AD models based on high-resolution data cannot assess the delay caused by vehicles behind the detectors but the findings show that delay of vehicles that can fit between detectors and stop lines can be projected fairly well.

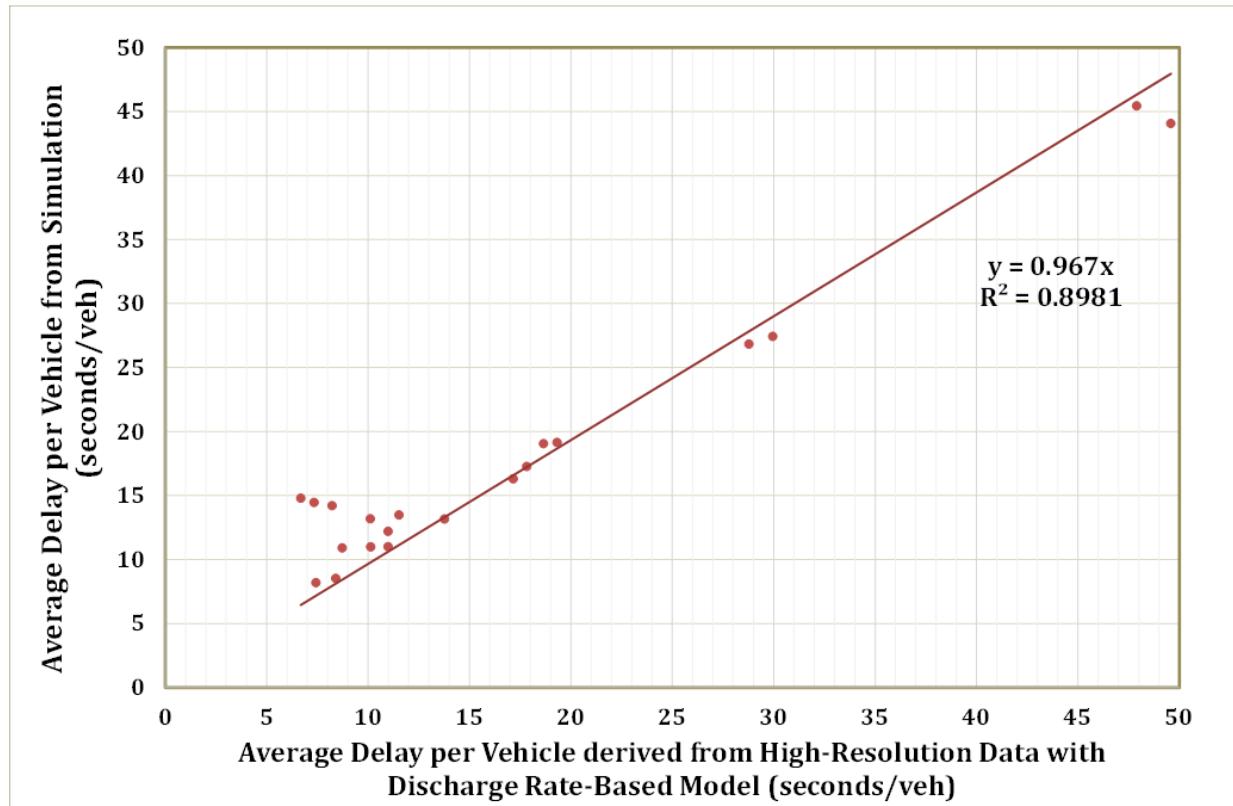


Figure 4-10. Average delay from simulation and proposed methodology

To test applicability of the formula for new AD, the same approach on the field data from UDOT was applied. Five intersections in Utah were chosen and both, NB and SB directions were observed. The relationship between high-resolution approach delay calculated by current UDOT's AD model and high-resolution AD delay obtained by discharge rate-based model is presented in Figure 4-11 below. Findings from the experiments show that:

- Proposed modified AD model can be implemented on the field data
- Current UDOT methodology seems to underestimate delays by around 45%, when compared to discharge rate-based AD model. Strong coefficient of determination (R^2 is 90%) again shows strong reliability of this linear relationship.

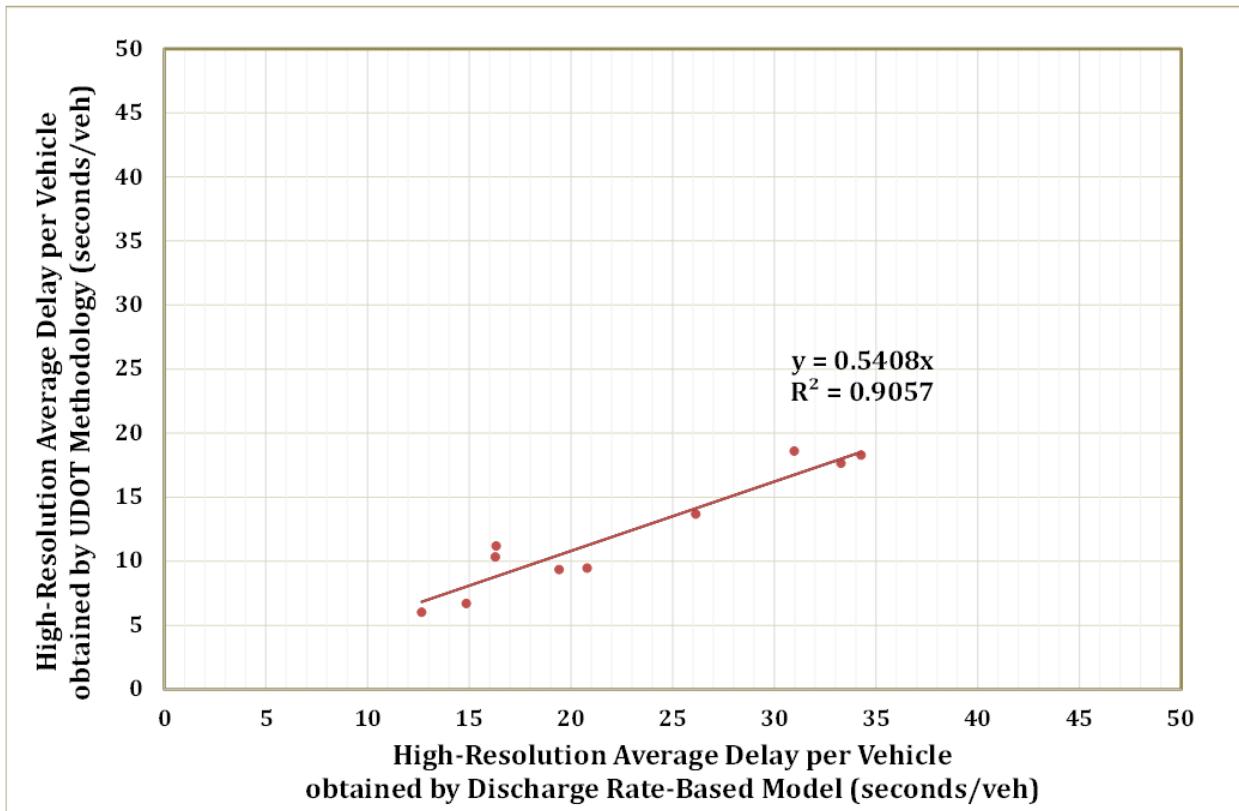


Figure 4-11. Average delay per vehicle from existing and newly proposed methodology
Both new models (for AAOGR and AD) are applicable for the field data and the results has shown that they can be successfully implemented in the field conditions.

The overview of currently addressed performance measures and the additional ones for the future usage is provided below.

Table 4.2. Possible performance measures and their status in the project (continued)

Num.	MOE	Addressed	Possible to address in future	Not addressed	Comments
1	OD Volume Matrix			X	Can it be obtained using TMC?
2	Unique ID Match Travel Time			X	Requires MAC address or AVL devices
3	GPS Travel Time			X	Requires GPS data
4	Travel Time Reliability			X	
5	Speed		X		Investigate after configuring speed detectors in the controller
6	Congestion Hours		X		Based on speed measurements
7	Vehicle Detector Occupancy		X		Comparing the total duration of activations against total time
8	Green Occupancy Ratio		X		Comparing the total duration of activations against green time for subject
9	Vehicle Volume per Approach	X			
10	Average Daily Traffic		X		Possible to calculate by using approach volumes
11	Peak Hour Volume	X			
12	HCM Vehicle Delay			X	
13	Approach Delay	X			
14	Estimated Queue Length		X		By using advanced detectors
15	Effective Cycle Length		X		
16	Split Monitor (Green Time Distribution)	X			
17	Green-to-Cycle Ratio	X			
18	Volume-to-Capacity Ratio		X		Volume is being collected, the capacity needs to be calculated.
19	Estimated Split Failures	X			
20	Recurring Split Failures	X			
21	Underutilized Green Time	X			
22	Lost Time		X		Investigate a possibility to place detectors and measure the lost time

Table 4.2. Possible performance measures and their status in the project (continued)

Num.	MOE	Addressed	Possible to address in future	Not addressed	Comments
23	Correctable Split Failures			X	
24	Number of Stops			X	
25	Percent on Green AoG	X			
26	Arrival Type		X		Defined by value of Platoon Ratio
27	Time-Space Diagram		X		
28	High Res. Flow and Phase Ind. Diagram	X			
29	Modeled Average Cyclic Flow Profile		X		
30	Observed Average Cyclic Flow Profile		X		
31	Virtual Probe Vehicle Trajectory			X	It could be possible in the simulation but hardly in the field with the existing high-resolution data that is being collected.
32	Temp. Oversaturation Severity Index		X		Work of H. Wu and H Liu
33	Spatial Oversaturation Severity Index		X		
34	Permitted Movement Conflict/Gap headway		X		Require extensive
35	Arrivals on red	X			
36	Pedestrian Delay		X		Needs to be configured in the controllers.
37	Preemption details		X		Needs to be configured in the controllers.
38	Purdue Phase Termination	X			
39	Purdue Coordination Diagram	X			
40	Purdue Split Failure		X		Needs to be configured in SPM tool.
41	Split Monitor	X			
42	Turning movement counts		X		Need to add detectors after the stop bar and then test.
43	Yellow and Red actuations		X		Need to add detectors after the stop bar and then test.
44	AAOGR		X		Proposed new performance measure
45	Modified AD		X		Modified existing performance measure

4.4 Potential Changes in the FDOT ASPMS Software

For the introduction of the proposed performance measures (AAOGR and modified AD), minor changes are needed because the majority of the necessary data is already being collected and processed in the current methodology. The changes require following actions. The data about number and duration of the cycles needs to be derived as also the data about number of vehicles in the queue for the subject approach. Appropriate changes in the source code and interface would be necessary. Potentially, the proposed measures do not need to replace the existing measures, yet could be used as supplement. In that case the agency staff can have wider spectrum of metrics for evaluating the traffic signal operations.

4.5 Statewide Implementation of FDOT ASPMS Software

The decision about suitability of FDOT's ASPMS software tool for statewide implementation depends on many factors. In order for some software to be accepted and included in regular operations on a state level, extensive testing needs to be performed.

For establishing the framework for this study and the thorough testing of the high-resolution data collection, and deriving various performance measures, six different controllers from six vendors have been used. The table with the information about the used controllers is provided below:

Table 4-3. Controllers used for the HILS setup

Vendor	Controller Name	Software Name	Software version
Econolite	Cobalt	Cobalt	32.63.00
Siemens	m50	SEPAC	3.52
PEEK	ATC-1000	GreenWave	03.019.3359
Trafficware	ATC 900	76.12H	Build 4486
McCain	ATC eX	OMNI	1.6.3
Intelight	Model 2070-LDX	MaxTime	1.9.2 (#268)

The ASPMS software and the entire HILS setup are tested on two units of each type from the Table 4-3. All controllers and the complete framework were functional for any controller type. It would be beneficial if the functionalities of ASPMS software can be successfully used for third party controllers.

Currently, the ASPMS software is set up to work with microsimulation software where the high-resolution data logs are downloaded manually, per request. For real systems connected with the controllers on the field, executable tasks should be defined so controllers can be regularly contacted, and the data uploaded or downloaded. This is a necessary modification of the existing test setup that should be performed so the ASPMS can work in real field and not microsimulation environment.

Finally, the ASPMS software can be considered ready and suitable for statewide implementation because it has been shown that the setup works at least with one version of the controllers from six different vendors on FDOT TERL list.

4.6 VISSIM Model

Test bed network model used for this project consists of a 3.3 mi long urban arterial corridor with 12 intersections on Glades Road in Boca Raton, FL. This network was chosen due to proximity to Florida Atlantic University (FAU) which makes it easier to examine real street conditions compared to simulation. Network model is part of signal optimization evaluation that was done in cooperation with the City of Boca Raton, FL (Stevanovic, 2012). Throughout this chapter, location of the corridor will be described as well as: geometry of intersections that will be used for HILS, traffic conditions and signal timings that are used for comparison TOD with real traffic controller hardware.

4.6.1 Corridor Description

The simulation network model for the Glades Road corridor in Boca Raton, Florida consists of 12 signalized intersections, from N Dixie Hwy to St Andrews Blvd. This segment of Glades Road is 3.3 mi long, crossing I-95 and has ramps to I-95 included in observed segment, while to the further West there is connection to Florida Turnpike which means that corridor in AM peak and PM peak is congested. Glades Road is also very important to Florida Atlantic University because of the connection to I-95 and Florida Turnpike due to large number of students and employees who do not live in Boca Raton. Figure 4-12. shows where studied corridor is located compared to FAU, I-95 and

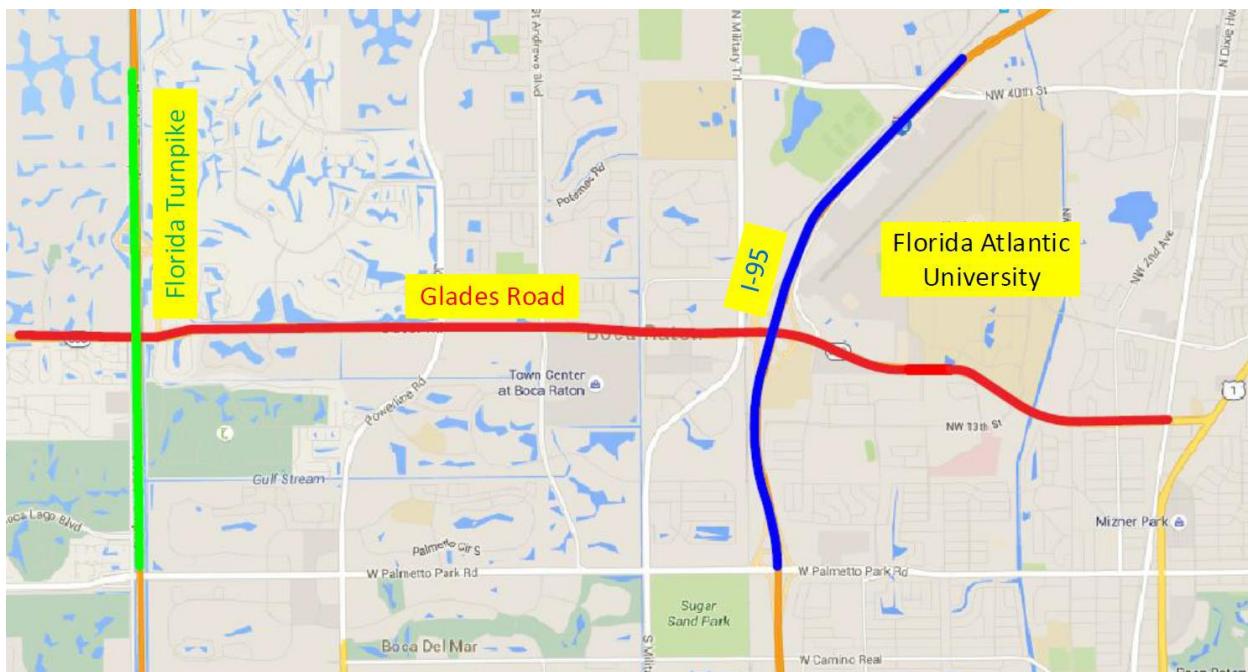


Figure 4-12. Location of Glades Rd

The 12 intersections that will be studied are shown in Figure 4-13 and Figure 4-14. as follows:

- Glades Rd – N Dixie Hwy (Intersection 1)
- Glades Rd – Boca Raton Blvd (Intersection 2)
- Glades Rd – NW 4th Ave (Intersection 3)

- Glades Rd – FAU Blvd (Intersection 4)
- Glades Rd – NW 10th Avenue (Intersection 5)
- Glades Rd – Airport Rd (Intersection 6)
- Glades Rd – I-95 NB (Intersection 7)
- Glades Rd – I-95 SB (Intersection 8)
- Glades Rd – NW Executive Center (Intersection 9)
- Glades Rd – Butts Rd (Intersection 10)
- Glades Rd – Town Center (Intersection 11)
- Glades Rd – St Andrews Blvd (Intersection 12)

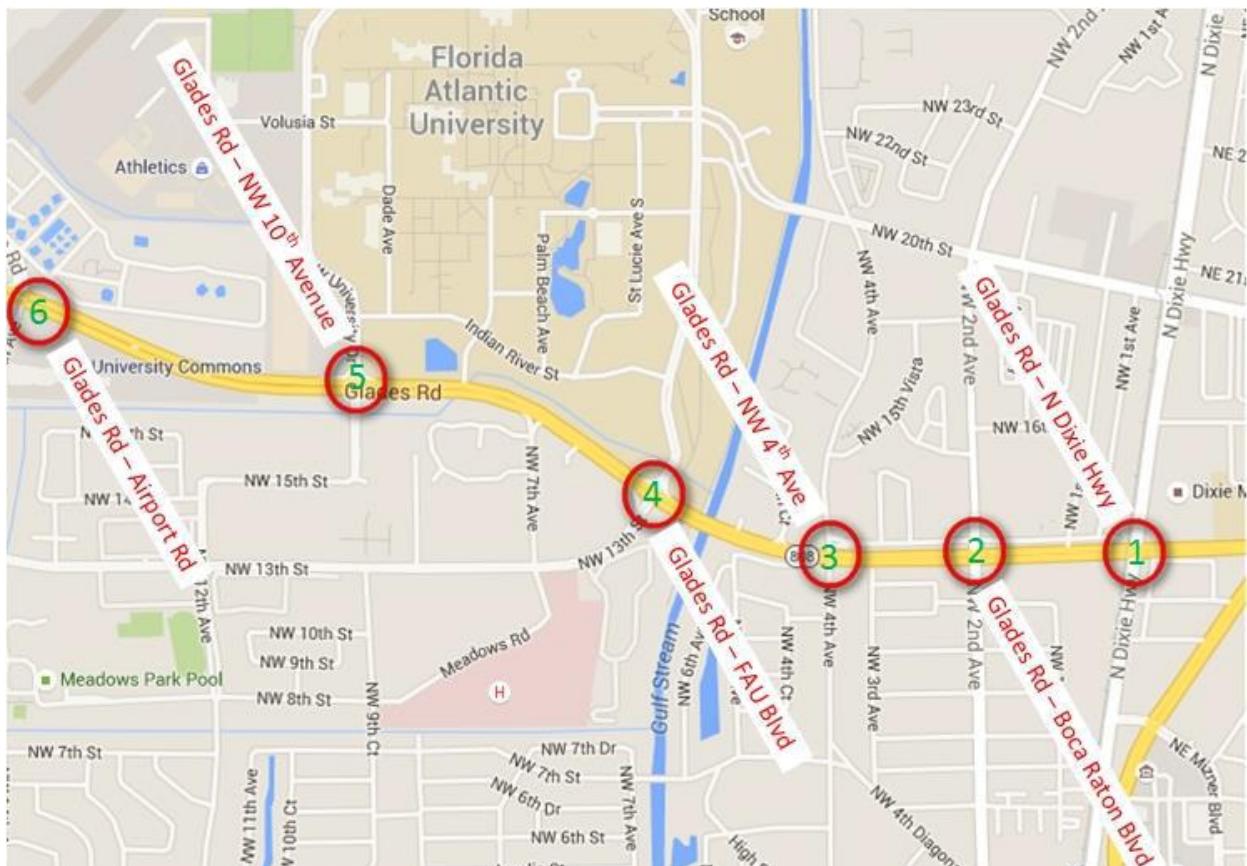


Figure 4-13. Overview of the intersections 1-6 on Glades Rd

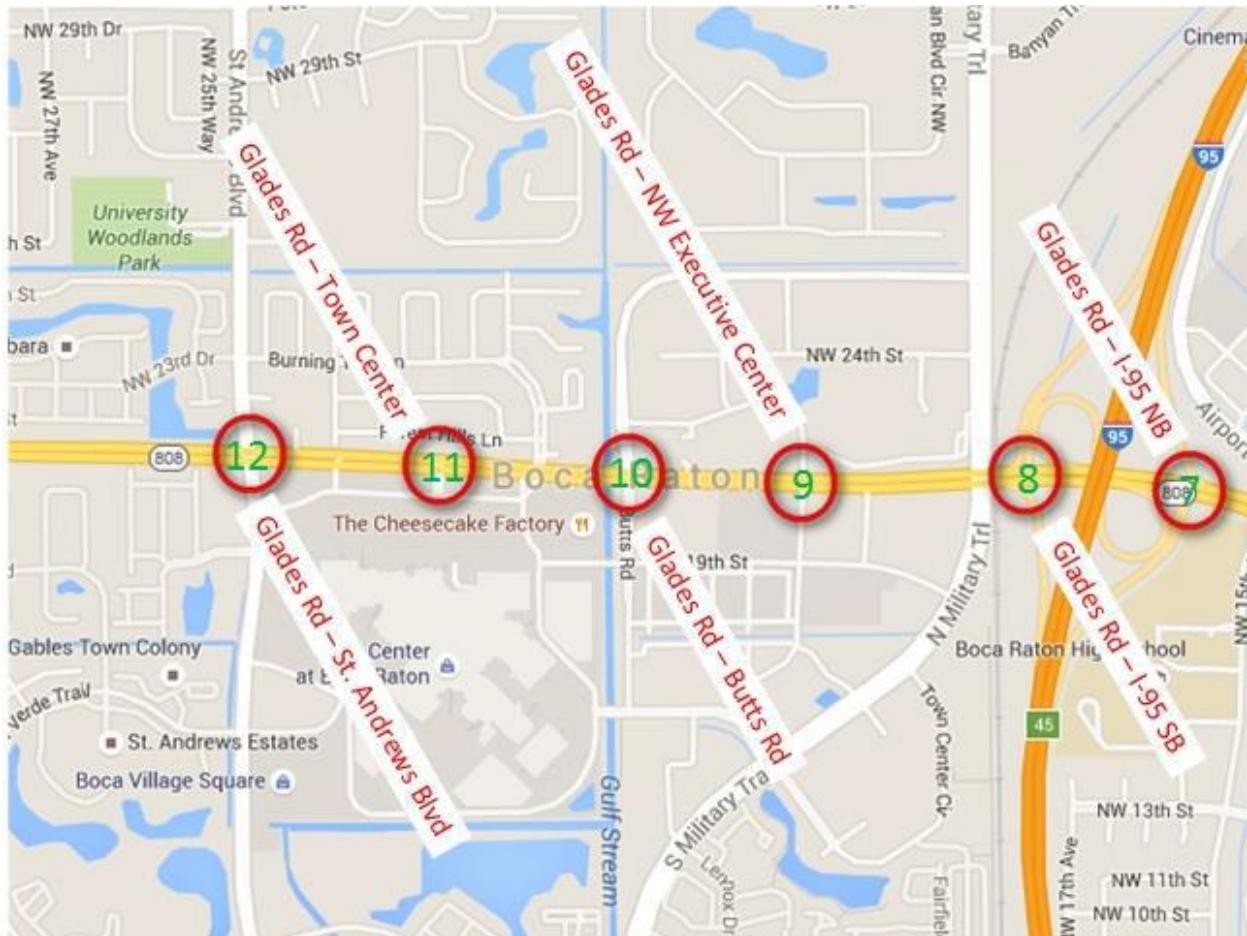


Figure 4-14. Overview of the intersections 7-12 on Glades Rd

4.6.2 Signal Timings

The portion of Glades Road used for this study is mostly three-lanes wide, although there are places where the approach to the intersection can be even six-lanes given left and right pocket lanes. Speed limit through-out the studied corridor is 45 miles per hour (mph). There are some un-signalized intersections or access points present on studied corridor.

Traffic volumes used in this study are collected by City of Boca Raton to identify AM and PM peak of the day where PM peak was found to be from 3:30 PM to 6:30 PM. Furthermore, turning movement counts were collected observing video recordings from field at intersections.

Signal timing implementation was done based on the traffic volume and travel times data collected during Tuesdays, Wednesdays and Thursdays in 2010 under fair weather conditions (Stevanovic, 2012). Travel times are obtained from GPS units, where students were hired to collect travel times along Glades Road. Signal timings for real signal controllers are taken from calibrated and validated RBC setup in VISSIM network. First six intersections are chosen from Glades Rd – N Dixie Hwy to Glades Rd – Airport Rd for HILS setup. Table 4-4 to Table 4-9 show the basic signal timings for real traffic signal controllers in HILS.

Table 4-4. Basic signal timings for Glades Rd - N Dixie Hwy for PEEK controller

Basic								
SG Number	1	2	3	4	5	6	7	8
SG Name								
Min Green	5	20		12	5	20	5	12
Veh Extension	3.5	4	4	4	4	4	4	4
Max 1	40	80		60	40	80	30	40
Yellow	4.5	4.5		4.5	4.5	4.5	4.5	4.5
Red Clearance	1.9	2.5		2.6	2	2.5	2.6	2.6

Table 4-5. Basic signal timing for Glades Rd - Boca Raton Blvd for Trafficware controller

SG Number	1	2	3	4	5	6	7	8
SG Name								
Min Green	5	18		12	5	18	5	12
Veh Extension	2	2	2	2	4	2	2	2
Max 1	30	60		60	25	70	25	40
Yellow	4	4.5		4.5	4.5	4.5	4	4.5
Red Clearance	2	2.3		2.4	2.3	2.3	2.3	2.4

Table 4-6. Basic signal timing for Glades Rd – NW 4th Ave for Siemens controller

SG Number	1	2	3	4	5	6	7	8
SG Name								
Min Green	7	18	5	12	5	18	5	12
Veh Extension	2.5	2	2	2	2	2	2	2
Max 1	48	60	30	45	35	65	25	50
Yellow	4.5	4.5	4	4.5	4.5	4.5	4	4.5
Red Clearance	2.4	2.1	2.4	3	2.1	2.1	2.4	3

Table 4-7. Basic signal timing for Glades Rd – FAU Blvd for Econolite controller

SG Number	1	2	3	4	5	6	7	8
SG Name								
Min Green	5	18		12	5	18	5	12
Veh Extension	2	2	3	2	2	2	2	2
Max 1	30	50		70	20	60	20	50
Yellow	4	4.5		4.5	4	4.5	4	4.5
Red Clearance	2.6	2		2.5	2.1	2	1.5	2.5

Table 4-8. Basic signal timing for Glades Rd – NW 10th Avenue for Intelight controller

SG Number	1	2	3	4	5	6	7	8
SG Name								
Min Green	7	18	5	12	5	18	5	12
Veh Extension	3.5	2	2	2	2	2	2	2
Max 1	50	70	30	45	20	80	30	45
Yellow	4	4.5	4	4.5	4	4.5	4	4.5
Red Clearance	3.1	2.3	2.3	2.9	2.8	2.3	2.3	2.9

Table 4-9. Basic signal timing for Glades Rd – Airport Rd for McCain controller

SG Number	1	2	3	4	5	6	7	8
SG Name								
Min Green	7	18	5	12	7	18	5	10
Veh Extension	2	2	2	2	2	2	2	2
Max 1	30	90	25	45	25	100	40	35
Yellow	4	4	4	4	4	4	4	4
Red Clearance	2	2	2	2	2	2	2	2

The remaining intersections are controlled by Ring Barrier Controllers defined in VISSIM microsimulation software according to the data from the field.

Configuration of the controllers is done based on the basic timings (timings taken from RBC VISSIM configuration), splits and cycle lengths. Other features in the controller needed to be changed for coordination setup. Only part that is changed in HILS setups versus RBC setup to test manual coordination are offsets on each intersection. Intersections in VISSIM model are not changed, meaning the RBC signal timings and coordination setup stayed the same as in original RBC VISSIM model. Table 4-10 show intersection offsets, splits and cycle length for RBC VISSIM virtual controllers.

Table 4-10. Signal timings for the six intersections operated by hardware controllers

Intesection	Cycle Length	150	Splits							
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Glades Rd - N Dixie Hwy	Offset	56	32	46	X	72	20	58	22	50
Intesection	Cycle Length	160	Splits							
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Glades Rd - Boca Raton Blvd	Offset	26	28	60	22	50	20	68	20	52
Intesection	Cycle Length	160	Splits							
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Glades Rd - NW 4th Avenue	Offset	24	30	65	X	65	21	74	20	45
Intesection	Cycle Length	160	Splits							
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Glades Rd - FAU Blvd	Offset	34	20	79	X	61	30	69	23	38
Intesection	Cycle Length	160	Splits							
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Glades Rd - NW 10th Ave	Offset	58	29	68	15	48	18	79	16	50
Intesection	Cycle Length	180	Splits							
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Glades Rd - Airport Rd	Offset	90	30	89	16	45	16	103	43	18

4.6.3 Intersections Geometry

HILS controllers used for simulation need to be configured based on the data available in VISSIM model. VISSIM model is created to represent real field geometry. Data from the model is validated and calibrated for PM peak. Each HILS controller needs to have same phase setup as the field has, data from the field is used to configure real traffic signal controllers. Geometry is important part of the VISSIM configuration.

Glades Rd – N Dixie Hwy (Intersection 1 – PEEK controller – see Figure 4-15)

The Glades Road and N Dixie Hwy intersection has four approaches and all of them are signalized. The north approach has four lanes of which two lanes are through movement, one right turn pocket lane of approximately 450 ft. and one is left turn lane. The east approach has five lanes from which three are through movement, one is right pocket turn lane of approximately 300 ft. and one left pocket turn lane of approximately 400 ft. The south approach has three lanes from which one is through movement, one right turn lane and one left pocket turn lane of approximately 150 ft. The west approach has four lanes from which three are through movement, one of through movement lane is also right turn lane and one left pocket turn lane of approximately 320 ft.

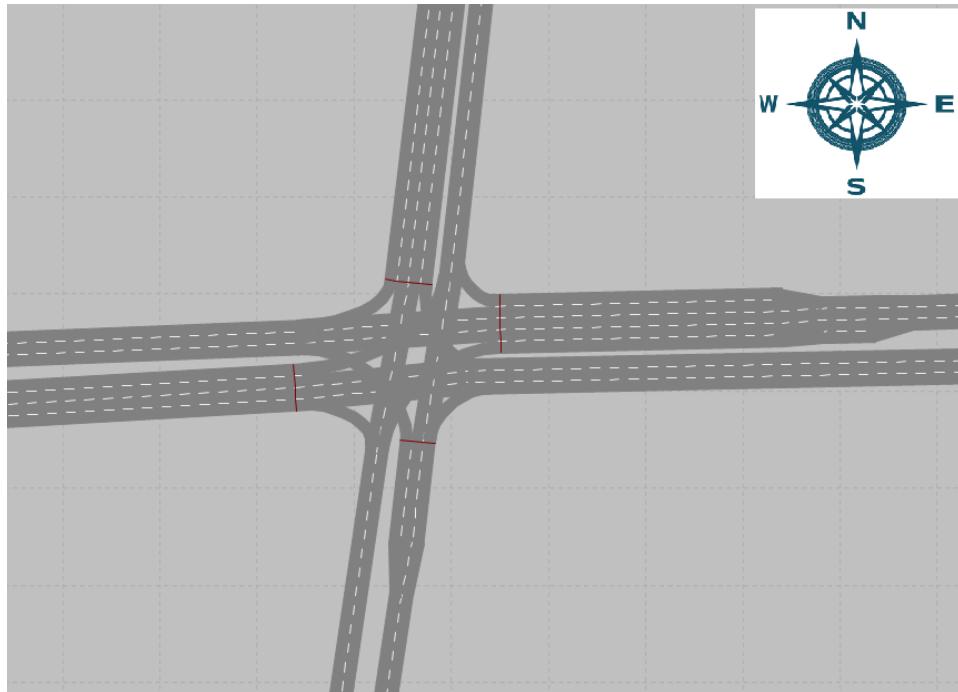


Figure 4-15. Geometry of Glades Rd - N Dixie Hwy for PEEK controller

Glades Rd – Boca Raton Blvd (Intersection 2 – Trafficware controller – see Figure 4-16)

The Glades Rd – Boca Raton Blvd intersection has four approaches and all of them are signalized. The north approach has four lanes of which two lanes are through movement, one right turn pocket lane of approximately 410 ft. and one is left turn lane. The east approach has five lanes from which three are through movement, one is right pocket turn lane of approximately 365 ft. and one left pocket turn lane of approximately 400 ft. The south approach

has three lanes from which two are through movement, one of trough movement lane is also right turn lane and one left pocket turn lane of approximately 240 ft. The west approach has six lanes from which three are through movement one is right pocket turn lane of approximately 260 ft. and two left pocket turn lanes of approximately 550 ft.

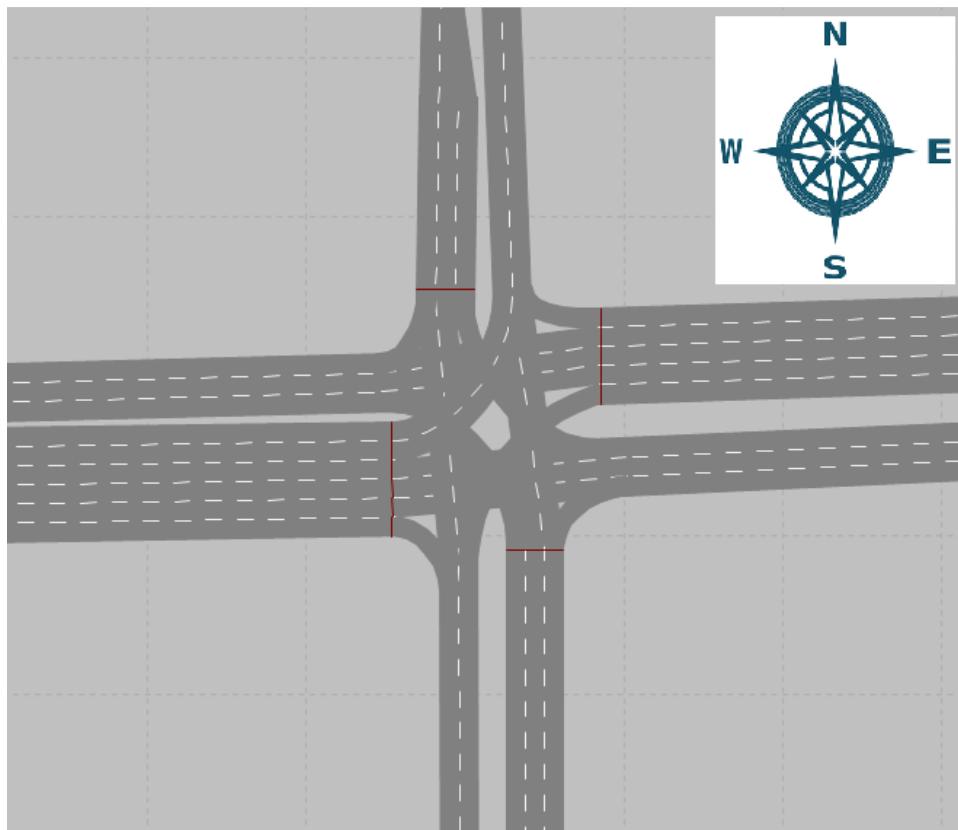


Figure 4-16. Geometry of Glades Rd – Boca Raton Blvd for Trafficware controller

Glades Rd – NW 4th Ave (Intersection 3 – Siemens controller – see Figure 4-17)

The Glades Rd – NW 4th Ave intersection has four approaches and all of them are signalized. The north approach has three lanes of which one lane is through movement, one right turn pocket lane of approximately 250 ft. and one is left turn pocket lane of approximately 245 ft. The east approach has four lanes from which three are through movement, one of trough movement lane is also right turn lane and one left pocket turn lane of approximately 320 ft. The south approach has three lanes from which two are through movement, one of trough movement lane is also right turn lane and one left pocket turn lane of approximately 270 ft. The west approach has four lanes from which three are through movement, one of through movement lane is also right turn lane and one left pocket turn lane of approximately 420 ft.

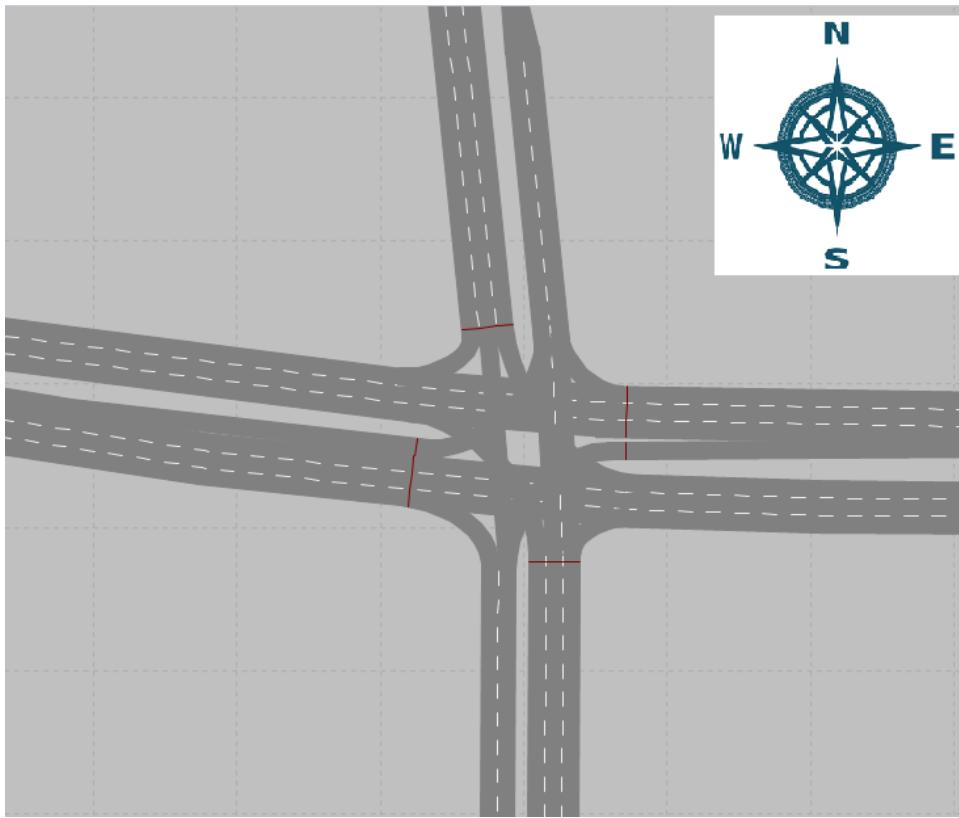


Figure 4-17. Geometry of Glades Rd – NW 4th Ave for Siemens controller

Glades Rd – FAU Blvd (Intersection 4 – Econolite controller – see Figure 4-18)

The Glades Rd – FAU Blvd intersection has four approaches and all of them are signalized. The north approach has three lanes of which two lanes are through movement and one left turn pocket lane of approximately 340 ft., while right turn is done un-signalized connects to main direction. The east approach has six lanes from which three are through movement, one right pocket turn lane that is un-signalized connects to main direction and two left pocket turn lanes of approximately 530 ft. The south approach has four lanes from which two are through movement, one right pocket turn lane of approximately 250 ft. and one left pocket turn lane of approximately 250 ft. West approach has six lanes from which three are through movement, one right pocket turn lane that is un-signalized connects to main direction of approximate length 400 ft. and two left pocket turn lane of approximately 430 ft.

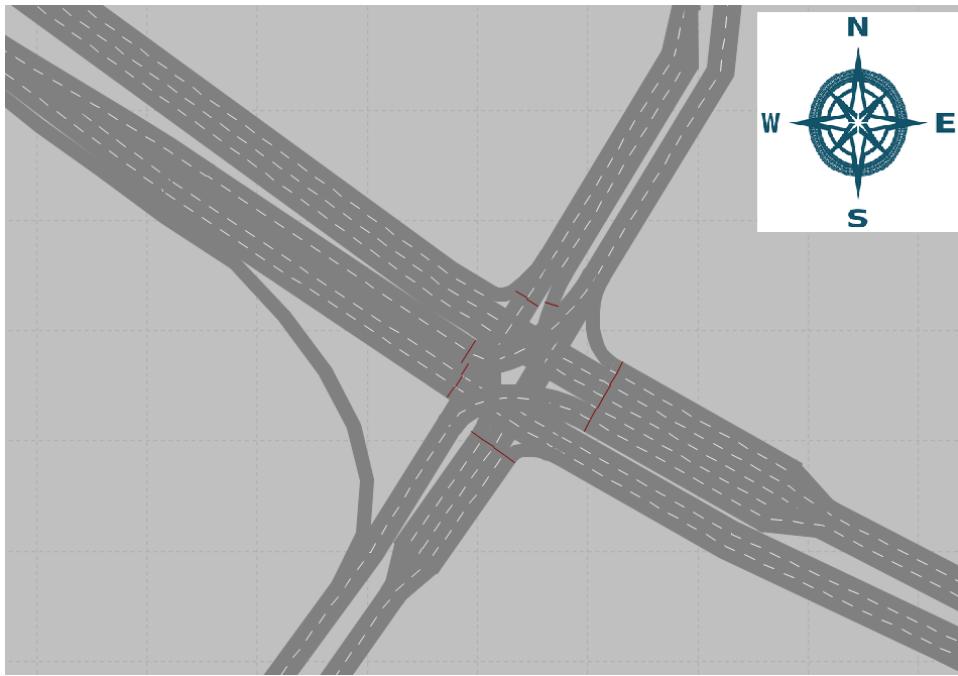


Figure 4-18. Geometry of Glades Rd – FAU Blvd for Econolite controller

Glades Rd – NW 10th Avenue (Intersection 5 – Intelight controller – see Figure 4-19)

The Glades Rd – NW 10th Avenue intersection has four approaches and all of them are signalized. The north approach has three lanes of which two lanes are through movement, one is left turn pocket lane of approximately 260 ft., while right turn is done un-signalized and connects to main direction. The east approach has five lanes from which three are through movement, one right pocket turn lane that is un-signalized connects to main direction and one left pocket turn lane of approximately 220 ft. The south approach has three lanes from which one is through movement, one right turn lane and one left pocket turn lane of approximately 180 ft. The west approach has five lanes from which three are through movement, one of through movement lane is also right turn lane and two left pocket turn lanes of approximately 740 ft.

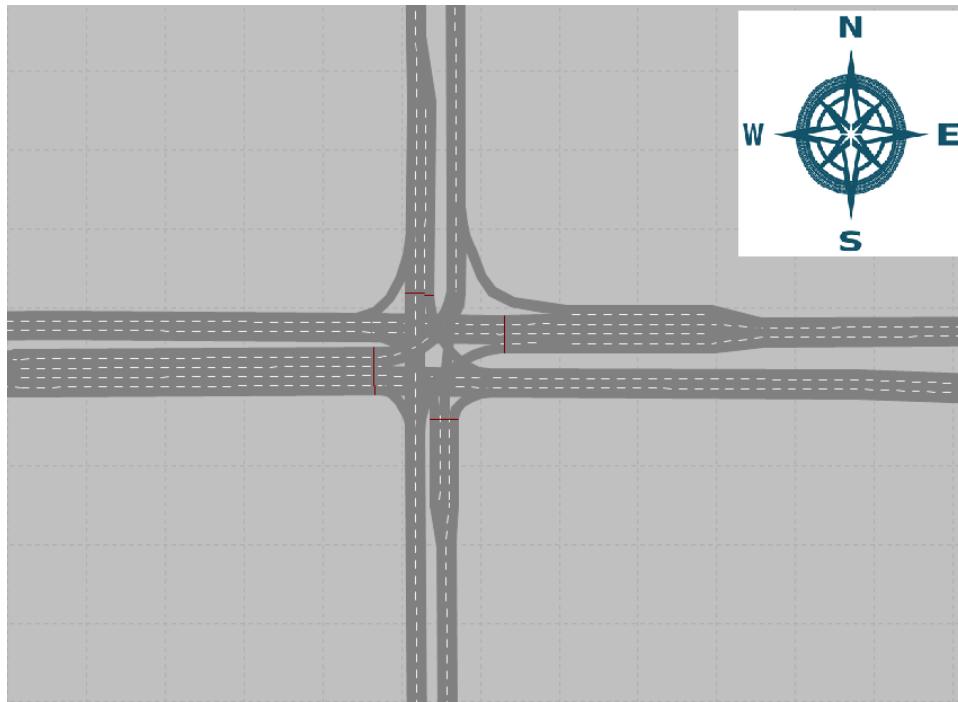


Figure 4-19. Geometry of Glades Rd – NW 10th Avenue for Intelight controller

Glades Rd – Airport Rd (Intersection 6 – McCain controller – see Figure 4-20)

The Glades Rd – Airport Rd intersection has four approaches and all of them are signalized. The north approach has four lanes of which one lane is through movement, one is left turn pocket lane of approximately 375 ft., while right turn is done as pocket signalized lane of approximately 670 ft. The east approach has five lanes from which three are through movement, one right pocket turn lane of approximately 340 ft. and one left pocket turn lane of approximately 340 ft. The south approach has four lanes from which one is through movement, one right turn lane and two left pocket turn lanes of approximately 300 ft. The west approach has six lanes from which three are through movement, one right pocket turn lane of approximately 345 ft. and two left pocket turn lanes of approximately 410 ft.

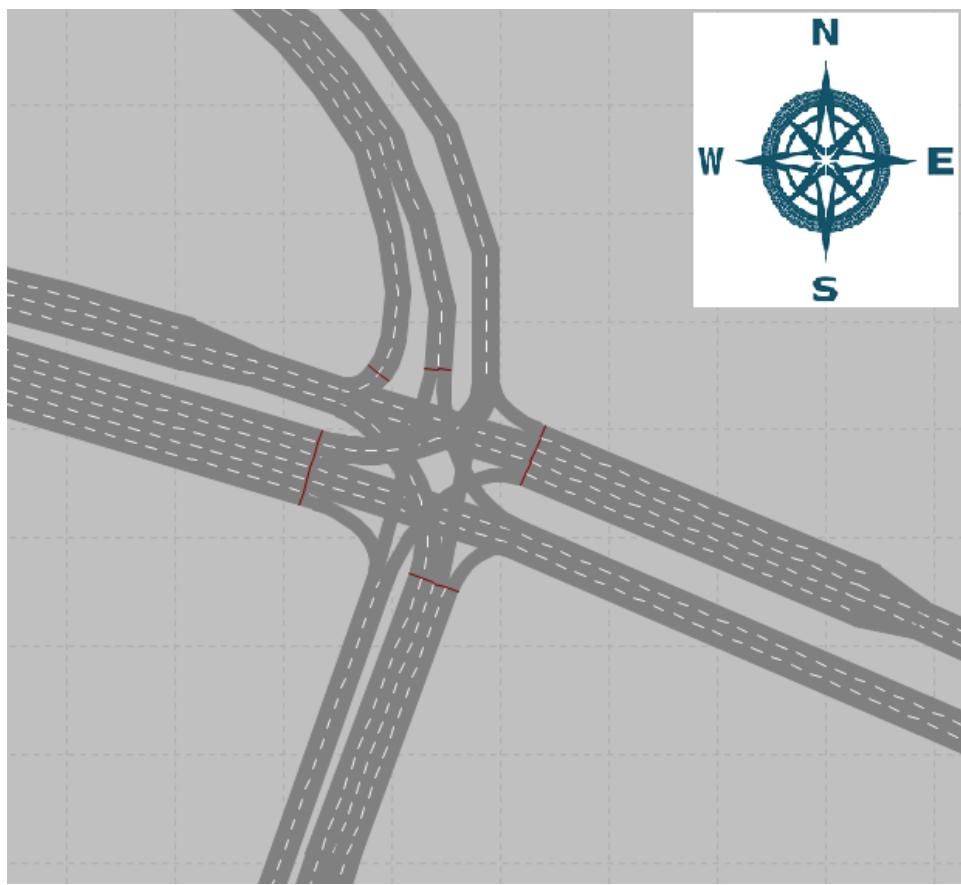


Figure 4-20. Geometry of Glades Rd – Airport Rd for McCain controller

4.6.4 Controller Detector Setup for Purdue Coordination Diagram

To produce Purdue Coordination Diagrams (PCD) for coordination assessment, advanced detectors need to be setup in each controller so that inputs from VISSIM can be recorded and later extracted for PCDs. Advanced detectors are positioned 330 ft. from the stop line so that arrivals on green can be calculated correctly. Only through movement on Glades Road has advanced detectors, side roads are not taken into consideration in this study. For a large part of corridor, the number of advanced detectors per intersection is six, three in each direction. Each controller has different advanced detector setup and because that controller manual is needed to setup the detectors. Besides advanced detectors, presence detectors also need to be configured, but the explanation on presence detector configuration is not part of this chapter.

4.6.4.1 PEEK Advanced Detector Setup

Storage of High Resolution Data files on PEEK controller needs to be done manually through display on controller. To enable storage of High Resolution Data files, the following steps are required:

1. Press “MNU” button
2. Press number “4” – Logs
3. Press number “3” – Advanced Controller Log
4. Press number “1” – Setup Logging Options
5. Enable Advanced Logging (X)
6. Enable necessary logs for High Resolution Data storage (see Figure 4-21)



Figure 4-21. Advanced Cu log setup interface

After High Resolution Data storage is enabled it is necessary to setup detectors so that they can be stored in the High Resolution Data files. Detector setup for High Resolution Data storing is done through 7 steps:

1. Press “MNU” button
2. Press number “2” – Programming

3. Press number “5” – Detectors
4. Press number “1” – Vehicle Detector Options
5. Enable Detectors Call (For High Resolution Data storing)
6. Enable Detectors Occupancy (Only High Resolution Data detectors)
7. Enable Detectors Volume (Only High Resolution Data detectors – see Figure 4-22)

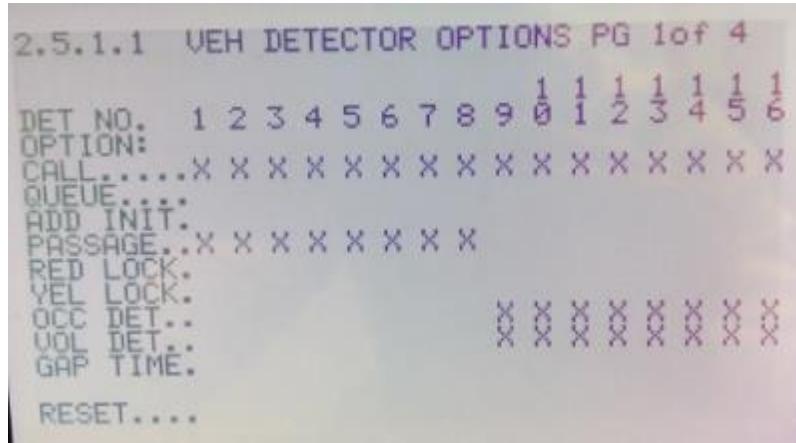


Figure 4-22. Vehicle detector options interface

Storage for detectors 1-8 is done by default because of the mapping of the I/O module. Because detectors 8-16 also need to be stored in High Resolution Data files, that mapping needs to be changed. First we need to check which inputs do we need to change and that is done through Input Outputs Pin Status screen. Navigate to Input Outputs Pin Status screen:

1. Press “MNU” button
2. Press number “1” – Status
3. Press number “2” – Input/Outputs/Port 1
4. Press number “4” – Input Outputs Pin Status
5. Change pages to locate detector actuation (write down which Pin and Function is activated when detector is activated – see Figure 4-23)

1.2.4 INPUTS OUTPUTS PIN STATUS PG10F5		
Pin	Function	State
MSA-A	: Fault Monitor	[0]x
MSA-B	: DC+ (24V)	[x]
MSA-C	: Voltage Monitor	[0]x
MSA-D	: Phase 1 Red Driver	[0]x
MSA-E	: Phase 1 DWLK Driver	[0]
MSA-F	: Phase 2 Red Driver	[0]
MSA-G	: Phase 2 DWLK Driver	[0]x
MSA-H	: Phase 2 Ped Clr Drvr	[0]
MSA-J	: Phase 2 Walk Driver	[0]
MSA-K	: Det Channel 2 Call	[1]
MSA-L	: Pedestrian Det 2	[1]
[A] Selects Device, x means Pin active		

Figure 4-23. Input output pin status interface

After all detector data is collected from Input Outputs Pin Status screen, next step is to remap PEEK controller I/O module. To remap I/O module:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “1” – Unit Configuration
4. Press number “5” – Comms and I/O Setup Menu
5. Press number “4” – I/O Cabinet Setup
6. Navigate through “Pin” enumerations and find the ones needed to be changed (change them to Vehicle Detector number that is needed)
7. Save the changes and restart controller

4.6.4.2 Trafficware Advanced Detector Setup

Trafficware controller needs to enable High Resolution Data storage manually so that files can be stored in the controller for 24 hours in 1 hour format. User needs to get to I/O Logging screen to enable High Resolution Data:

1. Press “Main Menu” button
2. Press number “1” – Controller
3. Press number “9” – I/O
4. Press number “5” – Logging
5. EnableLogs (ON)
6. Enable necessary logs for High Resolution Data storage (see Figure 4-24)

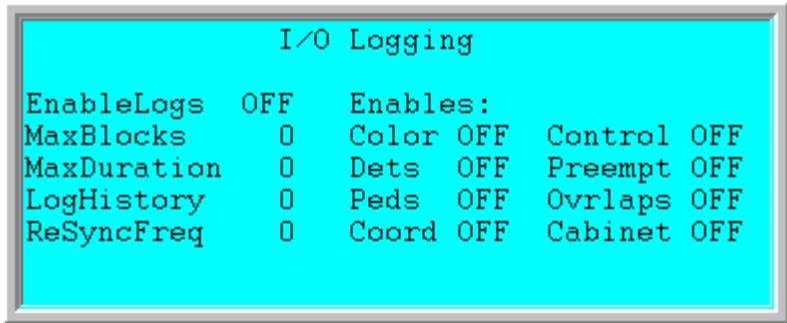


Figure 4-24. I/O logging interface

There are some additional possibilities to be enabled or changed on I/O Logging screen. Table 4-11 shows the possible storing options of specific Log parameters on Trafficware controller. These parameters do not need to be changed, but after EnableLogs is set to “ON” the High Resolution Data files will be stored. Changing the parameters just enables the user to have more options on High Resolution Data storage.

Table 4-11. High-resolution data log parameters and description

Parameter	Definition	Default Value
EnableLogs	Turns logging on/off	N/A
MaxBlocks	The maximum log file size measured in 100KB “blocks”	0 defaults to 512K Bytes
MaxDuration	The number of minutes before the log file rolls to the next period (synchronized to midnight)	0 defaults to 60 minutes
LogHistory	The number of hours to store log files	0 defaults to 24 hours
ReSyncFreq	The number of hours between resyncing enumeration data	0 defaults to 24 hours
Enables	Enables Enables/disable specific enumeration sets: Color, Control, Detectoors, Preemption, Pedestrians, Overlaps, Coordination and Cabinet.	ALL off defaults to ALL on

After High Resolution Data logs are enabled, the detectors need to be setup so that they can be stored in High Resolution Data file. Detector setup:

1. Press “Main Menu” button
2. Press number “5” – Detectors
3. Press number “1” – VehParms
4. Enable Call for all detectors needed (High Resolution Data detectors need to Call their channel (Det# 9 – Call 9))
5. Press “Back” button
6. Press number “2” – Veh Options

7. Enable Call for all detectors needed and Extend to ones that need extend option
8. Press “Back” button
9. Press number “8” – V/O Speed
10. Press number “1” – Report Params
11. Input Volume and Occupancy period

The Trafficware controller by default only activate detectors 1-8 while if user the wants to use more than 8 detectors, the I/O mode needs to be changed. Depending on how many detectors are needed for the project, user chooses the I/O mode. For this project Trafficware controller Mode 0 is changed to Mode 1:

1. Press “Main Menu” button
2. Press number “1” – Controller
3. Press number “2” – Unit, Ring
4. Press number “1” – Parameters
5. Navigate to “IO Mode” (Press number 1 to change mode – change to Mode 1)
6. Press “ENTR” button and restart the controller (see Figure 4-25)



Figure 4-25. I/O mode interface

4.6.4.3 Siemens Advanced Detector Setup

Configuration of Siemens advanced detectors is done through display attached to the controller which can be removed if necessary. Each detector used for High Resolution Data storage needs to be configured properly. Configuration of advanced detectors:

1. Press number “3” – Phase Data
2. Press number “8” Spec. Detectors
3. Press number “1” for Vehicle detectors 1-8
4. Press number “2” for Vehicle detectors 9-16

5. Setup vehicle detectors (see Figure 4-26)



Figure 4-26. Siemens detector configuration interface

Detector configuration for NEMA TS1 ABC Connector Pins is default for 1-8 detectors while 9-16 needs to be done by user manually. Before remapping the detectors, test can be performed to confirm the need of remapping. Simulation requires 1-16 detectors to be active and stored in High Resolution Data file, while only 1-8 are stored properly. Navigate to Siemens controller screen ABC Input Status (Figure 4-27ABC Input Status):

1. Press number “1” – Active Status
2. Press number “9” – Input/Output
3. Press number “1” – ABC Input Status



Figure 4-27. ABC input status interface

Detectors 9-16 must be enabled, respectively input pins can be remapped just by changing the Mode of operation of Siemens controller. Default operation Mode is 0 and for testing environment Mode 1 is necessary. To change the mapping of detectors 9-16 we need to change from Mode 0 to Mode 1:

1. Press number “4” – Unit Data
2. Press number “8” – I/O Misc
3. Navigate to “ABC” Conn column
4. Under row Input change to “1” (see Figure 4-28)

5. Restart the controller

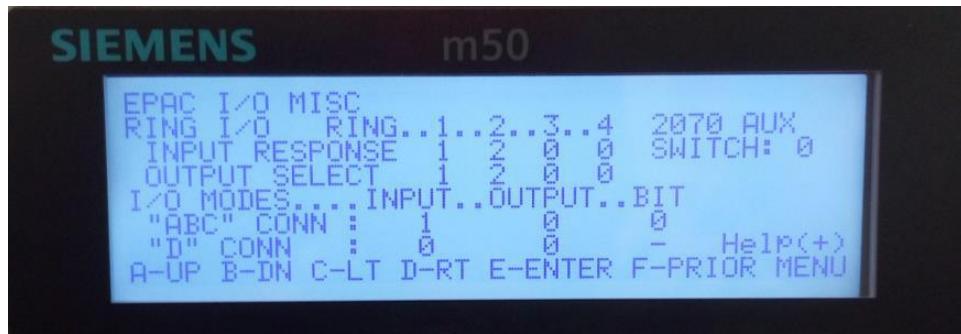


Figure 4-28. Siemens controller mapping interface (Mode 1)

4.6.4.4 Econolite Advanced Detector Setup

Data that controller stores when recording advance detector inputs is called High Resolution Data. For High Resolution Data to be stored in the controller, user needs to configure the detector options accordingly. Figure 4-29 shows how to setup detectors so that detector actuators are stored in High Resolution Data file. To configure advanced detectors in Econolite controller follow these steps:

1. Go to “Home” icon in left upper corner of the controller
2. Go to “Detection” icon
3. Press “Vehicle Detection” to change tab
4. Choose advanced detector channel under “Detector”
5. Enable “ECPI”
6. Enable “NTCIP Log Volume”
7. Enable “NTCIP Log Occupancy”
8. Change “Length” to advanced detector length
9. Restart the controller

	Vehicle Detection	Ped Detection	Detector Log	Vehicle Diagnostic	Ped Diagnostic
Detector	10	Plan	1	Phase	2
Type	NTCIP	Length	72 inch	Lock In	none
TS2	No	Also Calls			
ECPI Log	Yes	Cross Switch Phase	0		
NTCIP Log Volume	Yes	Extension Time	0		
NTCIP Log Occupancy	Yes	Delayed Time	0		
Call Option	No	Added Initial Calculate	No		
Extension Option	Passage	Preempt Queue Delay Calculate	No		

Figure 4-29. Cobalt detector setup for high resolution data storage

The controller default mapping of detectors is setup in so only their first 8 detectors are received from VISSIM as inputs. For this project more than 8 detectors are used and so the mapping needs to be changed. To remap detector configuration for Econolite controller follow these steps:

1. Insert USB drive in the Cobalt controller.
2. Select “save current configuration” or “save all” from the USB menu.
3. Remove the USB drive and insert it in your PC with the Configurator application (provided by the Econolite).
4. Open the Configurator, and select “Base DB”.
5. Then select the L3000.CFG file found inside the same directory as the Configurator application.
6. Select “Current DB”, and navigate to your USB drive where the configuration file from the controller is located.
7. Go to the various tabs at the top of the Configurator to view (see Figure 4-30) and change the pin mapping as needed.

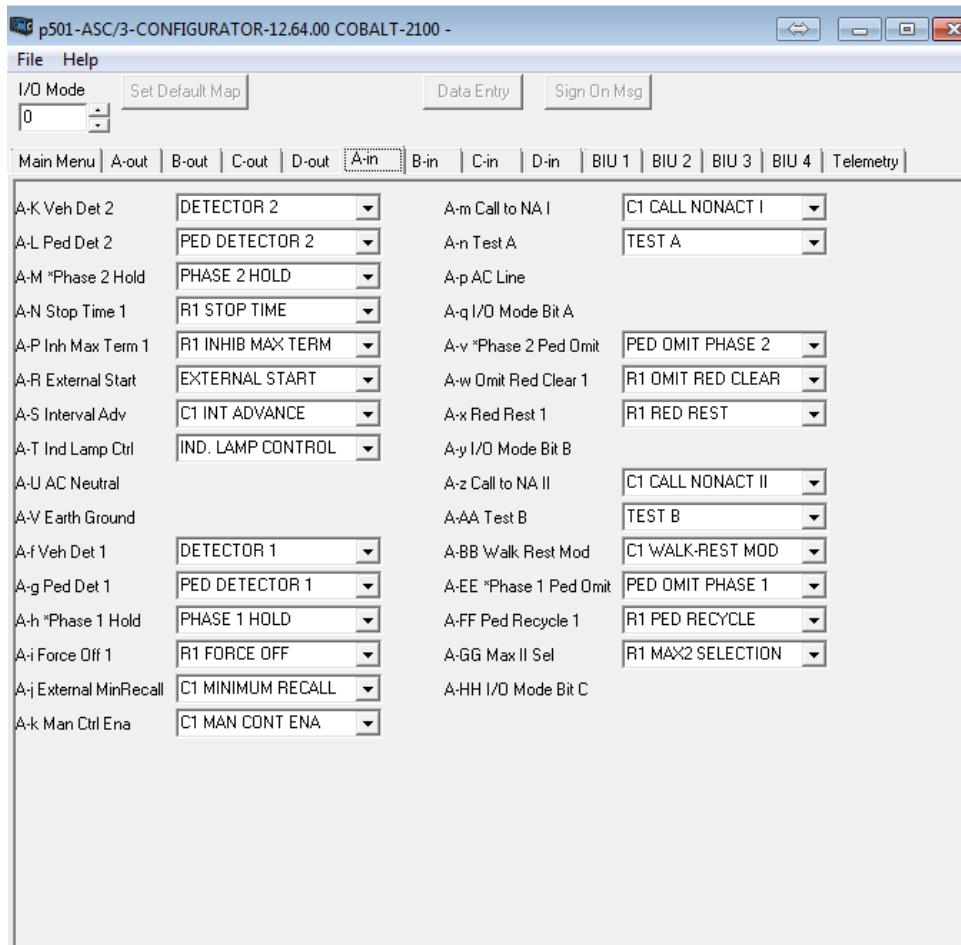


Figure 4-30. Cobalt mapping configuration application interface

After changing the mapping of detectors in the Configuration application database, that database needs to be returned to controller so that changes will have effect:

1. Go to File Menu.
2. Select Save DB (this will overwrite the configuration file on USB drive with the new mapping).
3. Eject your USB drive from PC and insert it back into the Cobalt controller.
4. In the USB menu, select “Database Update” (this will import the saved configuration and make the needed mapping change in the Cobalt controller).

4.6.4.5 Intelight Advanced Detector Setup

Intelight controller High Resolution Data storage is by default disabled and user needs to enable it in order to store high resolution data. To enable high resolution data user has two options: directly through controller display or through the web browser. For enabling High Resolution Data storage, the controller display is used. These steps are necessary in order to enable High Resolution Data storage:

1. Press number “3” – Administration
2. Press number “6” – Event Recorder
3. Press number “1” – System Events
4. Log Enabled – Set to “Enabled”, also user can choose where logs will be stored and log history (hours)
5. Press “ENT” button and restart the controller (see Figure 4-31)

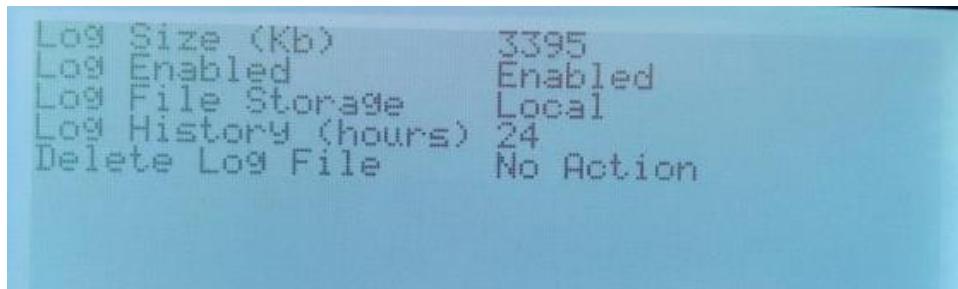


Figure 4-31. System events interface

The advanced detector setup for the Intelight controller is also done through controller display and following steps are necessary to setup detectors to be stored in High Resolution Data files:

1. Press number “2” – Controller
2. Press number “4” – Detector
3. Press number “1” – Vehicle Detector Parameters
4. Enable Call Phase for all detectors needed (High Resolution Data detectors need to Call their channel (Det# 9 – Call 9))
5. Press “ECS” button
6. Press number “2” – Vehicle Detector Options
7. Press number “4” – Detector
8. Enable Volume Detectors (Only High Resolution Data detectors)
9. Press “ECS” button
10. Press number “4” – Volume and Occupancy Setting
11. Set Data Collection Period and Number of Periods (see Figure 4-32)

	1	2	3
Detector	1234567890	1234567890	12345
Vol Det	90123456
Osc Det	12345678
Yel Lock Call
Red Lock Call
Extend	12345678
Add Initial
Queue
Call	12345678
Terminate
Min Grn2
Protected Perm

Figure 4-32. Vehicle detector parameters interface

Intelight mapping is by default set only for detectors 1-8 while detectors 9-16 need to be added by I/O remapping. To remap Intelight controller over controller display is not an easy process, that is why this is usually done through Web browser. To access Web interface of Intelight, controller user need to connect the controller to the same network as the computer or directly to the computer. For this project, controller and computer are on the same network, controller IP address is set up in that way. After accessing the controller over Web browser, using IP address of the controller follow these steps to remap I/O module:

1. Open Web browser and input IP address of the Intelight controller
2. Press “Status” on the left Menu
3. Press “Input & Output Status”
4. Find under “Output Points Status” which pin does specific detector activate (write that down – see Figure 4-33)

Output Points Status		
IO Module:	1	▼
Output Points	1	2
Status	●	●
Control	□	□
	3	4
Status	●	●
Control	□	□
	5	6
Status	●	●
Control	□	□
	7	8
Status	●	●
Control	□	□
	9	10
Status	□	□
Control	□	□
	11	12
Status	□	□
Control	□	□
	13	14
Status	□	□
Control	□	□
	15	16
Status	●	●
Control	□	□
	17	18
Status	□	□
Control	□	□
	19	20
Status	●	●
Control	□	□
	21	22
Status	□	□
Control	□	□
	23	24
Status	□	□
Control	□	□
	25	26
Status	□	□
Control	□	□
	27	28
Status	□	□
Control	□	□
	29	30
Status	□	□
Control	□	□
	31	32
Status	□	□
Control	□	□

Figure 4-33. Output points status interface

5. Press “Controller” on the left Menu
6. Press “Advance IO” on the left Menu
7. Press “Cabinet Configuration” on the left Menu
8. Press “Input Points”

- Under column “Index” find the appropriate Output Points Status (Detector activation on previous step) and change that Index to new Index that is real detector channel from project.

4.6.4.6 McCain Advanced Detector Setup

High Resolution Data storage in McCain controller needs to be enabled before controller can start with storing High Resolution Data files. Enabling High Resolution Data storage in McCain controller:

- Press number “9” – Logs
- Press number “4” – Enable Logs
- High Resolution – Enabled
- Press “ESC” button
- Press number “3” – Setup Logs
- Press number “4” – High Resolution
- Enable necessary logs for High Resolution Data storage (see Figure 4-34)



Figure 4-34. High resolution log setup interface

After the High Resolution Data storage is enabled and parameters are modified, the detector setup needs to be done so that data from the detectors used in the project can be stored properly. The detector setup is done through 5 steps:

- Press number “4” – Detectors
- Press number “1” – Vehicle Detectors
- Press number “1” – Select a Vehicle Detector Set

4. Enable Call for all detectors needed (High Resolution Data detectors need to Call their channel (Det# 9 – Call 9))
5. Press “ENT” than press “YES-Finalize DB Transaction” (see Figure 4-35)

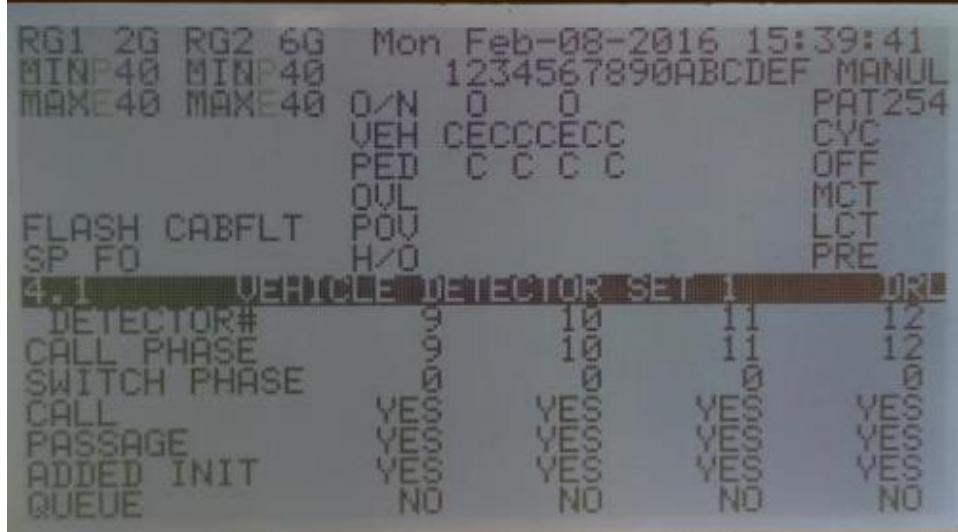


Figure 4-35. Vehicle detector setup interface

Pins for advanced detector need are required to be changed in order to have detector 8-16 actuators. To change the mapping on the McCain controller, follow these steps:

1. Press number “1” – Unit
2. Press number “5” – I/O Mapping
3. Press number “1” – NEMA ABCD
4. Press number “1” – Inputs
5. Navigate through “Pin” enumerations and find the ones needed to be changed (change them to Vehicle Detector number that is needed)
6. Save the changes and restart the controller

4.6.5 Controller Detector Setup for Trafficware Controller Interface Device (CID)

Even though all the cables are connected and controllers are turned on, the communication between controller and Trafficware CID is still not established. In order to enable SDLC communication that Trafficware CID uses to communicate with controllers, configuration of controllers SDLC communication is needed.

4.6.5.1 PEEK Controller Interface Device (CID) Setup

The PEEK controller needs to be connected to Trafficware CID with SDLC cable and Trafficware CID needs to be connected to computer with RS232 cable before continuing with the setup. First in order to enable SDLC communication PEEK operation mode needs to be changed.

SDLC communication only works with TS2 Type 1 operation mode. To change PEEK operation mode these steps are followed:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “1” – Unit Configuration
4. Press number “5” – Comms and I/O Setup Menu
5. Press number “4” – I/O Mapping
6. Change Operation Type to “TS2 Type 1”

Setting up PEEK controller SDLC communication is done with these steps:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “1” – Unit Configuration
4. Press number “5” – Comms and I/O Setup Menu
5. Press number “1” – Port 1
6. Enable “Term & Facils” 1,2,3,4
7. Enable “Detector rack” 1,2,3,4
8. MMU Enable – “X” (see Figure 4-36)

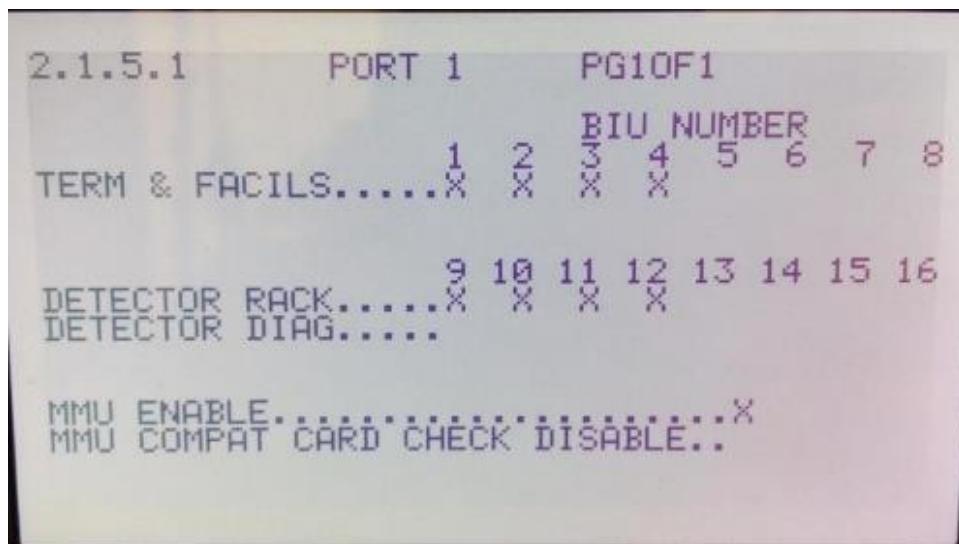


Figure 4-36. PEEK controller Port 1 interface

4.6.5.2 Trafficware Controller Interface Device (CID) Setup

The Trafficware controller needs to be connected to Trafficware CID with SDLC cable and Trafficware CID needs to be connected to computer with RS232 cable before continuing with the setup. Trafficware controller SDLC setup is done with these steps:

1. Press “Main Menu” button
2. Press number “1” – Controller
3. Press number “7” – Enable Run
4. Navigate to “Change to: Off” and press “ENTR” button
5. Go back by pressing “Main Menu” button
6. Press number “1” – Controller
7. Press number “3” – SDLC
8. Press number “1” – TS2 Devices
9. Enable “Term/Fac” 1,2,3,4
10. Enable “Detector” 1,2,3,4
11. Enable MMU – “X”
12. Press “ENTR” button to save and restart the controller (see Figure 4-37)



Figure 4-37. Trafficware SDLC interface

4.6.5.3 Siemens Controller Interface Device (CID) Setup

Controller needs to be connected to Trafficware CID with SDLC cable and Trafficware CID needs to be connected to computer with RS232 cable before continuing with the setup. For SDLC communication Siemens operation mode (TS2) needs to be changed. Siemens operation mode change instructions are shown below:

1. Press number “2” – Utilities
2. Press number “6” – Load Default

3. Press letter “C” – Than press number “2” to change Siemens controller operating mode to TS2

4. Restart the controller

After operating mode is changed, SDLC communication needs to be enabled. Enabling SDLC communication:

1. Press number “4” – Unit Data

2. Press number “7” – Port 1/ITS Data

3. Under column “PRES”, change T&F BIU #1,2,3,4 and DET BIU #1,2 and Malfunction Unit to “1” (see Figure 4-38)

4. Restart the controller

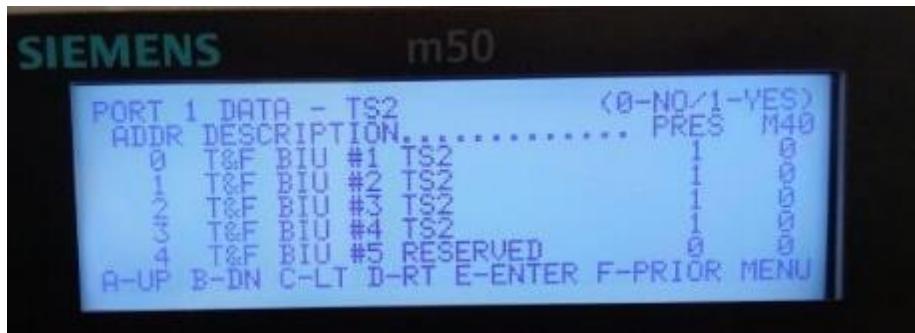


Figure 4-38. SDLC communication for Siemens controller

Trafficware CID has the default overlaps on 9, 10, 11 & 12 channels and the Siemens controller is set for the overlaps on channels 13, 14, 15, 16 and that needs to be changed for SDLC communication. Channing overlaps on Siemens controller is shown below:

1. Press number “4” – Unit Data

2. Press number “5” – Ring Structure

3. Edit Phase 2 and move Pedestrian Channel from 9 to 13

4. Edit phase 4 and move Pedestrian Channel from 10 to 14

5. Edit phase 6 and move Pedestrian Channel from 11 to 15

6. Edit Phase 8 and move Pedestrian Channel from 12 to 16

7. Press button “ENT” to save changes

8. Press button “ESC” to return one menu back

9. Press number “3” – Overlap Standard

10. Press button “A” – Change Overlap A from channel 13 to channel 9

11. Press button “B” – Change Overlap B from channel 14 to channel 10

12. Press button “C” – Change Overlap C from channel 15 to channel 11

13. Press button “D” – Change Overlap D from channel 16 to channel 12
14. Press button “ENT” to save changes
15. Press button “ESC” to return one menu back
16. Press number “9” – Signal Driver Outputs
17. Change Pedestrian channels from 2,4,6,8 to channels 13, 14,15,16
18. Change Overlap on A, B, C, D to output pins 17,18,19,20

4.6.5.4 Econolite Controller Interface Device (CID) Setup

The Econolite controller needs to be connected to Trafficware CID with SDLC cable and Trafficware CID needs to be connected to the computer with RS232 cable before continuing with the setup. To turn on SDLC communication, follow these steps:

1. Go to “Home” icon in left upper corner of the controller
2. Go to “Cabinet Config” icon
3. Press “SDLC Devices” to change tab
4. Enable “Term & Facility” 1 and 2
5. Enable “Detector Rack” 1 and 2
6. Enable “Malfunction Management Unit (MMU)” (see Figure 4-39)
7. Restart the controller

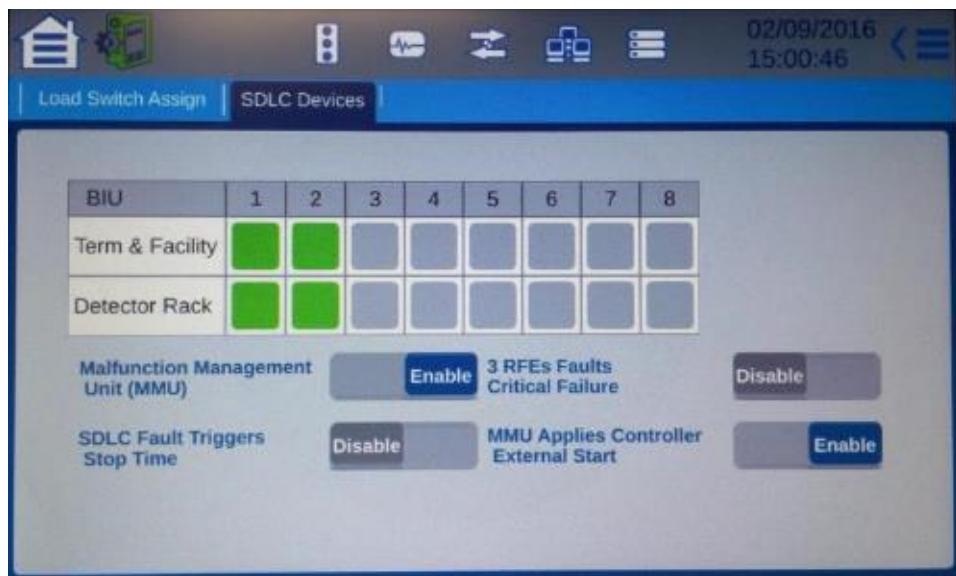


Figure 4-39. Cobalt SDLC setup example

4.6.5.5 Intelight Controller Interface Device (CID) Setup

Before connection Trafficware CID with the controller, user needs to see if right I/O module is in place. After right I/O module is in place, controller is connected to Trafficware CID with SDLC cable and Trafficware CID needs to be connected to computer with RS232 cable in order to continue with the setup:

1. Press “Controller” on the left Menu
2. Press “Advance IO” on the left Menu
3. Press “Cabinet Configuration” on the left Menu
4. Press “IO Modules”
5. Under IO Module 1 select “TS2 TF1 BIU”
6. Under IO Module 2 select “TS2 TF2 BIU”
7. Under IO Module 3 select “TS2 DR1 BIU”
8. Under IO Module 4 select “TS2 DR2 BIU”
9. Under IO Module 5 select “TS2 MMU”
10. Under IO Module 6 select “2070 2N”
11. Press “Apply” button (see Figure 4-40)

IO Modules

IO Module	Type
1	TS2 TF1 BIU
2	TS2 TF2 BIU
3	TS2 DR1 BIU
4	TS2 DR2 BIU
5	TS2 MMU
6	2070 2N
7	None
8	None
9	None
10	None

Apply

WARNING:
Changing the type of an IO Module will
reset any custom input/output point configuration.

Figure 4-40. IO modules interface

4.6.5.6 McCain Controller Interface Device (CID) Setup

Controller needs to be connected to Trafficware CID with SDLC cable and Trafficware CID needs to be connected to computer with RS232 cable before continuing with the setup. For SDLC communication operating mode to TS2 Type 1 BIU is changed:

1. Press letter “B” on Main Menu screen - Miscellaneous
2. Press number “2” – DB Management
3. Press number “1” – Initialize Database
4. Press number “2” – I/O Map Only
5. Press number “1” – NEMA TS2 Type 1 BIU
6. Press button “YES” and then button “ENT”
7. Press button “YES” – Finalize Database Transaction to save the changes
8. Restart the controller

After operating mode is changed SDLC communication is enabled for the Trafficware CID:

1. Press number “1” – Unit
2. Press number “7” – NEMA TS2 Setup
3. Enable “TF BIU” 1,2,3,4
4. Enable “Det BIU” 1,2,3,4
5. MMU – “NO”
6. Press button “ENT” and then button “YES” to Finalize Database Transaction (see Figure 4-41)

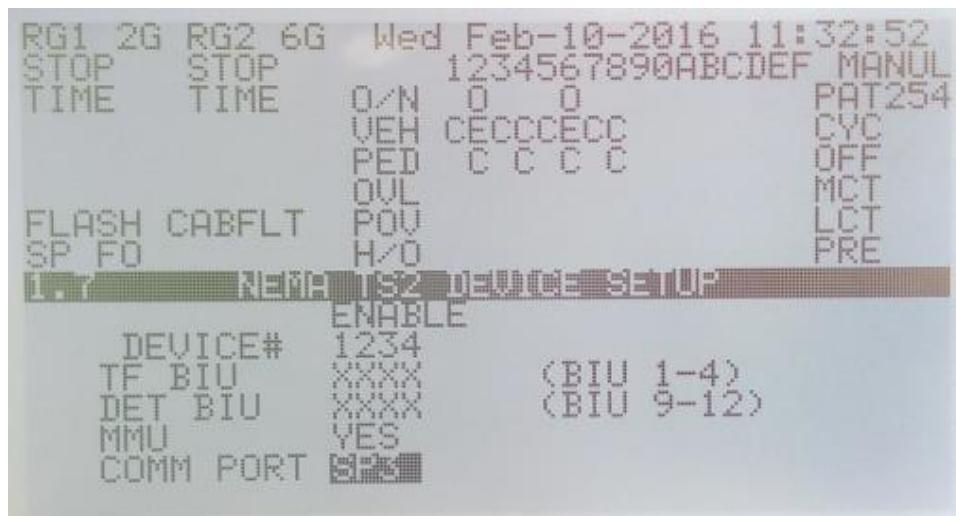


Figure 4-41. NEMA TS2 device setup interface

4.6.6 Manual Coordination Setup for Controllers

Manual coordination means that controller will be synchronized only by the clock. However, achieving manual coordination is not usually the way for real traffic corridor due to different ticks of different controller clocks. Each controller has different setup, meaning that configuration of controller is not easy and exactly the same for all the controllers. For the manual coordination Phases 2 and 6 are used, that are phases on Glades Road. Phase 2 is the main coordination phase for this study because PM peak is selected and Phase 2 is used for accommodating vehicles traveling to I-95 and Florida Turnpike. Cycle length in this study is decided to stay the same for all six HILS intersections like in RBC network model. Four intersections have cycle length of 160 seconds while one intersection (Glades Road – Airport Rd) is 180 seconds and second intersection (Glades Road & Dixie Hwy) is 150 seconds. Manual coordination is created for Phase 2 and 6, but Phase 2 has priority for PM peak setup.

4.6.6.1 PEEK Controller Coordination Manual Setup

The PEEK controller is on first intersection in the corridor and its clock is the most important one. Later in the configuration all controllers should have the same time and date as PEEK controller. Also, important is to configure coordination reference point from Phase 2 of PEEK controller that will be starting point of the coordination (0 second in cycle). To configure coordination parameters, follow this steps:

1. Press “MNU” button
2. Press number “2” – Programming
3. Press number “3” – Coordination
4. Press number “1” – Unit/Global Settings. Only important changes for this study are presented:
 - a. Operation Mode - 1 (0-255), this is pattern mode used for the study.
 - b. Pattern Sync – 00000, this is time when synchronization is done (see Figure 4-42).

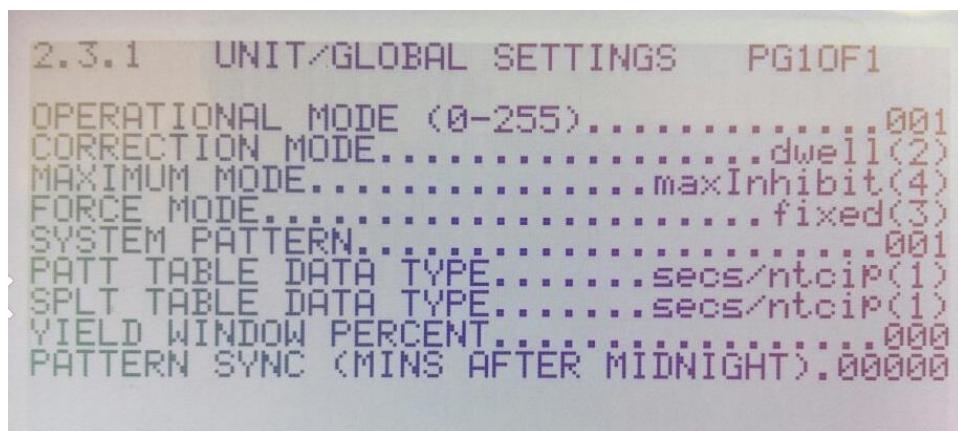
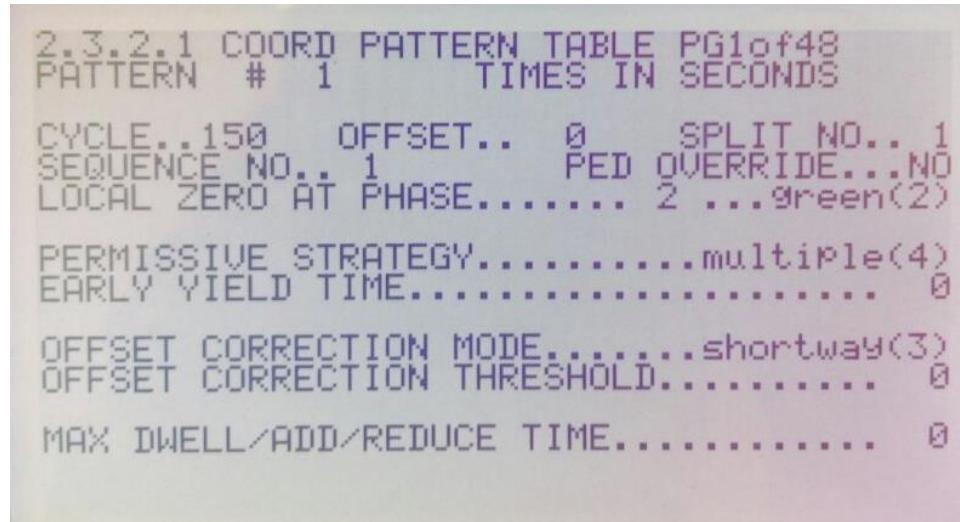


Figure 4-42. PEEK Unit/Global settings interface

5. Press button “PRV” to return to Coordination menu
6. Press number “2” – Pattern Table. Only important changes for this study are presented:
 - a. Cycle – 150 seconds, cycle time that is used for this study.
 - b. Offset – 0, 0 is used because this is first intersection and there is no offset.
 - c. Split No. – 1, time that is used for configured Split 1.
 - d. Sequence No. – 1, configured sequence based on the TOD (see Figure 4-43).



```

2.3.2.1 COORD PATTERN TABLE PG1of48
PATTERN # 1 TIMES IN SECONDS

CYCLE...150   OFFSET... 0   SPLIT NO... 1
SEQUENCE NO... 1   PED OVERRIDE... NO
LOCAL ZERO AT PHASE..... 2 ...green(2)

PERMISSIVE STRATEGY.....multiple(4)
EARLY YIELD TIME..... 0

OFFSET CORRECTION MODE...shortway(3)
OFFSET CORRECTION THRESHOLD..... 0

MAX DWELL/ADD/REDUCE TIME..... 0
  
```

Figure 4-43. PEEK pattern table interface

7. Press button “PRV” to return to Coordination menu
8. Press number “3” – Split Table. Change split timing based on TOD configuration for selected intersection, chose coordination phases (2 and 6) (see Figure 4-44).

2.3.3. 1 COORD SPLIT TABLE PG 1 of 16								
TABLE # 1 TIMES IN SECONDS								
PHASE :	1	2	3	4	5	6	7	8
SPLIT :	32	46	0	72	20	58	22	50
MODE :	3	4	2	3	3	4	3	3
COORD PH:	X					X		
ST PERM:	0	0	0	0	0	0	0	0
END PERM:	0	0	0	0	0	0	0	0
PHASE :	9	10	11	12	13	14	15	16
SPLIT :	0	0	0	0	0	0	0	0
MODE :	2	2	2	2	2	2	2	2
COORD PH:								
ST PERM:	0	0	0	0	0	0	0	0
END PERM:	0	0	0	0	0	0	0	0

Figure 4-44. PEEK split table interface

4.6.6.2 Trafficware Controller Coordination Manual Setup

The Trafficware controller manual coordination is done through screen on the controller. The Trafficware controller clock needs to manually be synchronized with PEEK controller because PEEK controller is assigned to be the “Master controller” considering the time clock. Also, important is to configure coordination reference point from Phase 2 of the Trafficware controller. To configure coordination parameters, follow this steps:

1. Press “Main Menu” button
2. Press number “2” – Coordinate
3. Press number “1” – Modes, +
- a. Test OpMode – 1. Overwrites program used for coordination (see Figure 4-45).

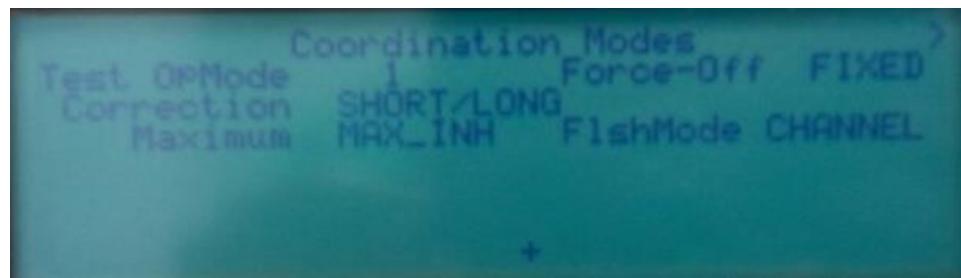


Figure 4-45. Trafficware modes + interface

4. Go back by pressing “Back” button
5. Press number “4” – Pattern Tbl
- a. Under Pat# - 1

- i. Cycle – 160
- ii. Offset – 33 (offset can be changed manually based on the vehicle arrivals)
- iii. Split – 1
- iv. Seqnc – 1 (see Figure 4-46)

Path#	Cycle	Offset	Split	Seqnc
1	160	33	1	1
2	000	00	2	1
3	000	00	3	1
4	000	00	4	1
5	000	00	5	1
6	000	00	6	1
7	000	00	7	1
8	000	00	8	1

Figure 4-46. Trafficware pattern table interface

6. Go back by pressing “Back” button
7. Press number “7” – Splits
8. Under “Enter Split” – 1 and then press button “Entr”
 - a. Press number “1”
 - i. Change split timing based on TOD configuration for selected intersection, chose coordination phases (2 and 6) (see Figure 4-47).

SPI - 1	P...1...	2...	3...	4...	5...	6...	7...	8...
Time	28	60	22	50	20	68	20	52
Coor-P	X							
Mode	MIN	MAX	MIN	MIN	MIN	MAX	MIN	MIN

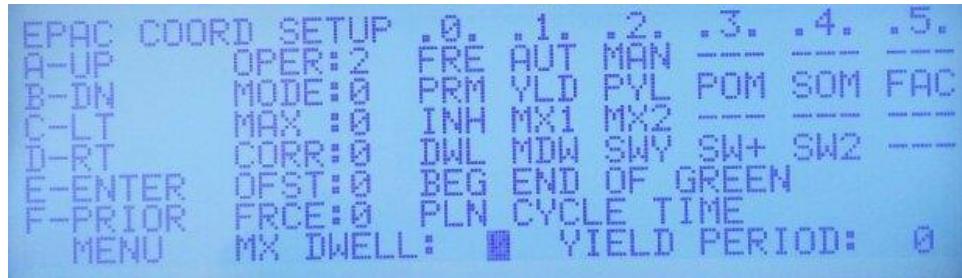
Figure 4-47. Trafficware splits interface

4.6.6.3 Siemens Controller Coordination Manual Setup

Siemens controller manual coordination is done via screen on the controller. Siemens controller clock needs to manually be synchronized with PEEK controller because PEEK controller is assigned to be the “Master controller” considering the time clock. Also, important is to configure coordination reference point from phase 2 of Siemens controller. To configure coordination parameters, follow this steps:

1. Press number “5” – Coord Data
2. Press number “1” – Setup Coord
 - a. Under “Oper” – 2. Overwrites program used for coordination (manually).

- b. Under “Ofst” – 0. Coordination phase offset is set to be: Beginning of green.
- c. Under “Frce” – 0 (see Figure 4-48).



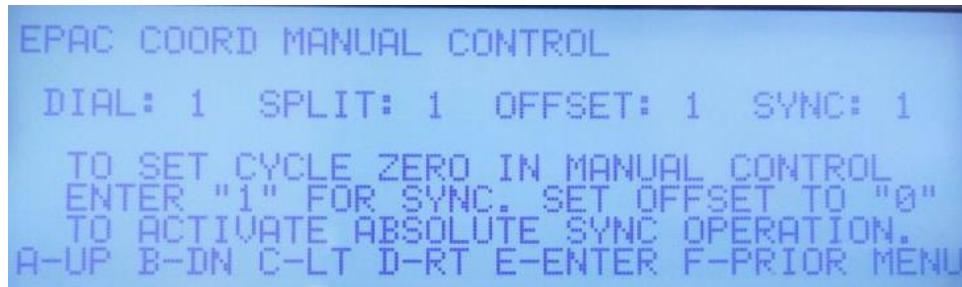
```

EPAC COORD SETUP .0. .1. .2. .3. .4. .5.
A-UP OPER:2 FRE AUT MAN ---- ---- ----
B-DN MODE:0 PRM YLD PYL POM SOM FAC
C-LT MAX:0 INH MX1 MX2 ---- ---- ----
D-RT CORR:0 DWL MDW SWY SW+ SW2 ----
E-ENTER OFST:0 BEG END OF GREEN
F-PRIOR FRCE:0 PLN CYCLE TIME
MENU MX DWELL: ■ YIELD PERIOD: 0

```

Figure 4-48. Siemens setup coordination interface

- 3. Go back by pressing “esc” button
- 4. Press number “2” – Manual Control
 - a. Under “Dial” – 1
 - b. Under “Split” – 1
 - c. Under “Offset” – 1
 - d. Under “Sync” – 1 (see Figure 4-49)



```

EPAC COORD MANUAL CONTROL
DIAL: 1 SPLIT: 1 OFFSET: 1 SYNC: 1
TO SET CYCLE ZERO IN MANUAL CONTROL
ENTER "1" FOR SYNC. SET OFFSET TO "0"
TO ACTIVATE ABSOLUTE SYNC OPERATION.
A-UP B-DN C-LT D-RT E-ENTER F-PRIOR MENU

```

Figure 4-49. Siemens manual control interface

- 5. Go back by pressing “esc” button
- 6. Press number “3” – Dial/Split Data
 - a. Under “Dial” – 1
 - b. Under “Split” – 1
 - c. Under “Level” – 1 (Offset parameters).
 - i. Under Dial Pat# - 001
 - 1. Under “Tim Sec” – 67 (Siemens intersection offset time).

2. Under “Pat Mod” – 1 (Pattern used for study).
3. Under “Cor Mod” – 1 (see Figure 4-50).



Figure 4-50. Siemens offset interface

7. Go back by pressing “esc” button
 - a. Under “Dial” – 1
 - b. Under “Split” – 1
 - c. Under “Level” – 2 (Split parameters).
 - i. Under “Time” – Change split timing based on TOD configuration for selected intersection.
 - ii. Under “Mode” – Change to 1 for coordinated phases (2 and 6) (see Figure 4-51).



Figure 4-51. Siemens split interface

4.6.6.4 Econolite Controller Coordination Manual Setup

The Econolite controller manual coordination is done only via touch screen. The Econolite controller clock needs to be manually synchronized with PEEK controller because PEEK controller is assigned to be the “Master controller” considering the time clock. Also, important is to configure coordination reference point from phase 2 of Econolite controller. To configure coordination parameters, follow this steps:

1. Go to “Home” icon in left upper corner of the controller
2. Go to “Coordination” icon
 - a. Offset Reference – Ring 1, in Ring 1 is Phase 2 located.

b. Priority System Source – Time-Based (see Figure 4-52).



Figure 4-52. Econolite coordination interface

3. Go to “Home” icon in left upper corner of the controller
4. Go to ”Event Plans” icon
5. Press “Add New Plan”
 - a. Chose Plan name (6 – thesis), Type (Coordination) and press “Ok”
 - b. Select Event Plan (6 - thesis)
 - i. Sequence - 1 (configured sequence based on the TOD)
 - ii. Timing Plan – 1 (plan used for this study)
 - iii. Manual Override select Yes (this is selected so that for this study only this Event Plan is used) (see Figure 4-53)

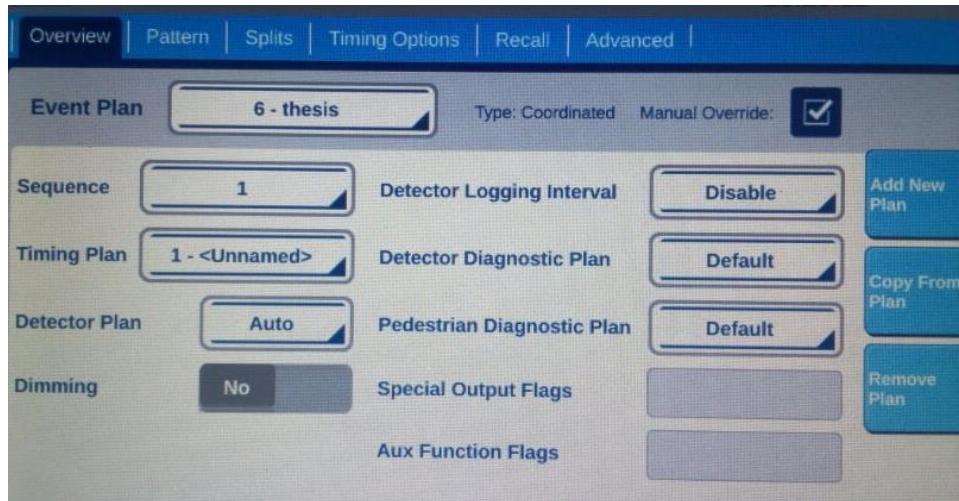


Figure 4-53. Econolite coordination overview interface

6. Press Tab “Pattern”

- Under “Cycle” – 160 seconds
- Under “Offset Value” – 105 seconds (this time can be changed depending on the manual coordination requirements) (see Figure 4-54).



Figure 4-54. Econolite coordination pattern interface

7. Press Tab “Splits”

- Split - Change split timing based on TOD configuration for selected intersection.
- Ring Coord Phase – Select phases 2 and 6 (see Figure 4-55)

- c. Offset Value – 105 seconds (this time can be changed depending on the manual coordination requirements)

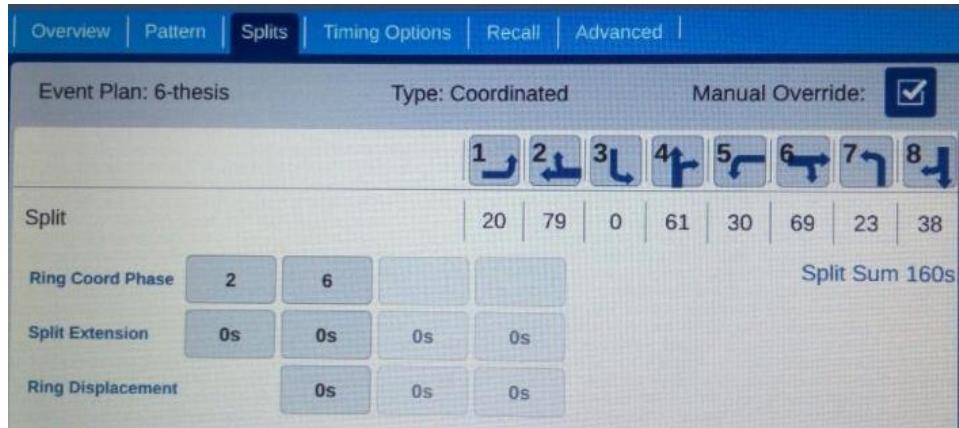


Figure 4-55. Econolite coordination splits interface

4.6.6.5 Intelight Controller Coordination Manual Setup

The Intelight controller manual coordination is done via screen on the controller. The Intelight controller clock needs to manually be synchronized with PEEK controller because PEEK controller is assigned to be the “Master controller” considering the time clock. Also, important is to configure coordination reference point from Phase 2 of Intelight controller (step 7). To configure coordination parameters, follow this steps:

1. Press number “2” – Controller
2. Press number “5” – Coordination
3. Press number “1” – Coord Parameters
 - a. Under “Operational Mode” – Pattern 1 (see Figure 4-56)

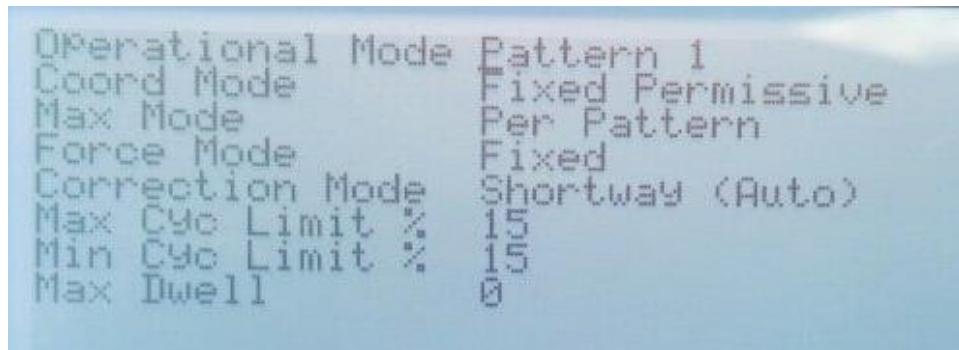


Figure 4-56. Intelight coordination parameters interface

4. Press “ESC” button to return to Coordination menu

5. Press number “2” – Patterns

- a. Under “Cycle Time” – 160
- b. Under “Offset Time” – 11
- c. Under “Split Number” – 1
- d. Under “Seq Number” – 1 (see Figure 4-57)
- e. Under “Reference Point” – 1

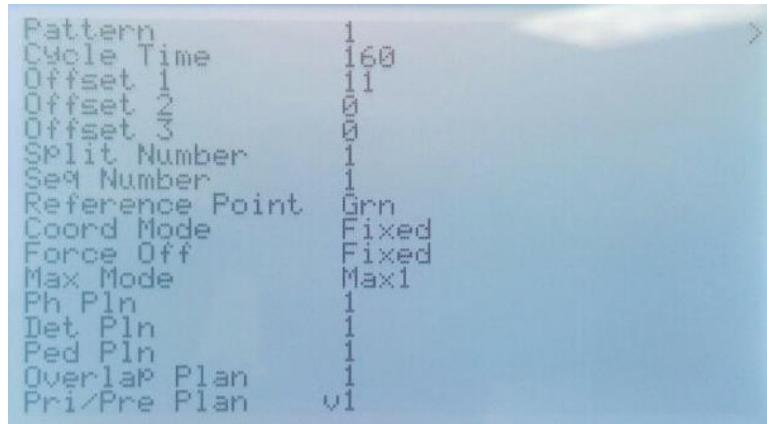


Figure 4-57. Intelight patterns interface

6. Press “ESC” button to return to Coordination menu

7. Press number “3” – Splits

- a. Select Split 1 and press “ENT” button
 - i. Under “Time” – Change split timing based on TOD configuration for selected intersection.
 - ii. Under “Min” – Change minimum timing of phases based on TOD configuration for selected intersection.
 - iii. Under “Max” – Change maximum timing of phases based on TOD configuration for selected intersection.
 - iv. Under “Coord” – Select phases 2 and 6.
 - v. Under “Ref” – Select phase 2 as reference offset point (see Figure 4-58).

Phase	Time	Min	Max	Coord	Ref	Point
1	29	10	20	C	R	
2	00	10	20	.	.	
3	00	10	14	.	.	
4	00	10	14	.	.	
5	00	10	15	C	.	
6	00	10	15	.	.	
7	00	10	16	.	.	
8	00	10	17	.	.	
9	00	10	18	.	.	
10	00	10	19	.	.	
11	00	10	20	.	.	
12	00	10	20	.	.	
13	00	10	20	.	.	
14	00	10	20	.	.	
15	00	10	20	.	.	

Figure 4-58. Intelight split interface

4.6.6.6 McCain Controller Coordination Manual Setup

The McCain controller manual coordination is done via screen on the controller. The McCain controller clock needs to manually be synchronized with PEEK controller because PEEK controller is assigned to be the “Master controller” considering the time clock. Also, important is to configure coordination reference point from phase 2 of McCain controller. To configure coordination parameters, follow this steps:

1. Press number “5” – Coordination
2. Press number “1” – Constants (Change if necessary – see Figure 4-59).

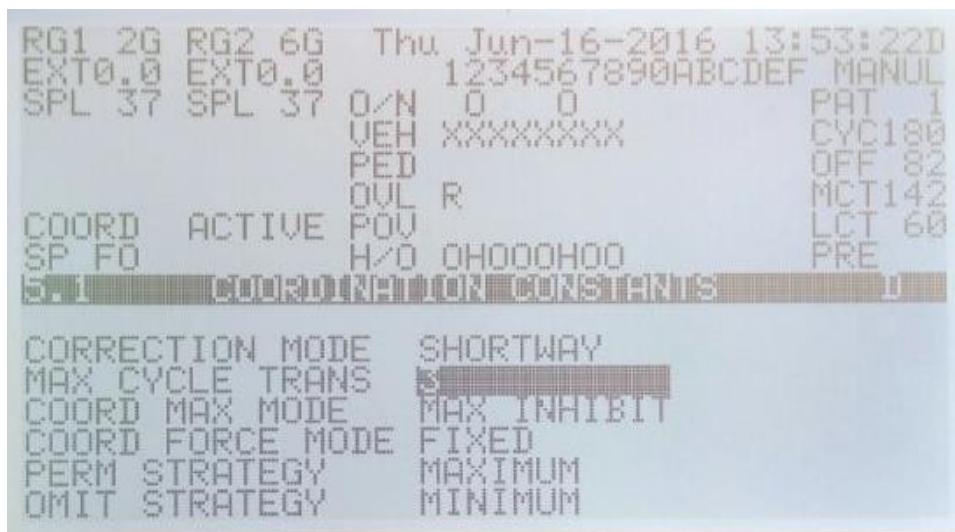


Figure 4-59. McCain pattern interface

3. Press “ESC” button to return to Coordination menu
4. Press number “2” – Pattern

- a. Under “Select a Pattern” – 1 and press “ENT” button
 - i. Under “Cycle Time” – 180
 - ii. Under “Offset Time” – 82
 - iii. Under “Split” – 1
 - iv. Under “Sequence” – 1 (see Figure 4-60)

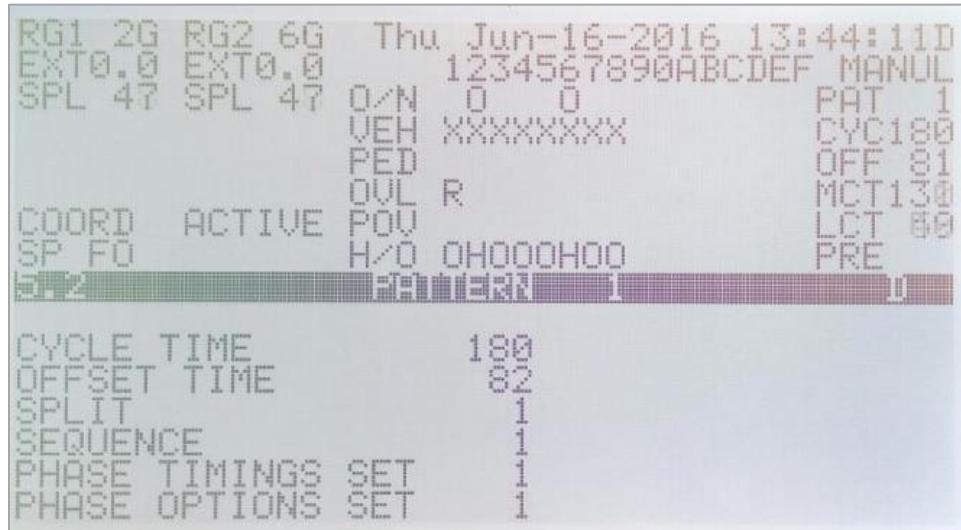


Figure 4-60. McCain pattern interface

- 5. Press “ESC” button two times to get back to Coordination menu
- 6. Press number “3” – Split Tables
 - b. Under “Select a Split Table” – 1 and press “ENT” button
 - i. Under “Time” – Change split timing based on TOD configuration for selected intersection.
 - ii. Under “Mode” – Select phase recall options.
 - iii. Under “Coord” – Select phases 2 and 6 (see Figure 4-61).

RG1	20	RG2	60	Sat	Jul-09-2016	18:17:21D
EXT2.0	EXT2.0			1234567890ABCDEF		MANUL
SPL 39	SPL 38	O/N	O	O	PAT	1
		VEH	CXCRRXCC		CYC180	
		PED			OFF	82
		OVL	R		MCT	141
COORD	ACTIVE	POU			LCT	59
SP FO	H/O	OHOOOHOO			PRE	
PHASE#	1	2	3	4	5	6
TIME	30	89	16	45	16	103
MODE	MINU	MAXU	MINU	MINU	MINU	MAXU
COORD		X				X
MAN PERM	0	0	0	0	0	0
MAN OMIT	0	0	0	0	0	0

Figure 4-61. McCain split table interface

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A Appendix: High Resolution Data Performance Metrics Graphs

A.1 Econolite (Cobalt) High Resolution Data Performance Metrics

a) Approach Delay – Cobalt (C:\inetpub\wwwroot\SignalPerformanceMetrics)

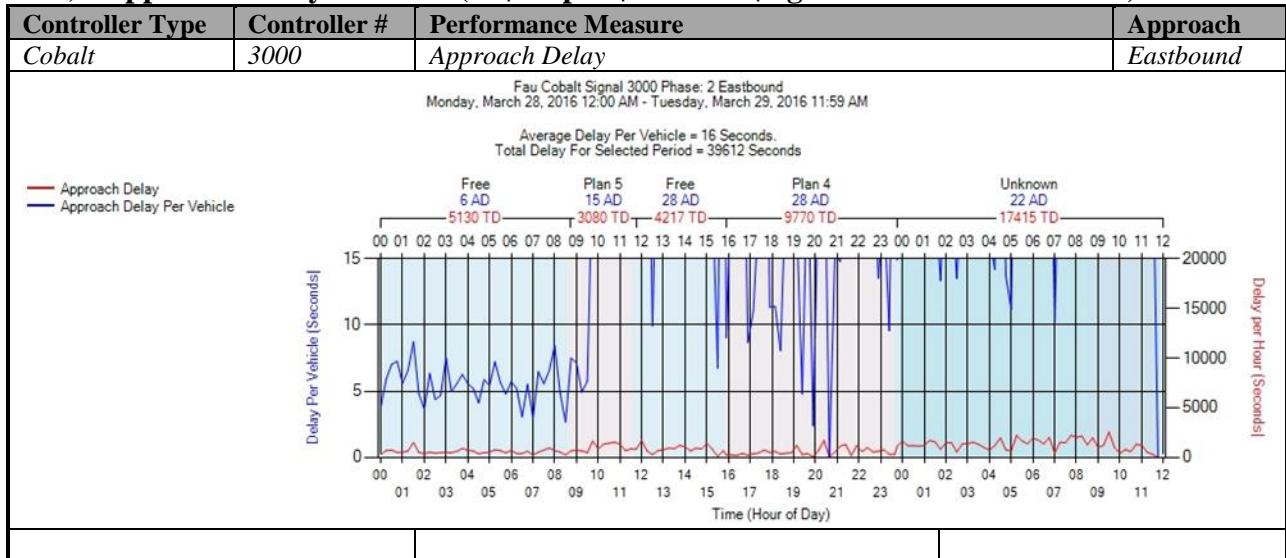


Figure A-1. Cobalt – Approach Delay – EB

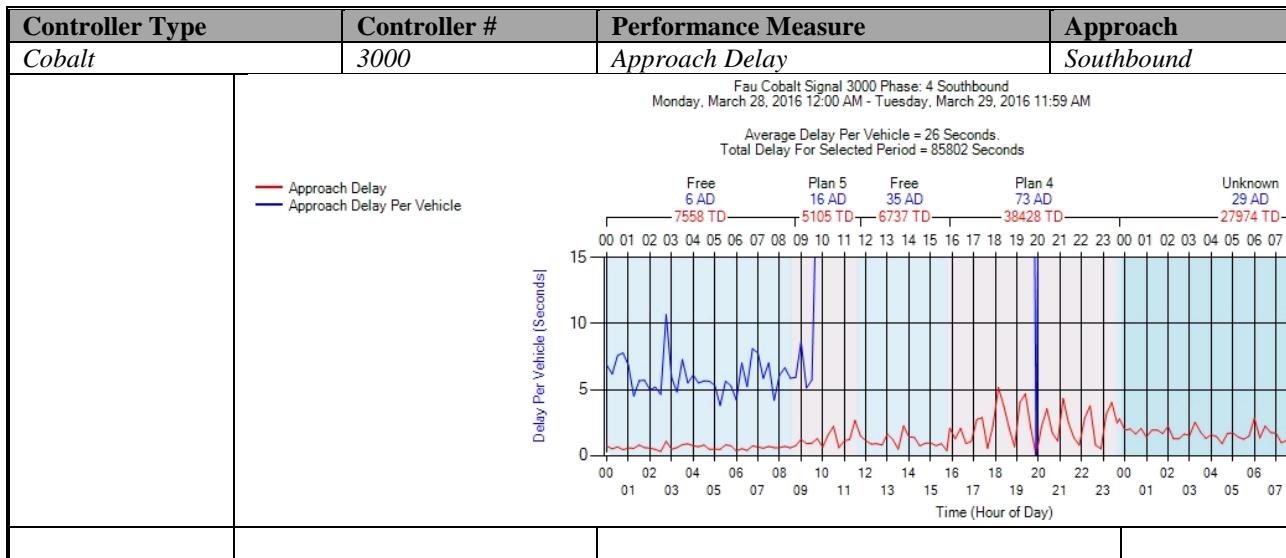


Figure A-2. Cobalt – Approach Delay – SB

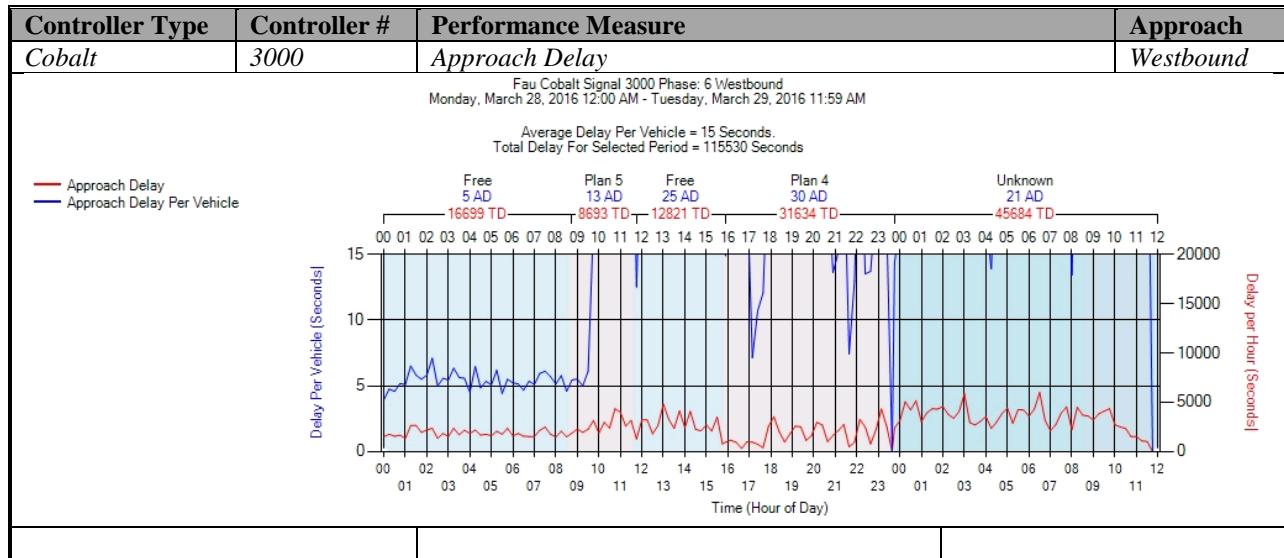


Figure A-3. Cobalt – Approach Delay – WB

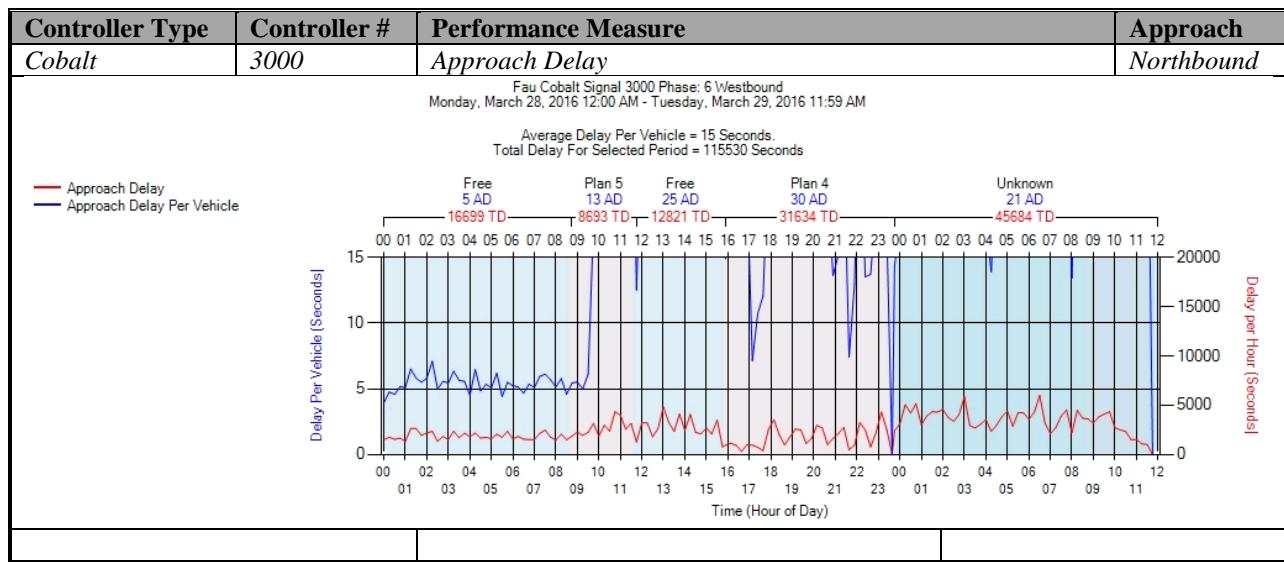


Figure A-4. Cobalt – Approach Delay – NB

b) Approach Volume - Cobalt (C:\inetpub\wwwroot\SignalPerformanceMetrics)

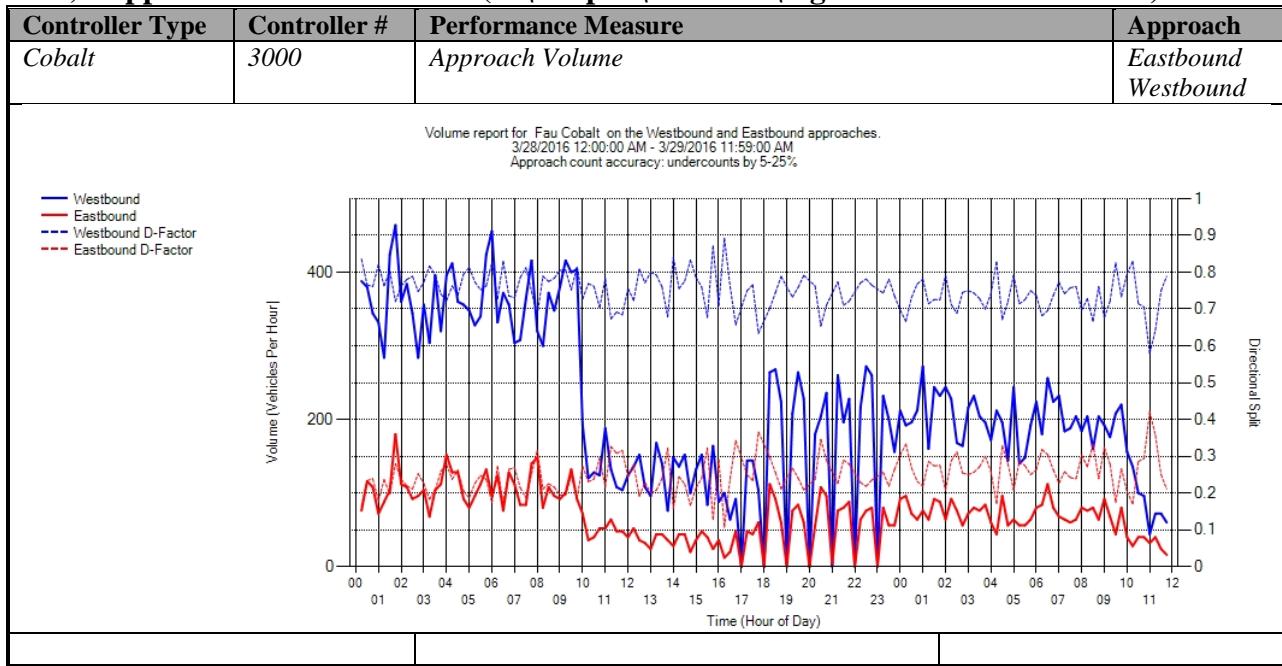


Figure A-5. Cobalt – Approach Volume – WB & EB

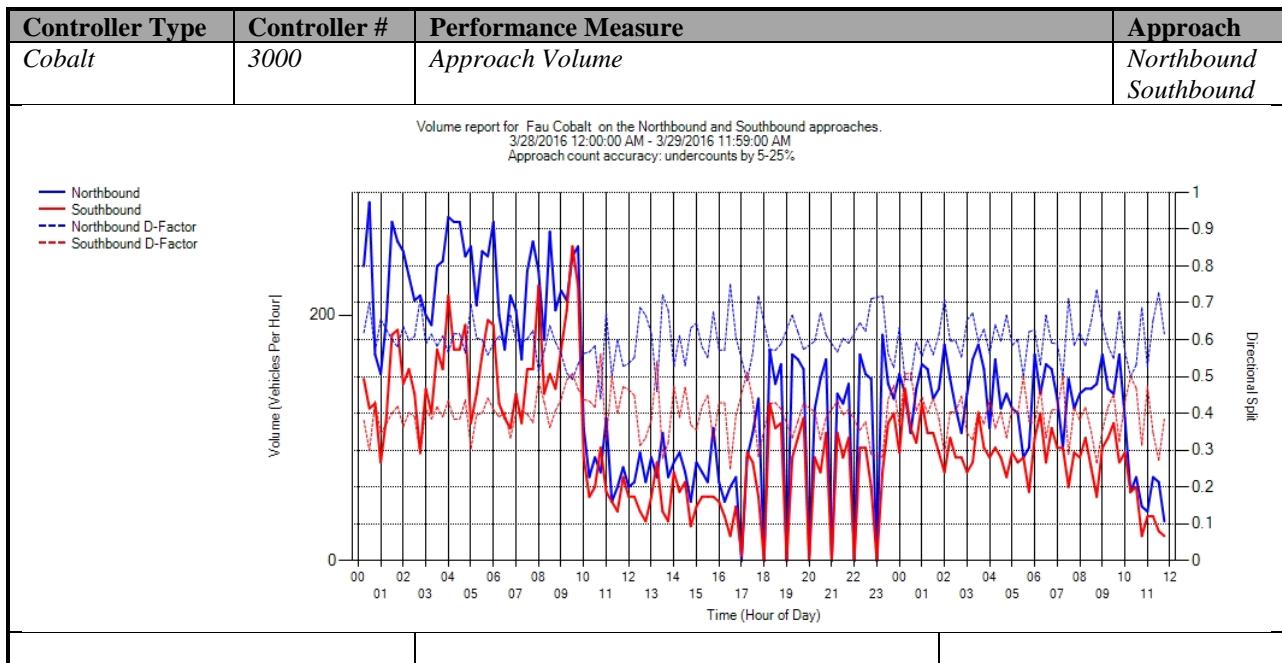


Figure A-6. Cobalt – Approach Volume – NB & SB

Controller Type	Controller #	Performance Measure	Approach																																							
<i>Cobalt</i>	3000	<i>Approach Volume</i>	<i>Total</i>																																							
<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>8,397</td></tr> <tr> <td>Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>458</td></tr> <tr> <td>PHF</td><td>0.923</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Northbound Total Volume</td><td>5,036</td></tr> <tr> <td>Northbound Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Northbound Peak Hour Volume</td><td>270</td></tr> <tr> <td>Northbound PHF</td><td>0.964</td></tr> <tr> <td>Northbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Northbound Peak-Hour D-factor</td><td>0.696</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Southbound Total Volume</td><td>3,361</td></tr> <tr> <td>Southbound Peak Hour</td><td>9:00 AM - 10:00 AM</td></tr> <tr> <td>Southbound Peak Hour Volume</td><td>214</td></tr> <tr> <td>Southbound PHF</td><td>1</td></tr> <tr> <td>Southbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Southbound Peak-Hour D-factor</td><td>1.09</td></tr> </tbody> </table>			Metric	Value	Total Volume	8,397	Peak Hour	4:00 AM - 5:00 AM	Peak Hour Volume	458	PHF	0.923	Peak-Hour K-factor	NA			Northbound Total Volume	5,036	Northbound Peak Hour	4:00 AM - 5:00 AM	Northbound Peak Hour Volume	270	Northbound PHF	0.964	Northbound Peak-Hour K-factor	NA	Northbound Peak-Hour D-factor	0.696			Southbound Total Volume	3,361	Southbound Peak Hour	9:00 AM - 10:00 AM	Southbound Peak Hour Volume	214	Southbound PHF	1	Southbound Peak-Hour K-factor	NA	Southbound Peak-Hour D-factor	1.09
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Eastbound Peak-Hour D-factor	2.86																																									

Figure A-7. Cobalt – Approach Volume – WB

c) Arrivals On Red - Cobalt (C:\inetpub\wwwroot\SignalPerformanceMetrics)

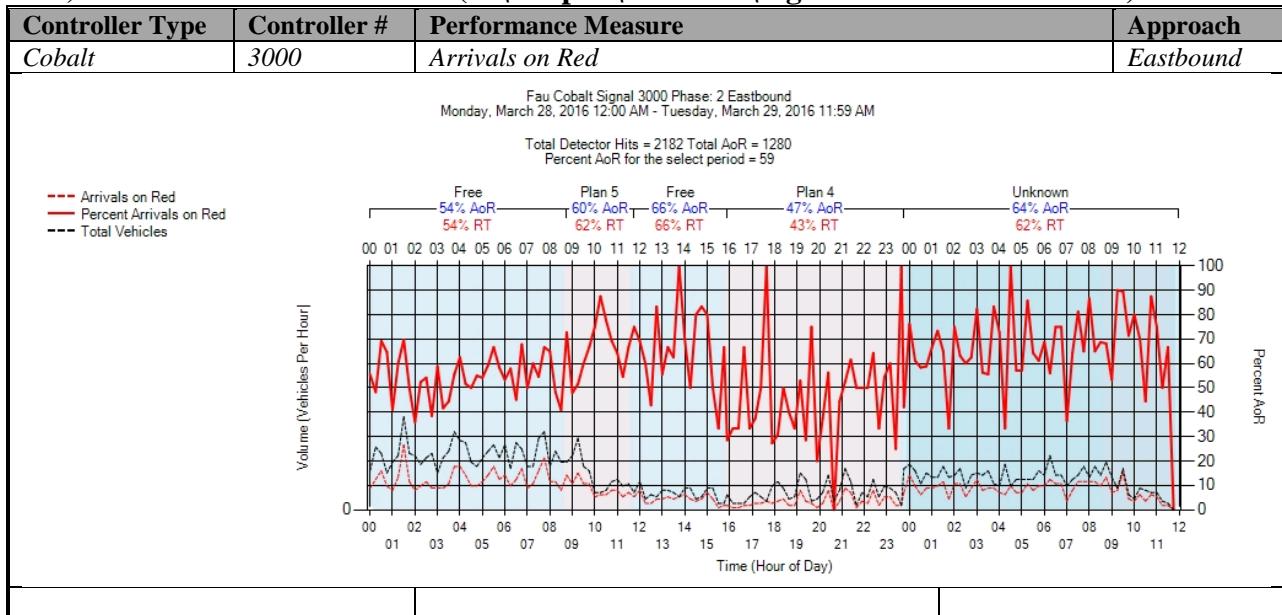


Figure A-8. Cobalt – Arrivals on Red – EB

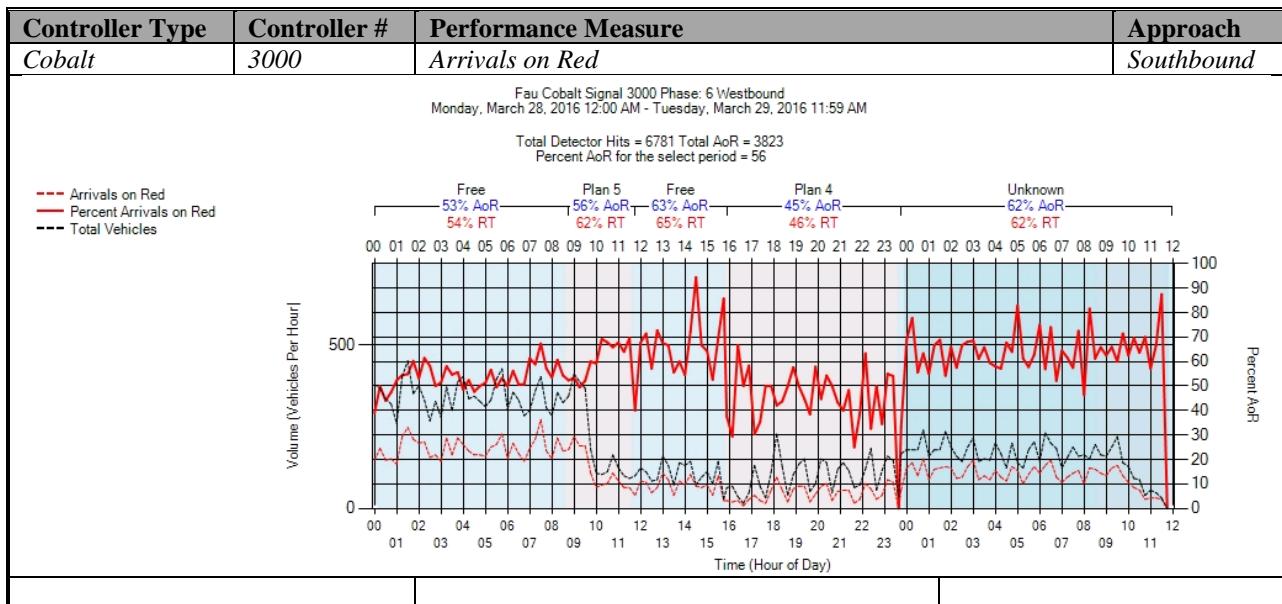


Figure A-9. Cobalt – Arrivals on Red – SB

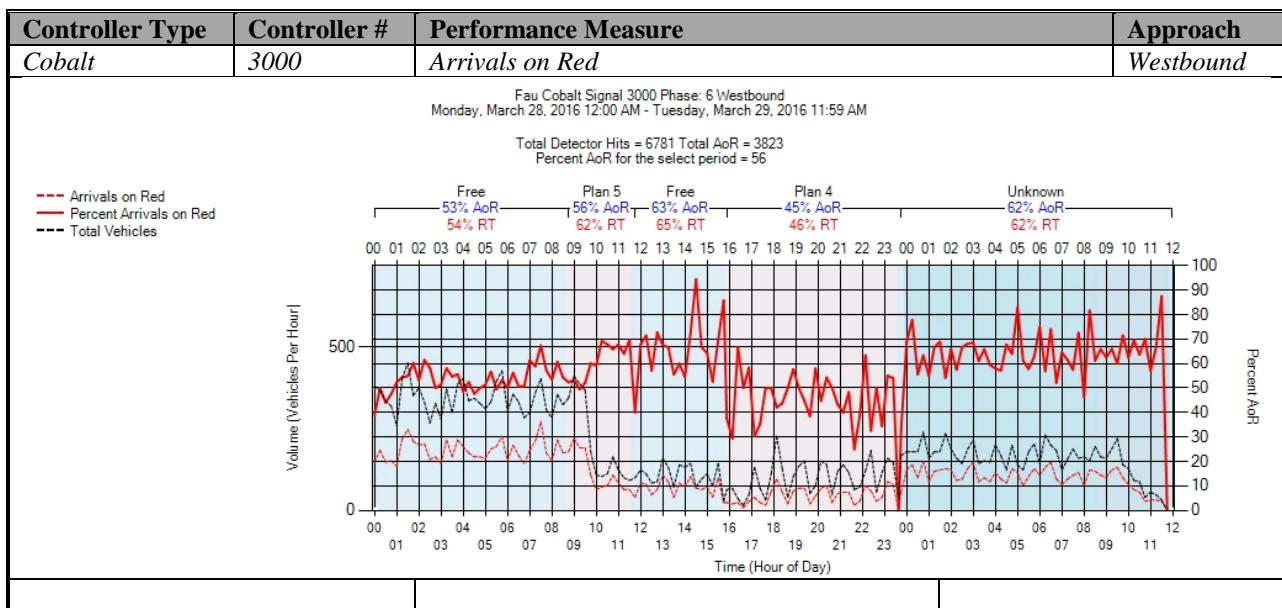


Figure A-10. Cobalt – Arrivals on Red – WB

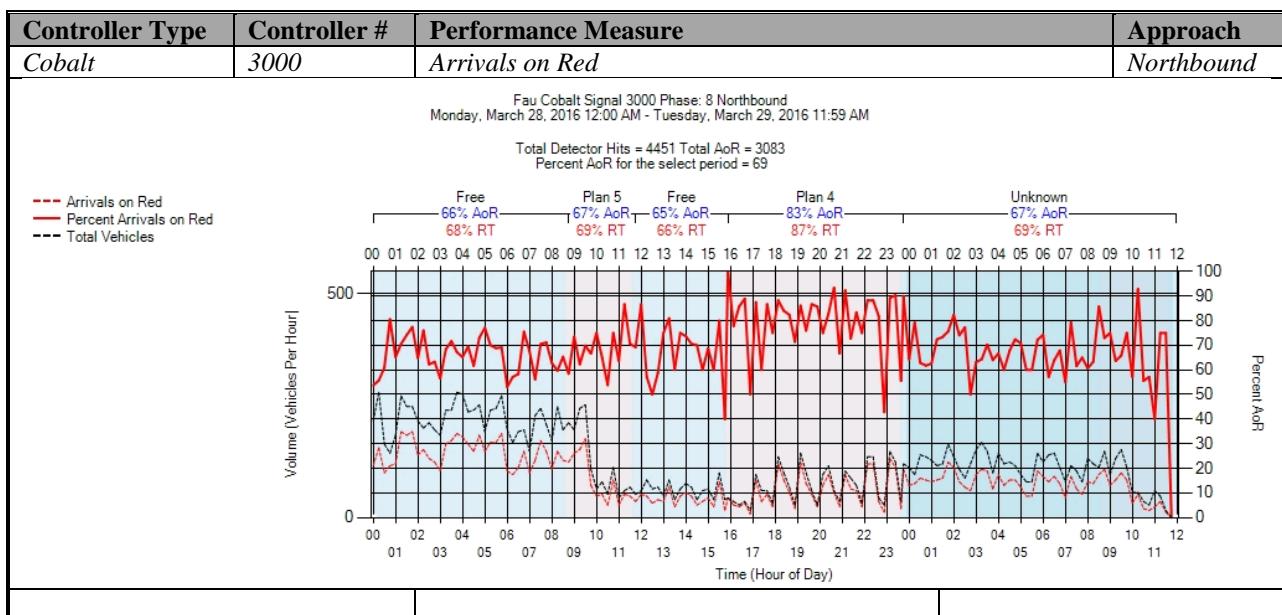


Figure A-11. Cobalt – Arrivals on Red – NB

d) Purdue Coordination Diagram - Cobalt(C:\inetpub\wwwroot\SPMImages)

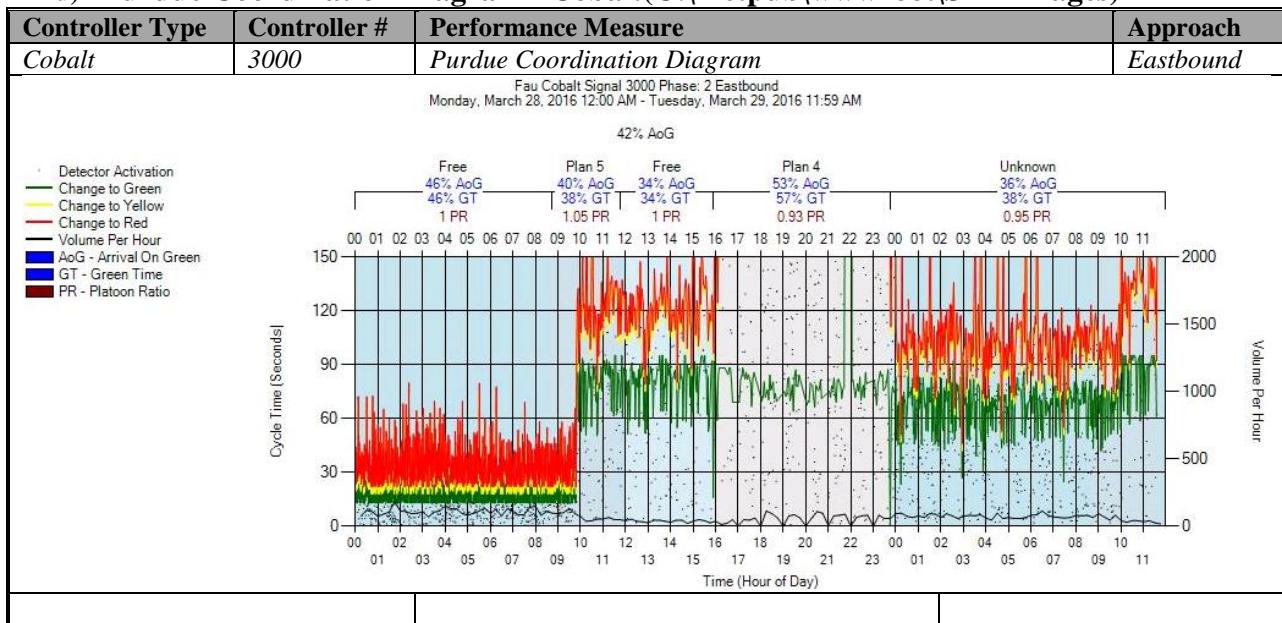


Figure A-12. Cobalt – Purdue Coordination Diagram – EB

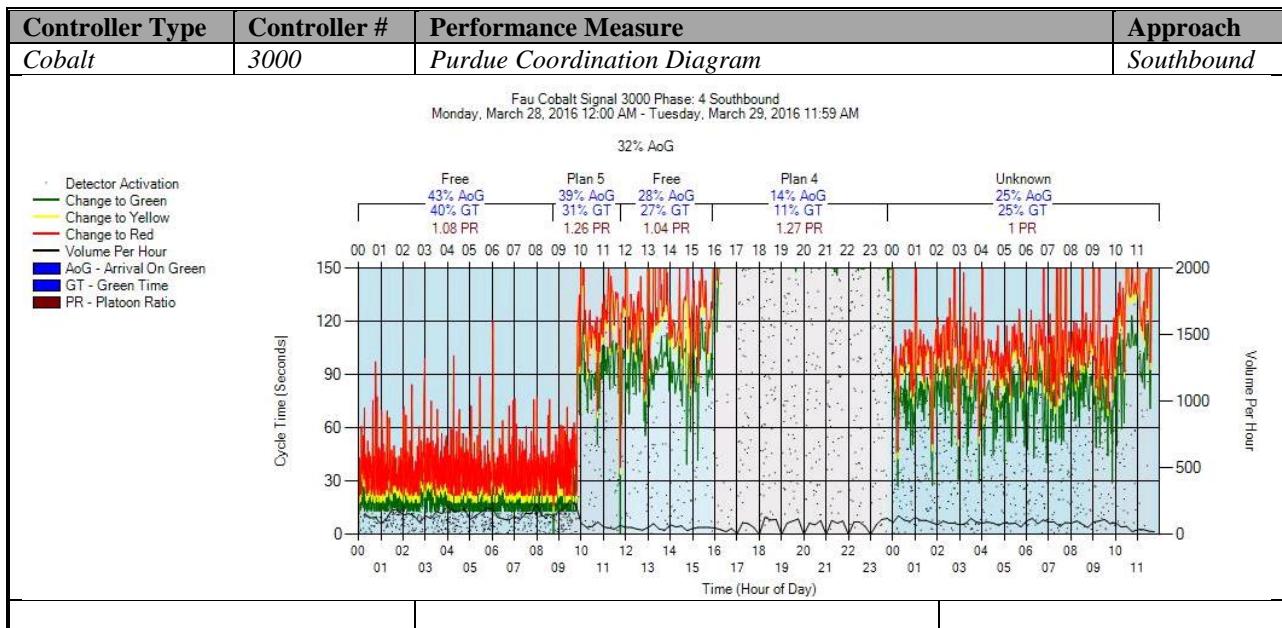


Figure A-13. Cobalt – Purdue Coordination Diagram – SB

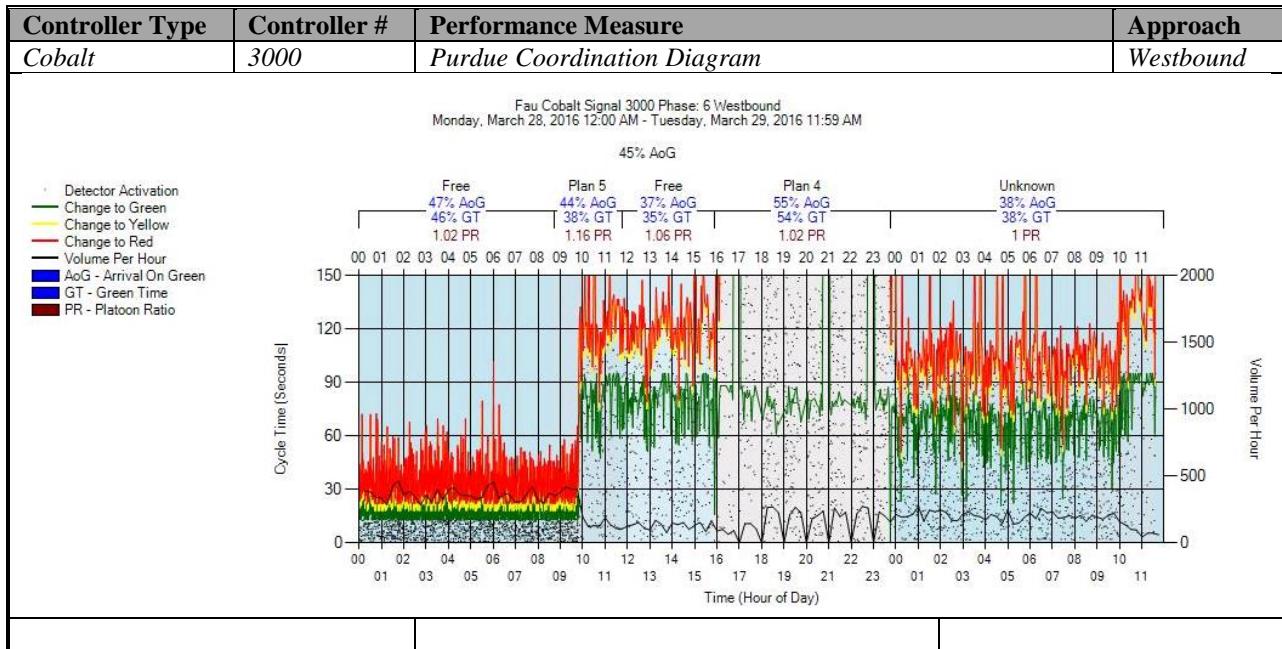


Figure A-14. Cobalt – Purdue Coordination Diagram – WB

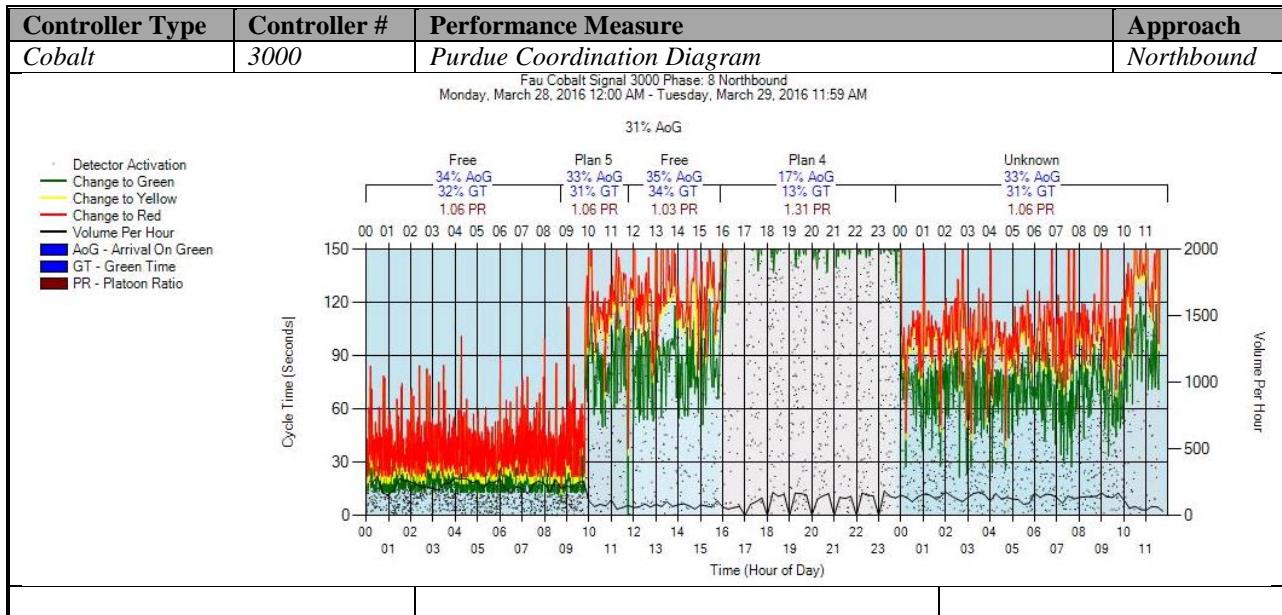


Figure A-15. Cobalt – Purdue Coordination Diagram – NB

e) Purdue Split Failure

No graphs – Needs to be configured in the SPM Tool. To be accomplished later.

f) Pedestrian Delay

No graphs – Needs to be configured in the controller. To be accomplished later.

g) Preemption Details

No graphs – Needs to be configured in the controller. To be accomplished later.

h) Purdue Phase Termination

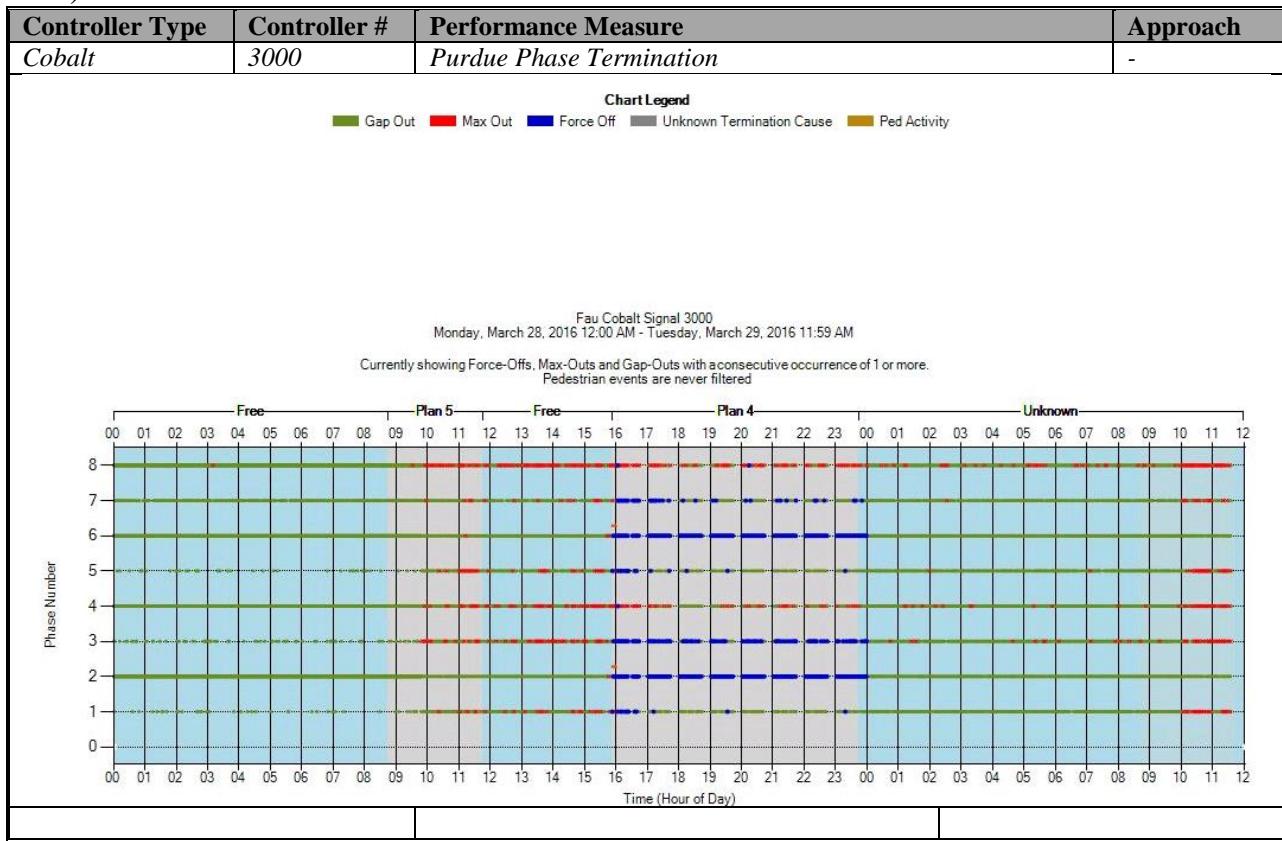


Figure A-16. Cobalt – Purdue Phase Termination

i) Speed (Check in C:\inetpub\wwwroot\SignalPerformanceMetrics\misc)

The graphs are given below, but without data from the controller because speed detectors need to be configured in the controller. To be accomplished later.

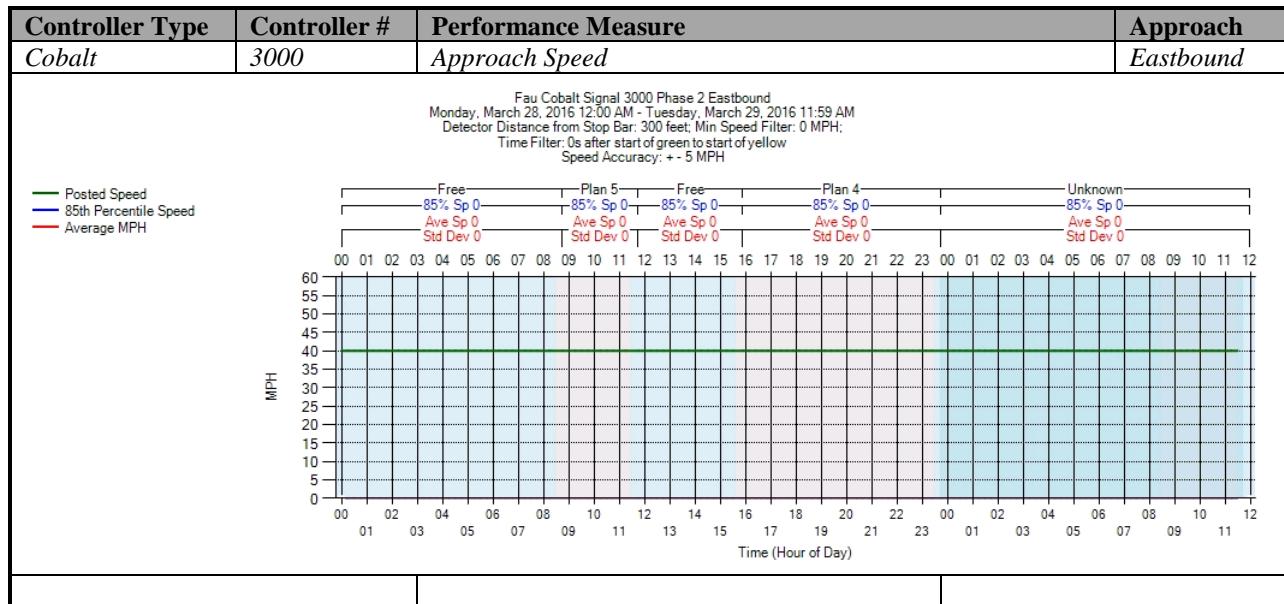


Figure A-17. Cobalt – Approach Speed – EB

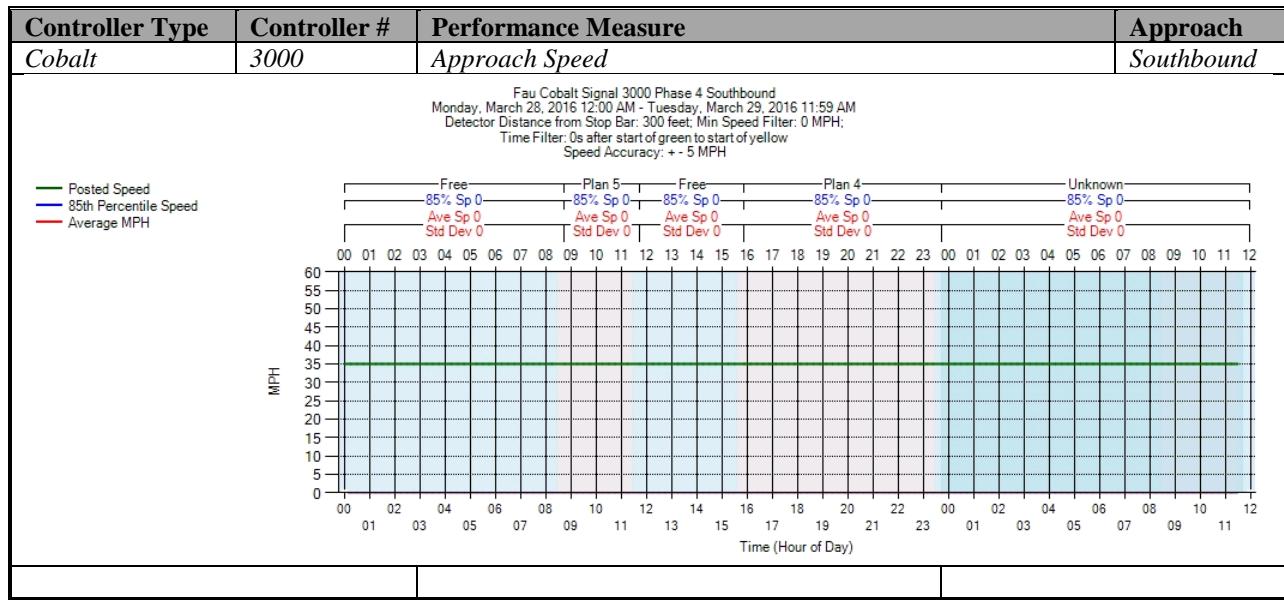


Figure A-18. Cobalt – Approach Speed – SB

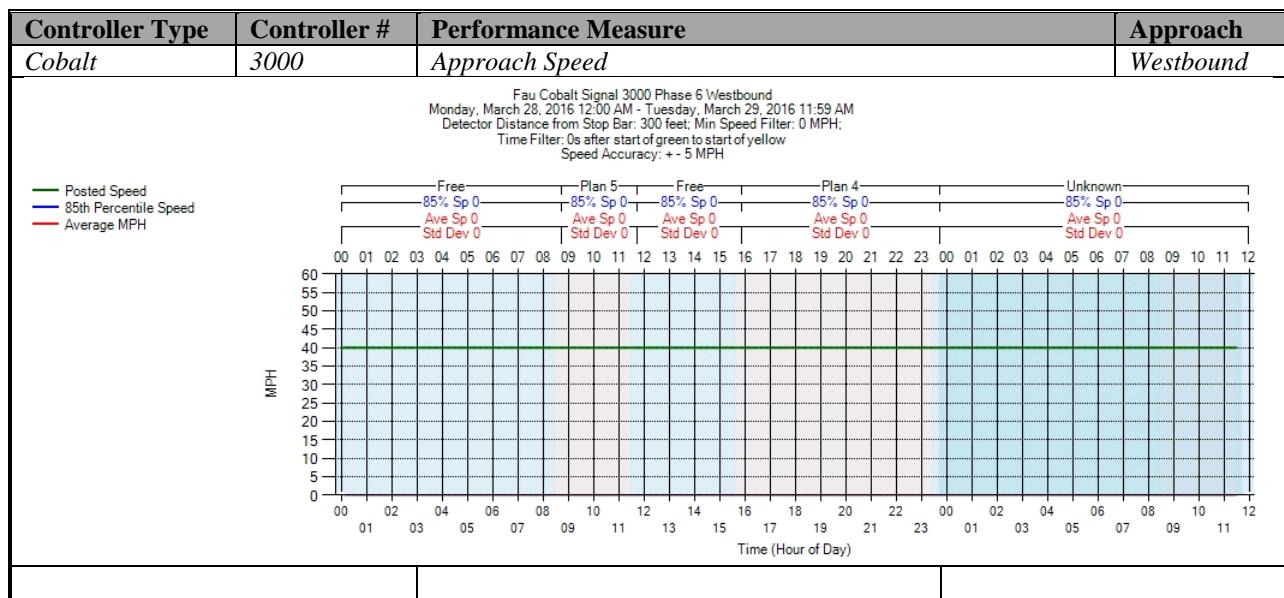


Figure A-19. Cobalt – Approach Speed – WB

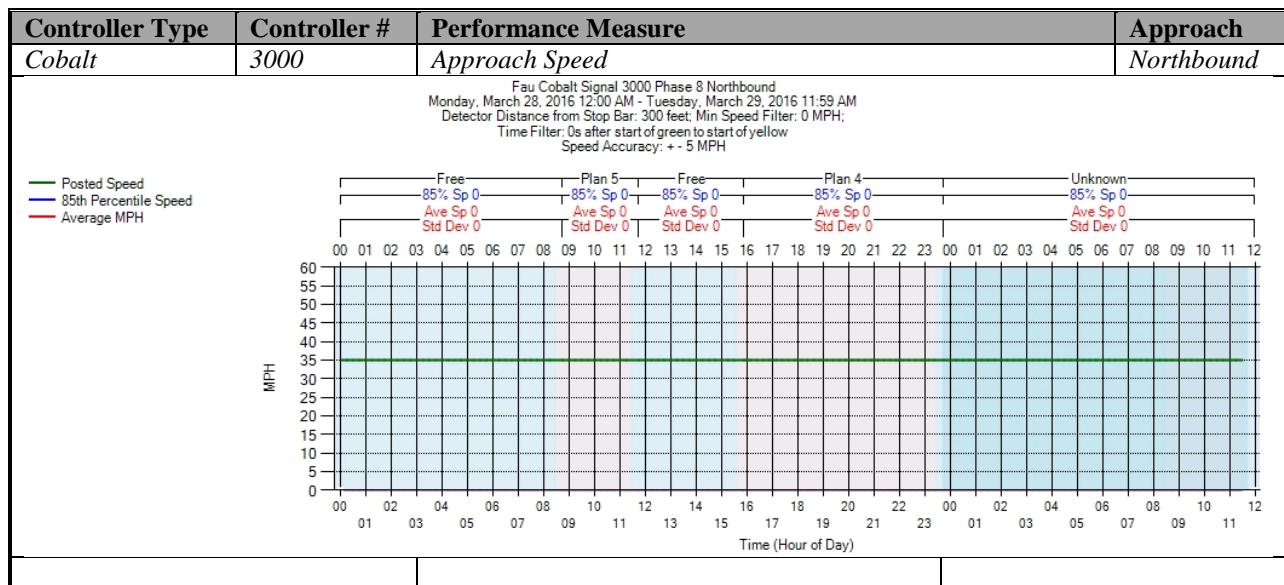


Figure A-20. Cobalt – Approach Speed – NB

j) Split Monitor – Cobalt

(C:\Installs\Deeptistuff\SPMWebFiles\SPMWebFiles\SPMSourceFiles\v3.2Deepti\Signal Timing Diagrams)

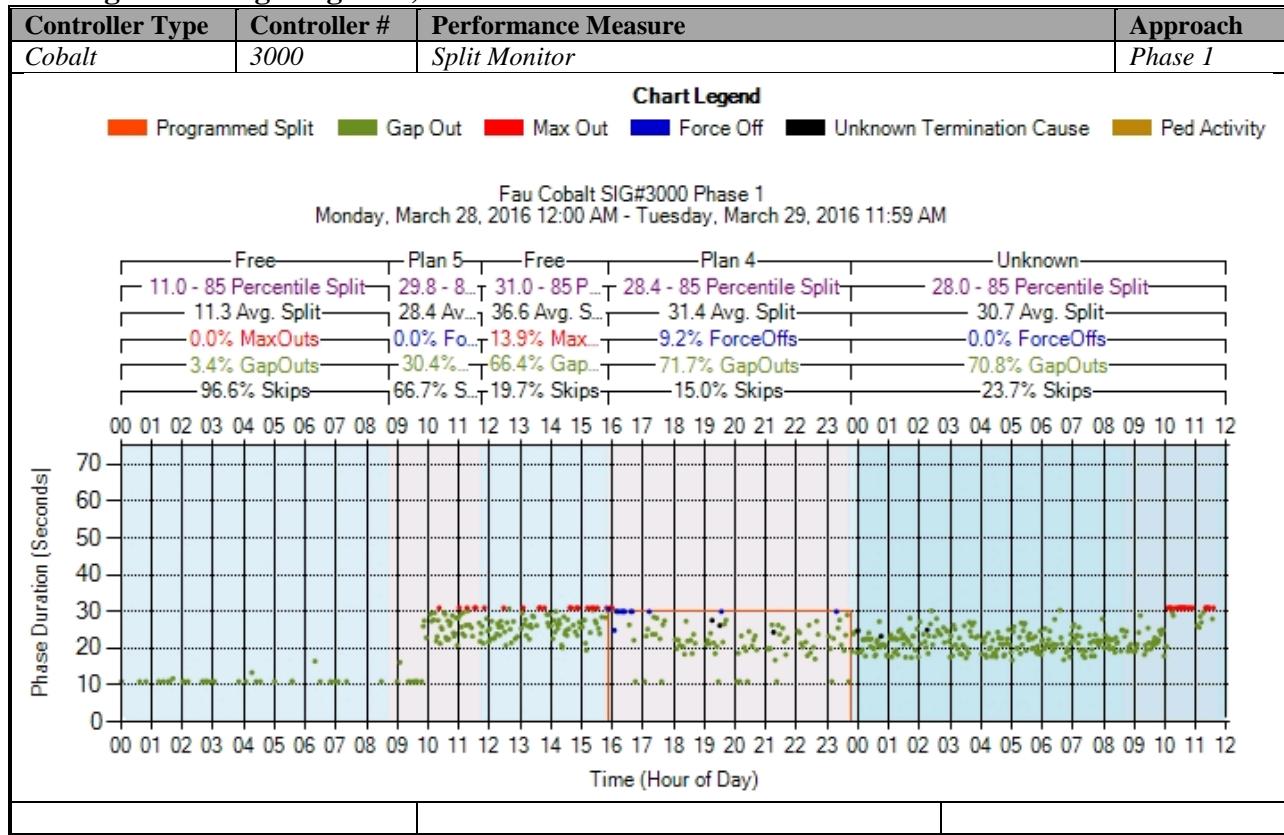


Figure A-21. Cobalt – Split Monitor – Phase 1

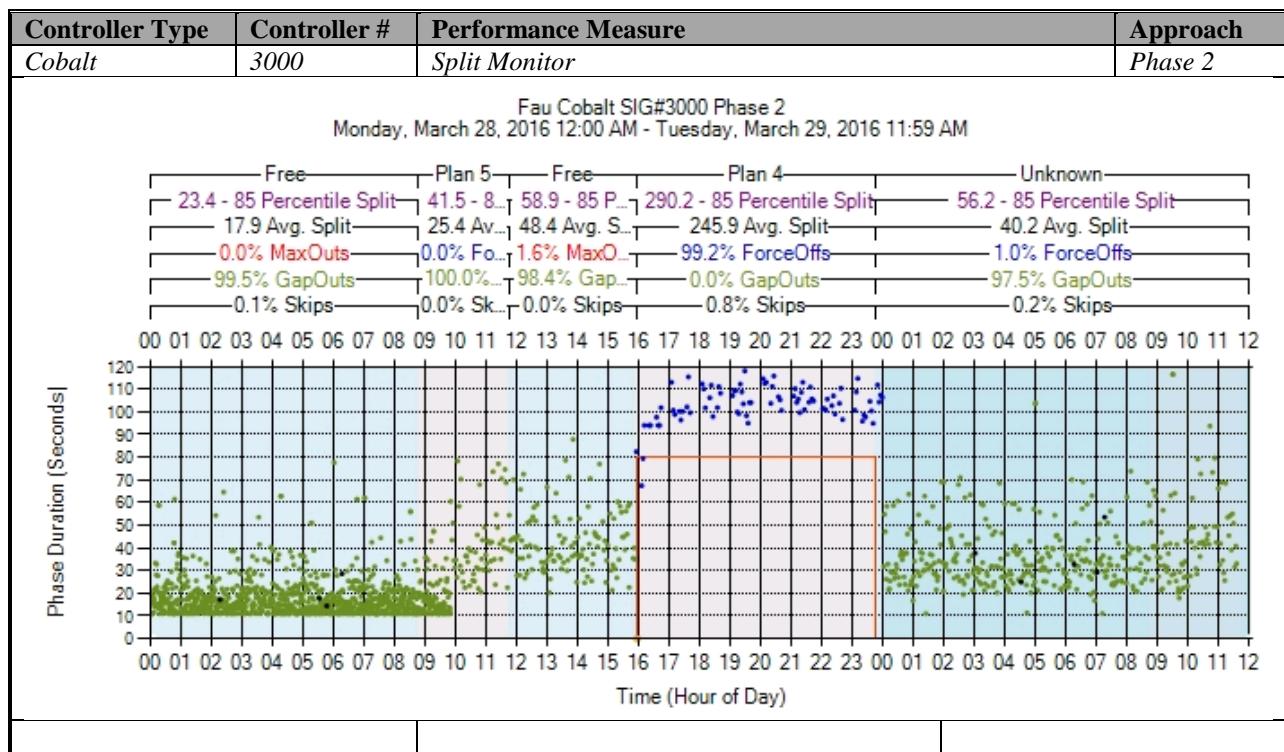


Figure A-22. Cobalt – Split Monitor – Phase 2

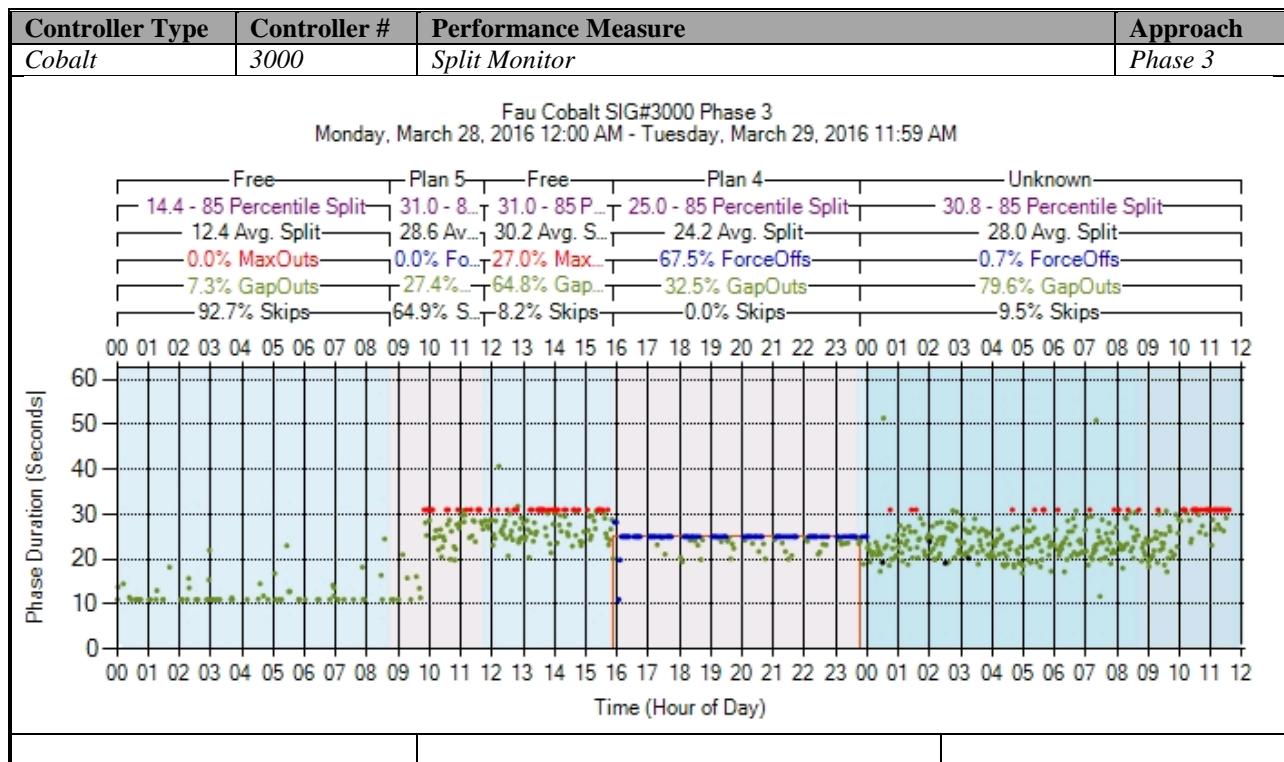


Figure A-23. Cobalt – Split Monitor – Phase 3

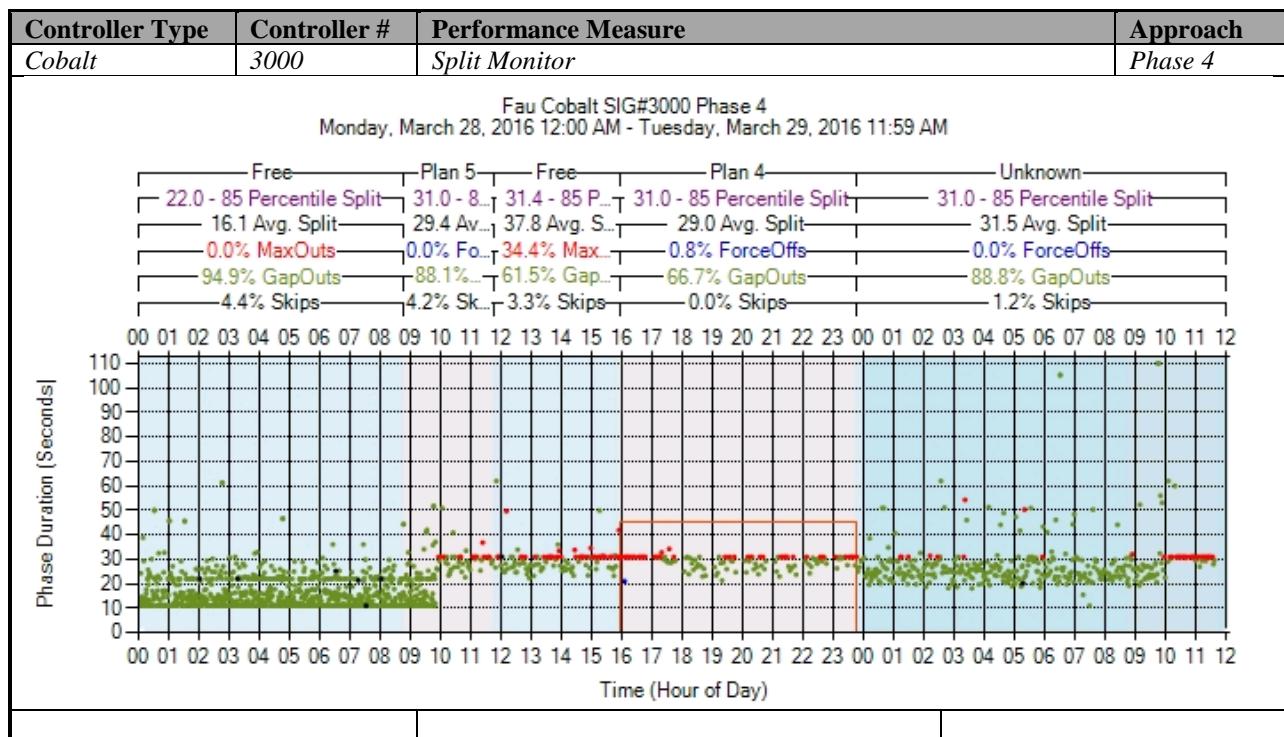


Figure A-24. Cobalt – Split Monitor – Phase 4

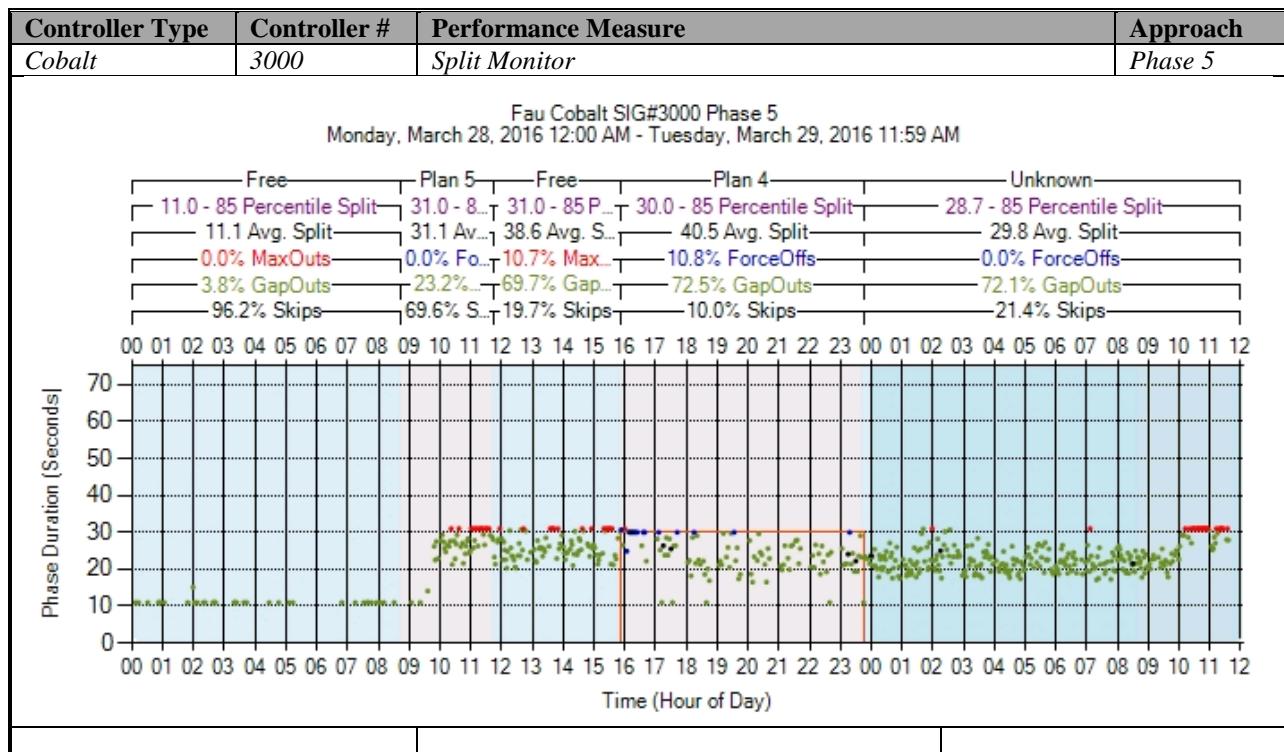


Figure A-25. Cobalt – Split Monitor – Phase 5

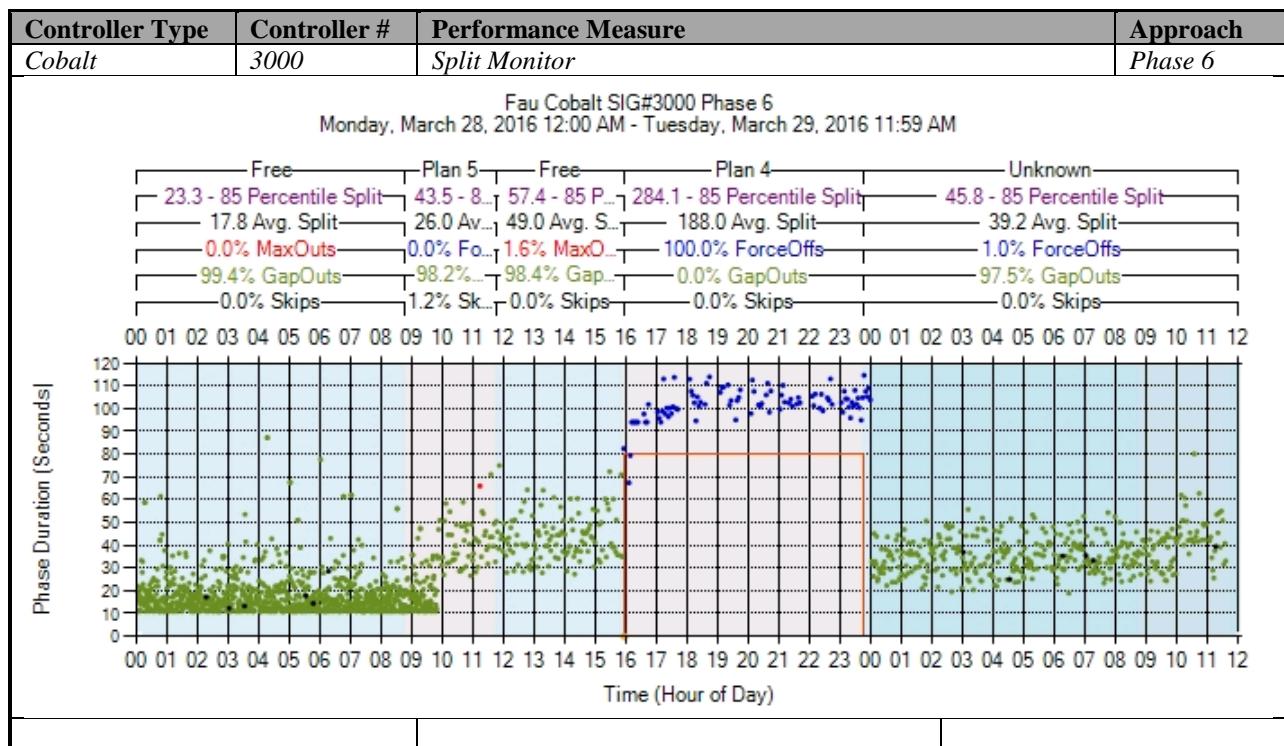


Figure A-26. Cobalt – Split Monitor – Phase 6

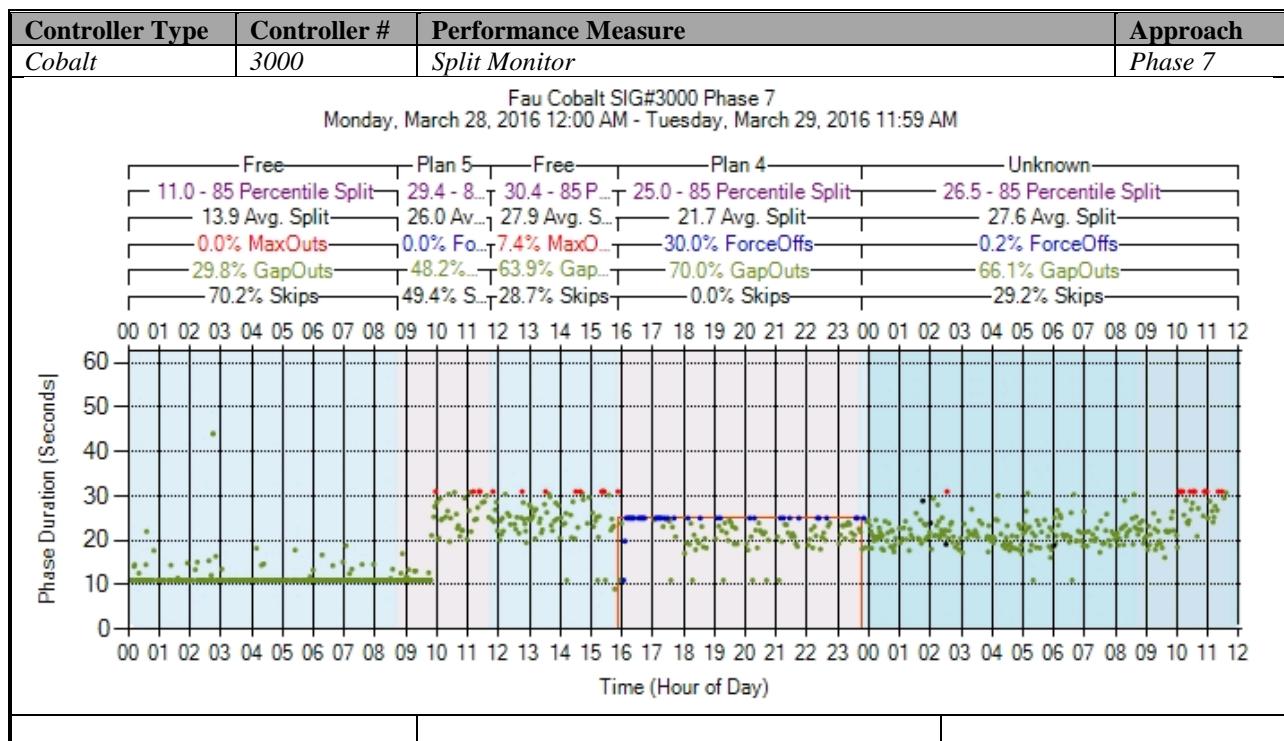


Figure A-27. Cobalt – Split Monitor – Phase 7

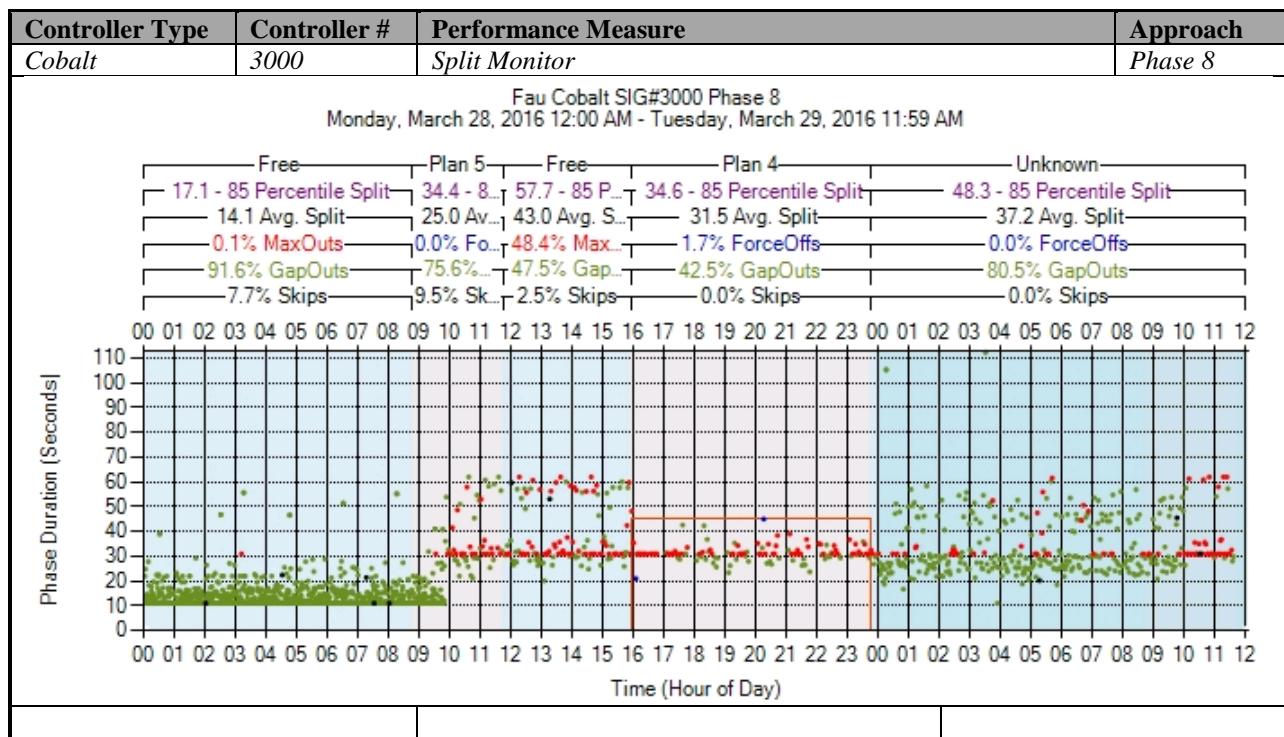


Figure A-28. Cobalt – Split Monitor – Phase 8

k) Turning Movement Counts

No graphs – Need to add new detectors after the stop bar. To be accomplished later.

l) Yellow and Red Actuations

No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.

A.2 Siemens (m50) High Resolution Data Performance Metrics

a) Approach Delay – Siemens (C:\inetpub\wwwroot\SignalPerformanceMetrics)

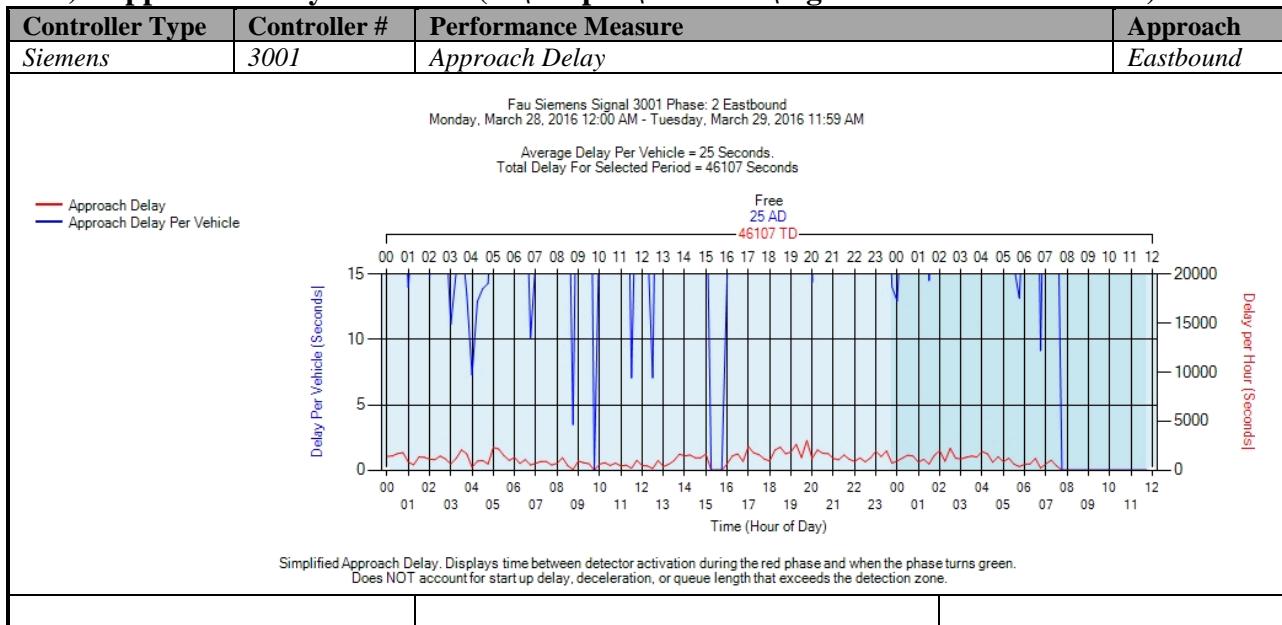


Figure A-29. Siemens – Approach Delay – EB

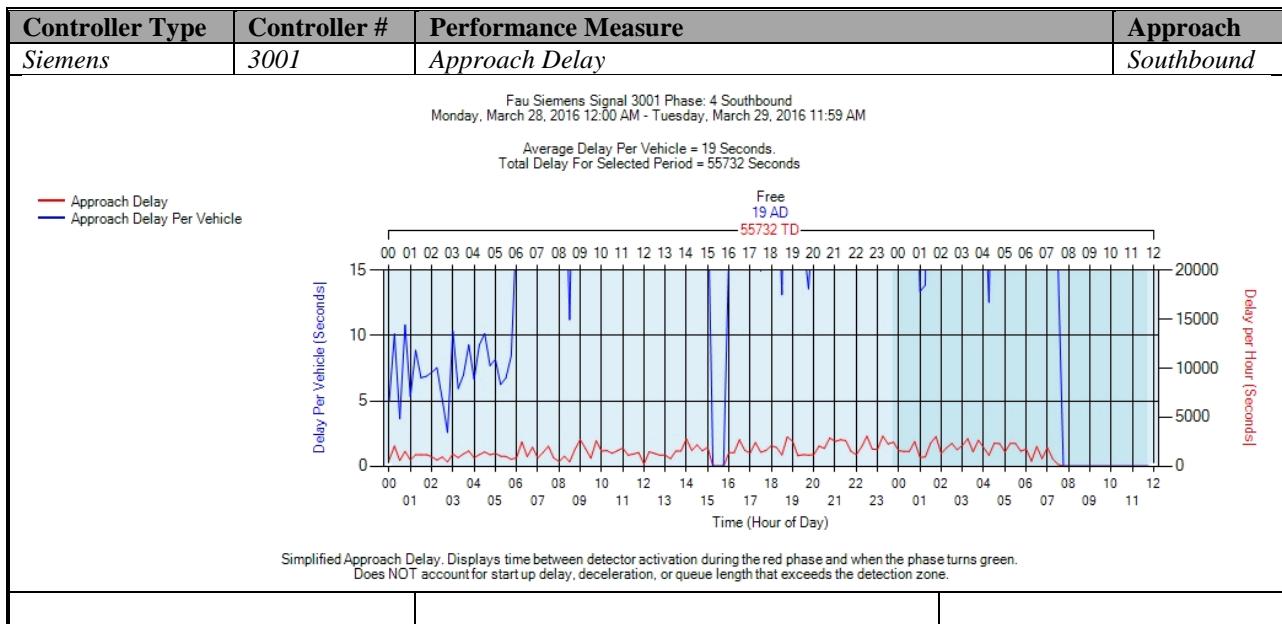


Figure A-30. Siemens – Approach Delay – SB

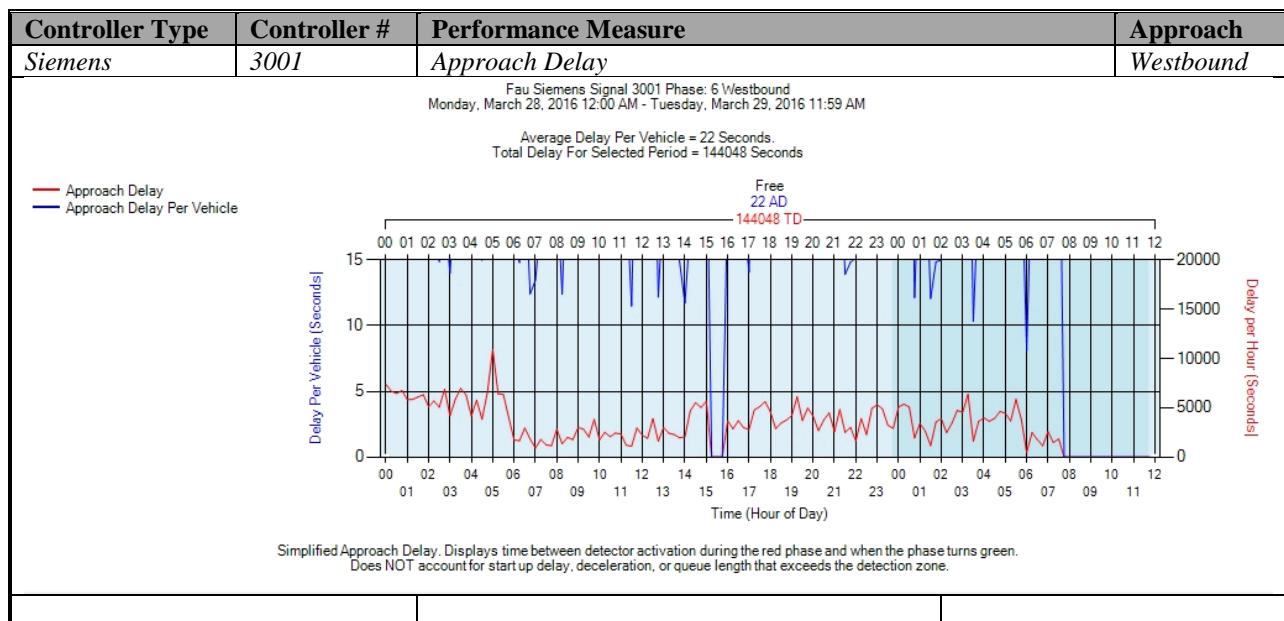


Figure A-31. Siemens – Approach Delay – WB

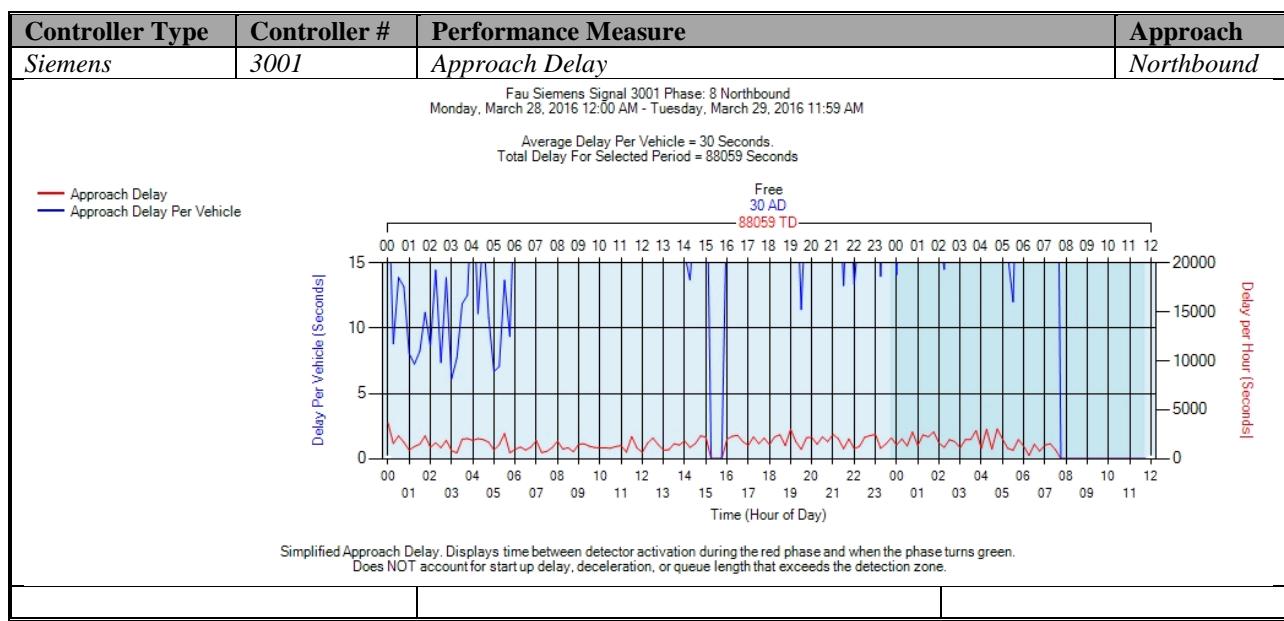


Figure A-32. Siemens – Approach Delay – NB

b) Approach Volume - Siemens (C:\inetpub\wwwroot\SignalPerformanceMetrics)

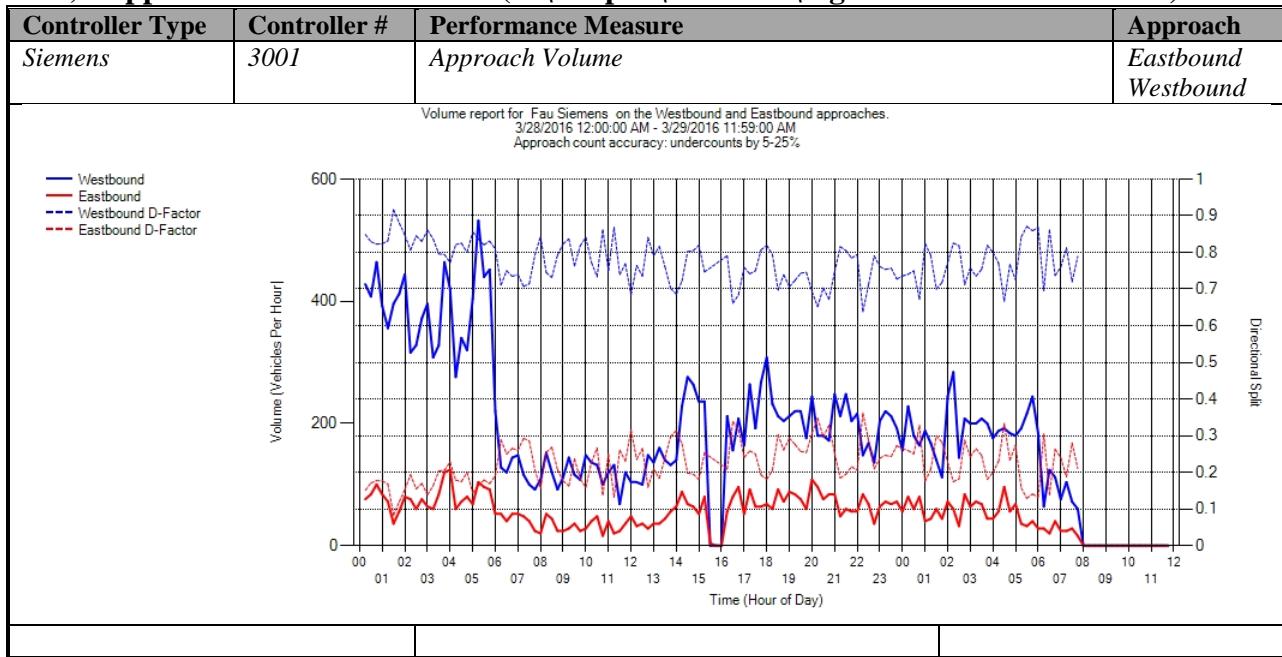


Figure A-33. Siemens – Approach Delay – WB & EB

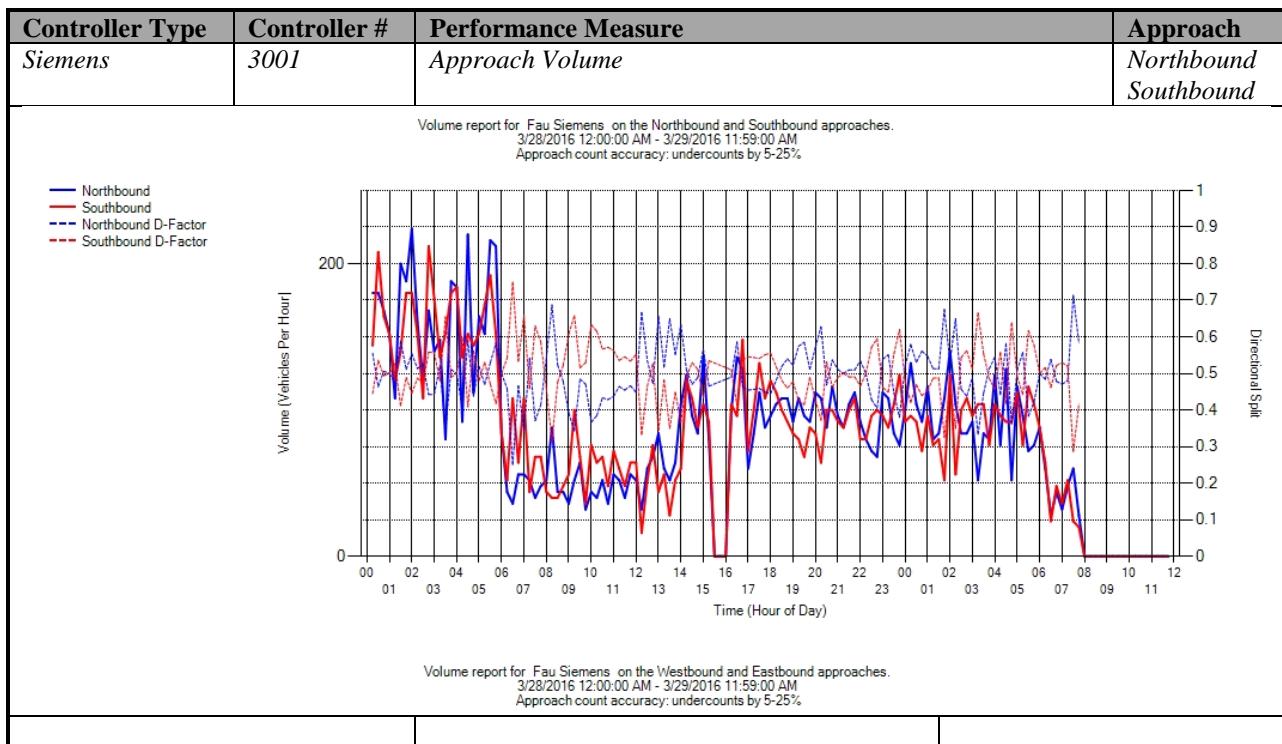


Figure A-34. Siemens – Approach Delay – NB & SB

Controller Type	Controller #	Performance Measure	Approach
<i>Siemens</i>	<i>3001</i>	<i>Approach Volume</i>	<i>Total</i>
Metric			Value
Total Volume			5,876
Peak Hour			1:30 AM - 2:30 AM
Peak Hour Volume			356
PHF			0.881
Peak-Hour K-factor			NA
Northbound Total Volume			2,937
Northbound Peak Hour			1:30 AM - 2:30 AM
Northbound Peak Hour Volume			193
Northbound PHF			0.862
Northbound Peak-Hour K-factor			NA
Northbound Peak-Hour D-factor			0.845
Southbound Total Volume			2,939
Southbound Peak Hour			2:45 AM - 3:45 AM
Southbound Peak Hour Volume			169
Southbound PHF			1
Southbound Peak-Hour K-factor			NA
Southbound Peak-Hour D-factor			0.793
Metric			Value
Total Volume			8,364
Peak Hour			5:00 AM - 6:00 AM
Peak Hour Volume			547
PHF			0.86
Peak-Hour K-factor			NA
Westbound Total Volume			6,550
Westbound Peak Hour			5:00 AM - 6:00 AM
Westbound Peak Hour Volume			457
Westbound PHF			0.859
Westbound Peak-Hour K-factor			NA
Westbound Peak-Hour D-factor			0.197
Eastbound Total Volume			1,814
Eastbound Peak Hour			3:15 AM - 4:15 AM
Eastbound Peak Hour Volume			97
Eastbound PHF			1
Eastbound Peak-Hour K-factor			NA
Eastbound Peak-Hour D-factor			3.92

Figure A-35. Siemens – Approach Volume – WB

c) Arrivals On Red - Siemens (C:\inetpub\wwwroot\SignalPerformanceMetrics)

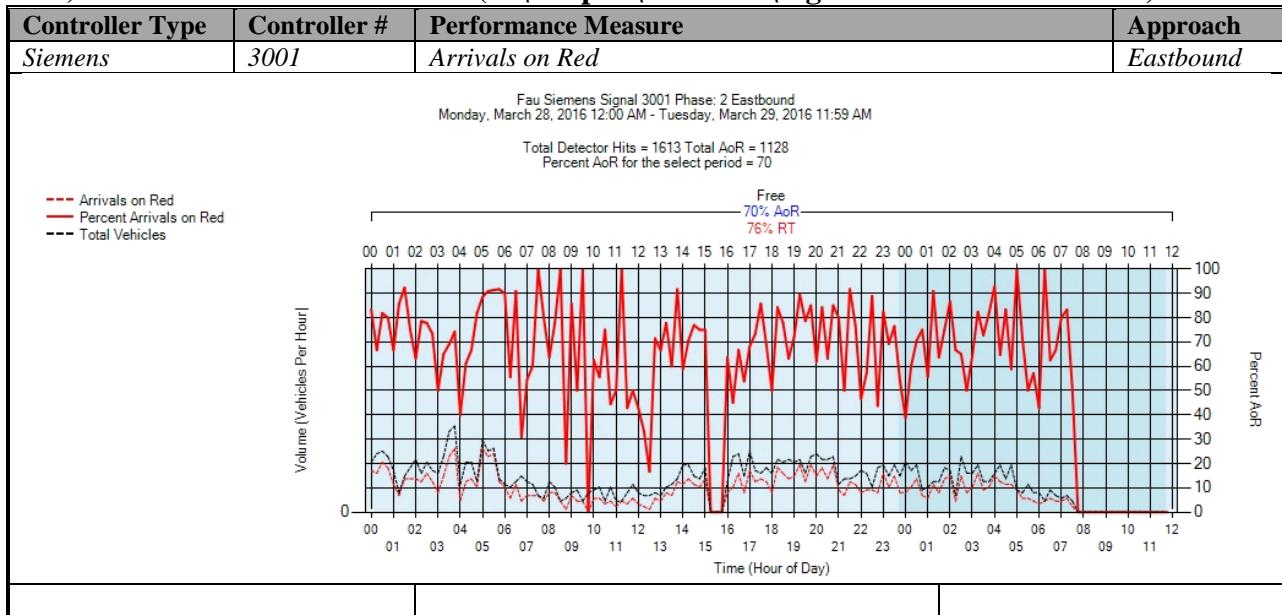


Figure A-36. Siemens – Arrivals on Red – EB

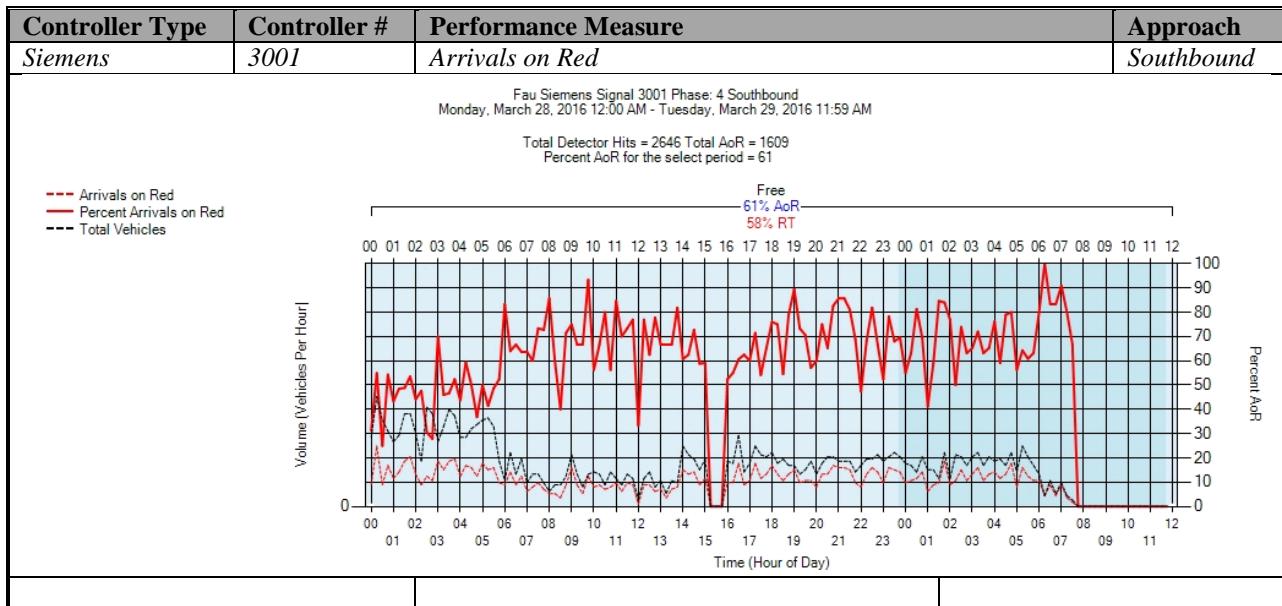


Figure A-37. Siemens – Arrivals on Red – SB

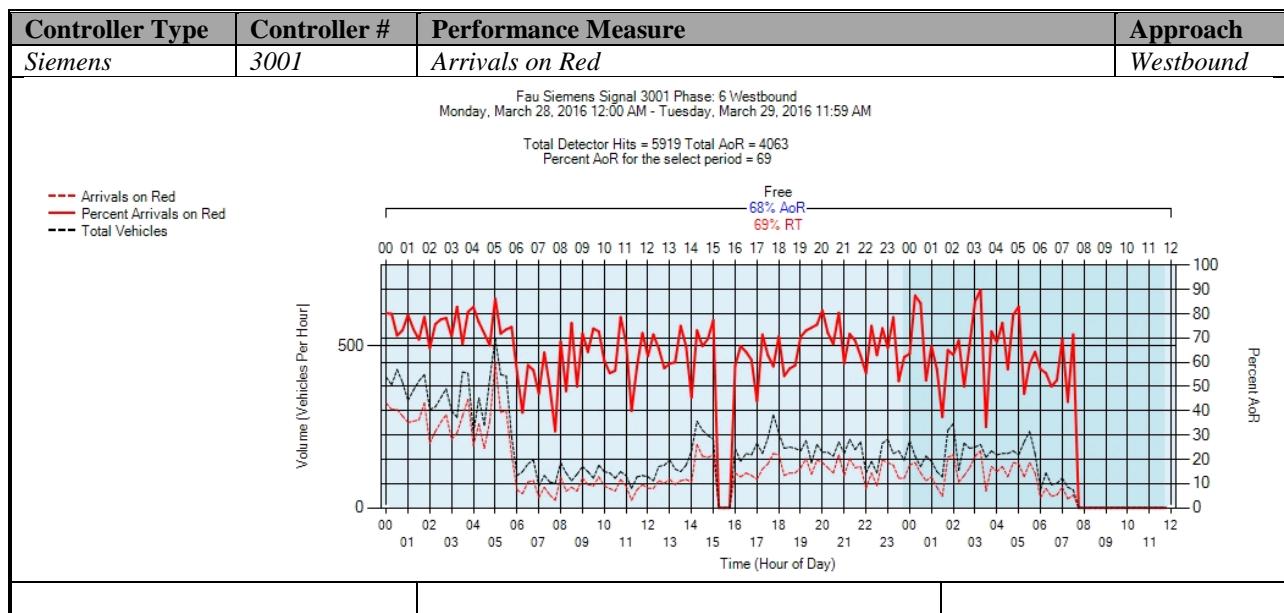


Figure A-38. Siemens – Arrivals on Red – WB

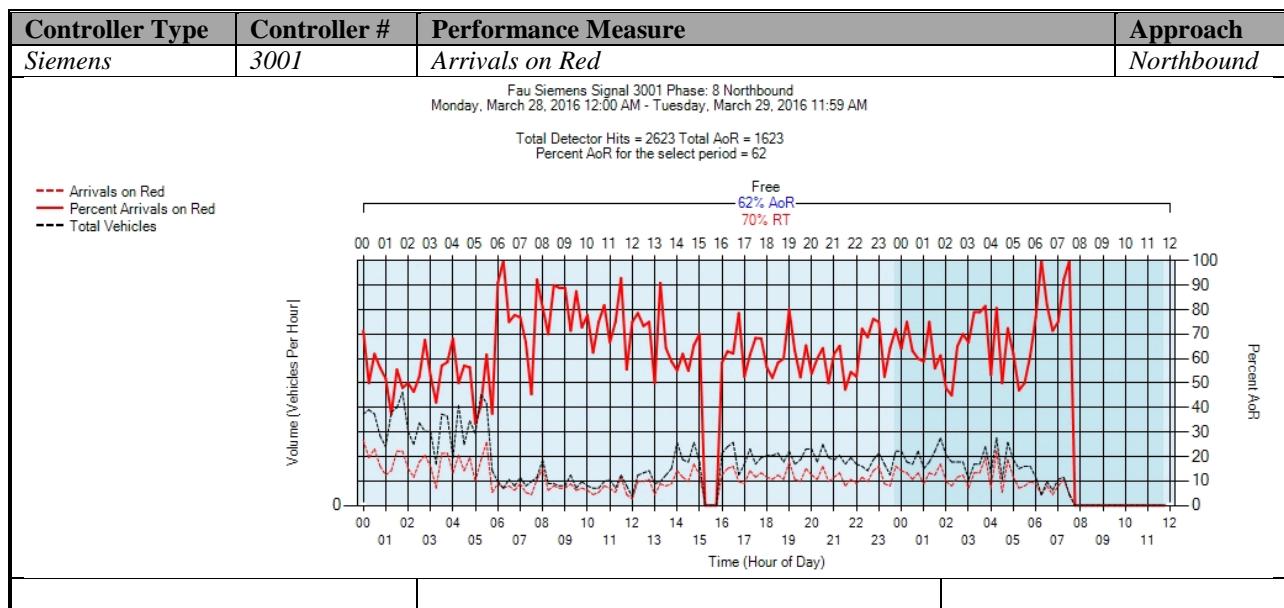


Figure A-39. Siemens – Arrivals on Red – NB

d) Purdue Coordination Diagram – Siemens (C:\inetpub\wwwroot\SPMImages)

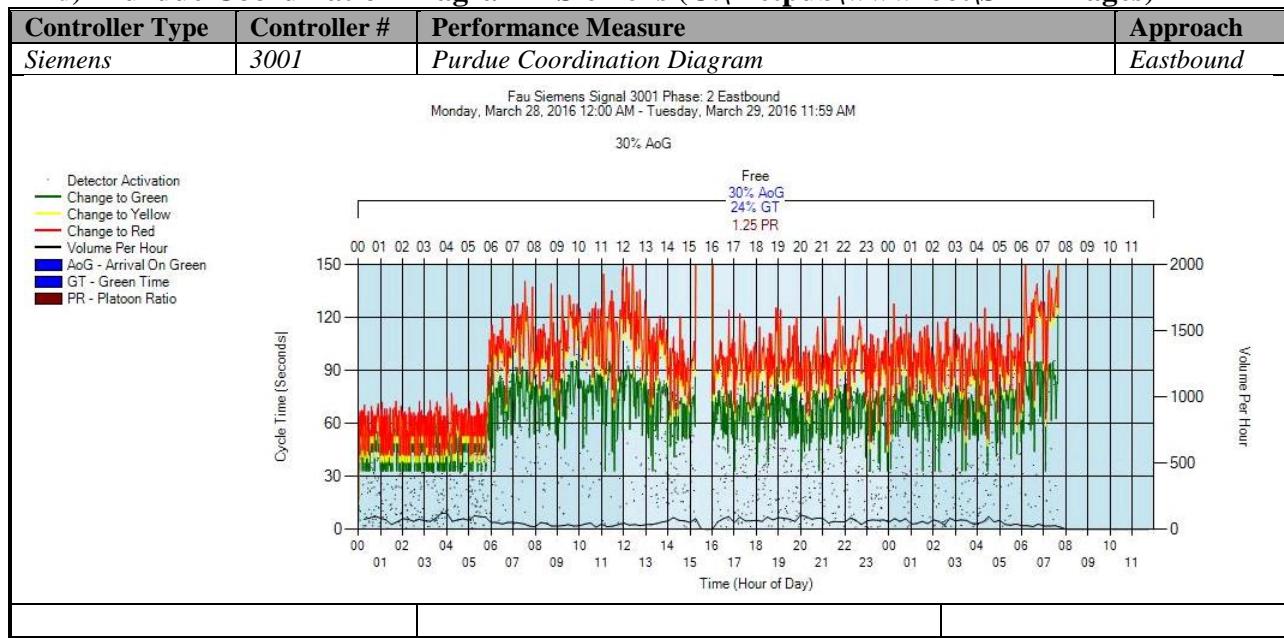


Figure A-40. Siemens – Purdue Coordination Diagram – EB

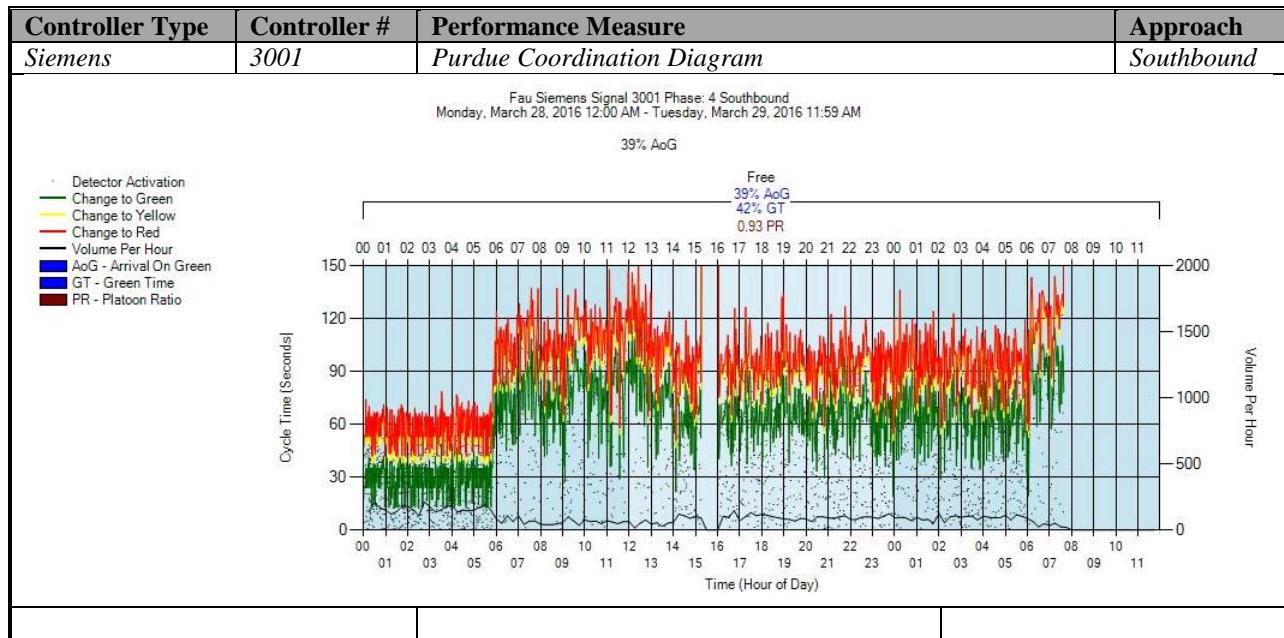


Figure A-41. Siemens – Purdue Coordination Diagram – SB

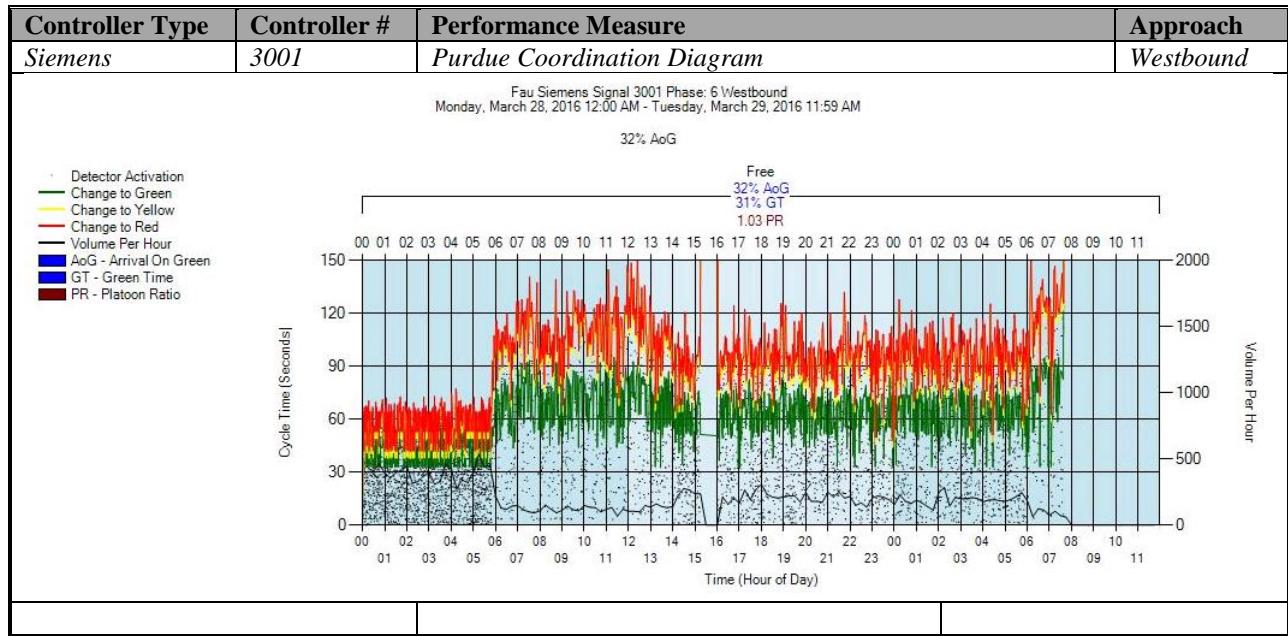


Figure A-42. Siemens – Purdue Coordination Diagram – WB

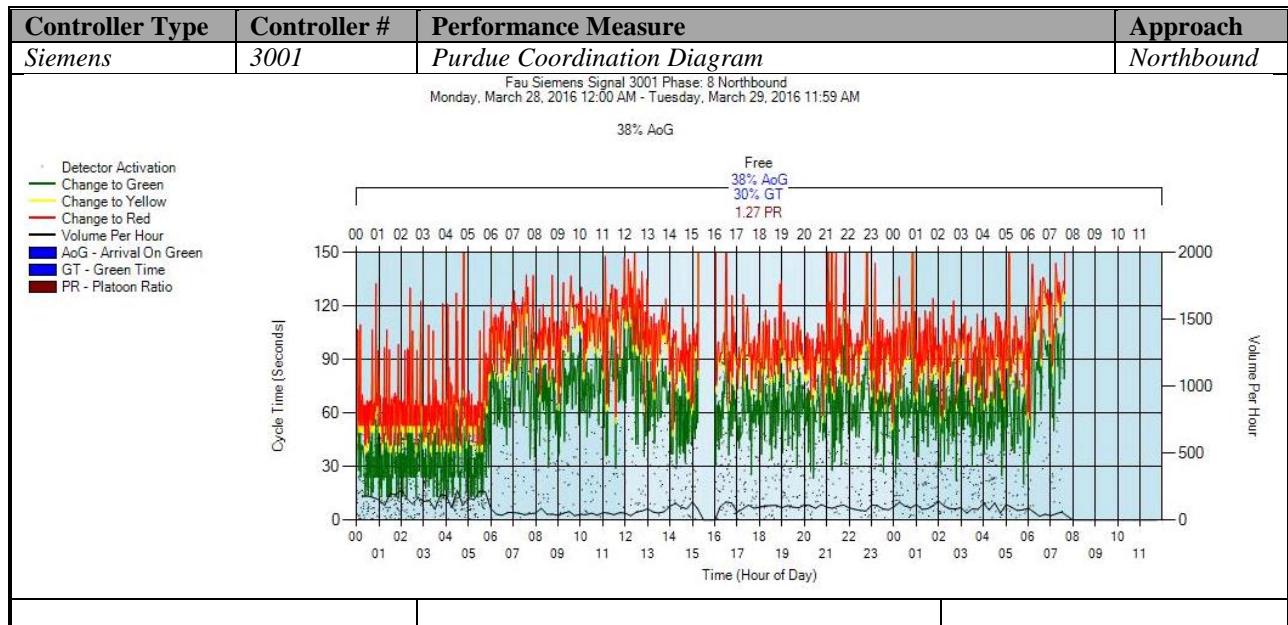


Figure A-43. Siemens – Purdue Coordination Diagram – NB

e) Purdue Split Failure

No graphs – Needs to be configured in the SPM Tool. To be accomplished later.

f) Pedestrian Delay

No graphs – Needs to be configured in the controller. To be accomplished later.

g) Preemption Details

No graphs – Needs to be configured in the controller. To be accomplished later.

h) Purdue Phase Termination

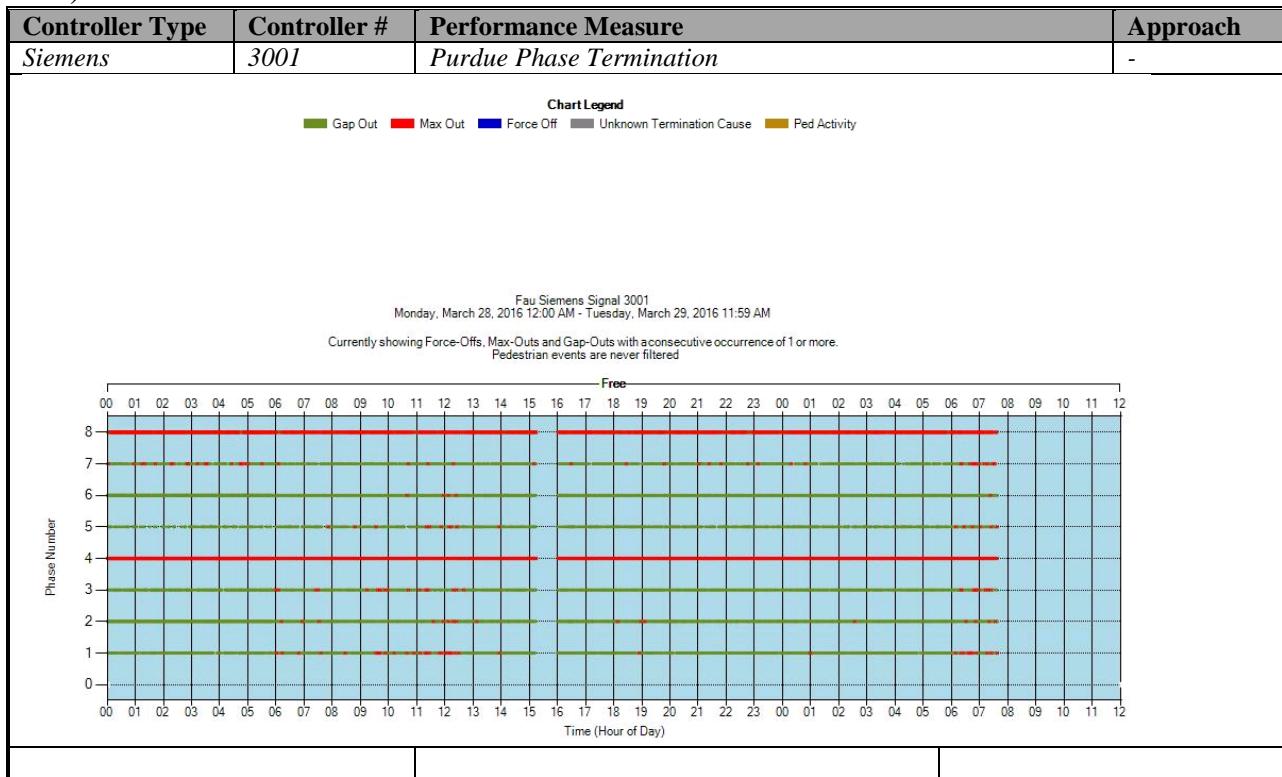


Figure A-44. Siemens – Purdue Phase Termination

i) Speed (Check in C:\inetpub\wwwroot\SignalPerformanceMetrics\misc)

The graphs are displayed below, but without data from the controller because speed detectors need to be configured in the controller. To be accomplished later.

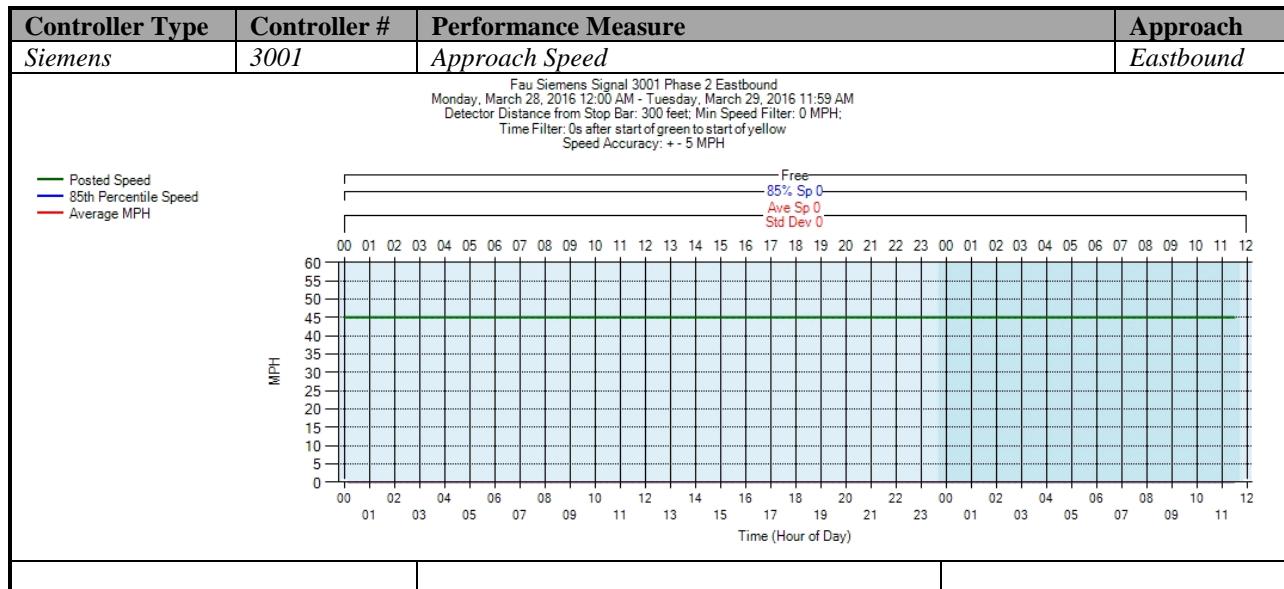


Figure A-45. Siemens – Approach Speed – EB

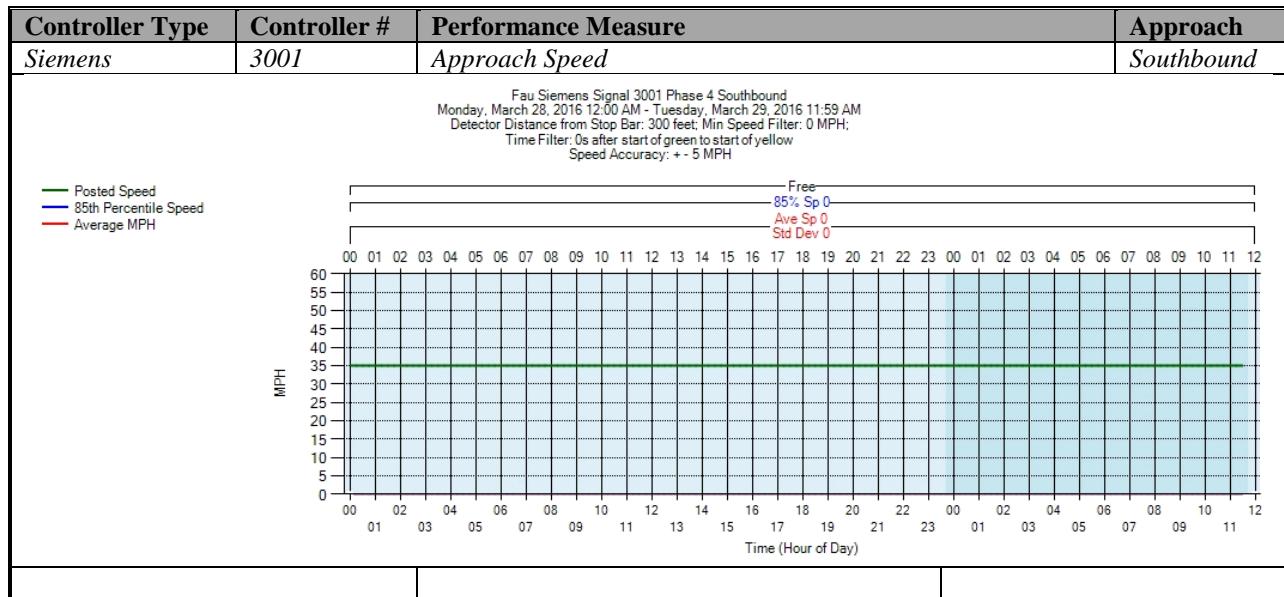


Figure A-46. Siemens – Approach Speed – SB

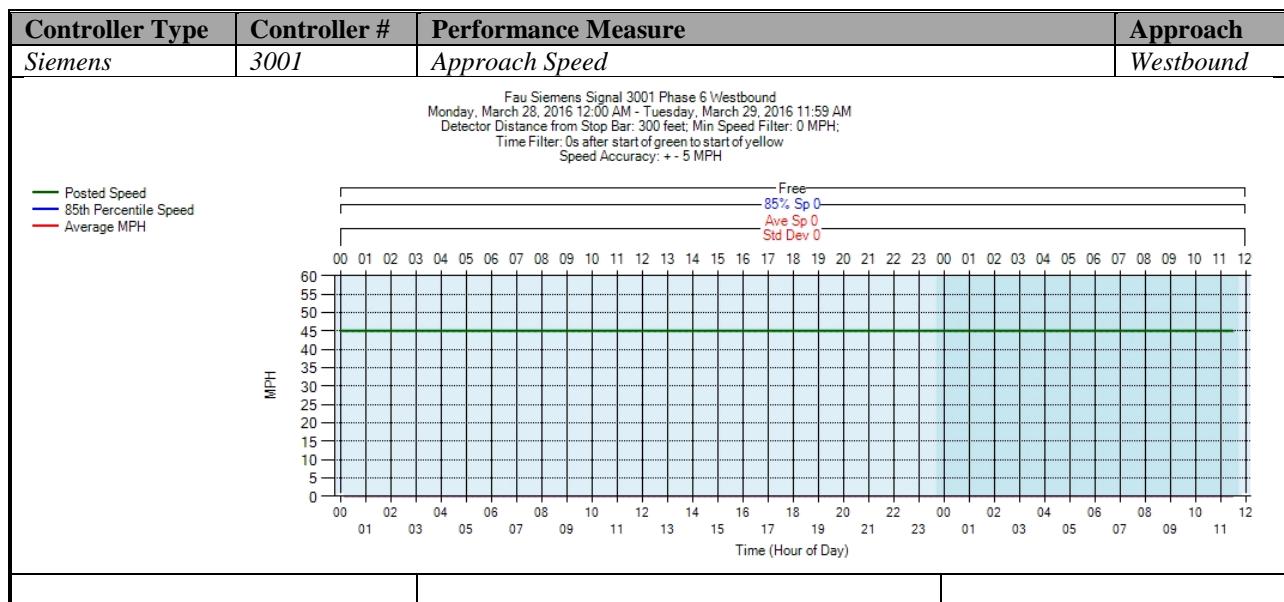


Figure A-47. Siemens – Approach Speed – WB

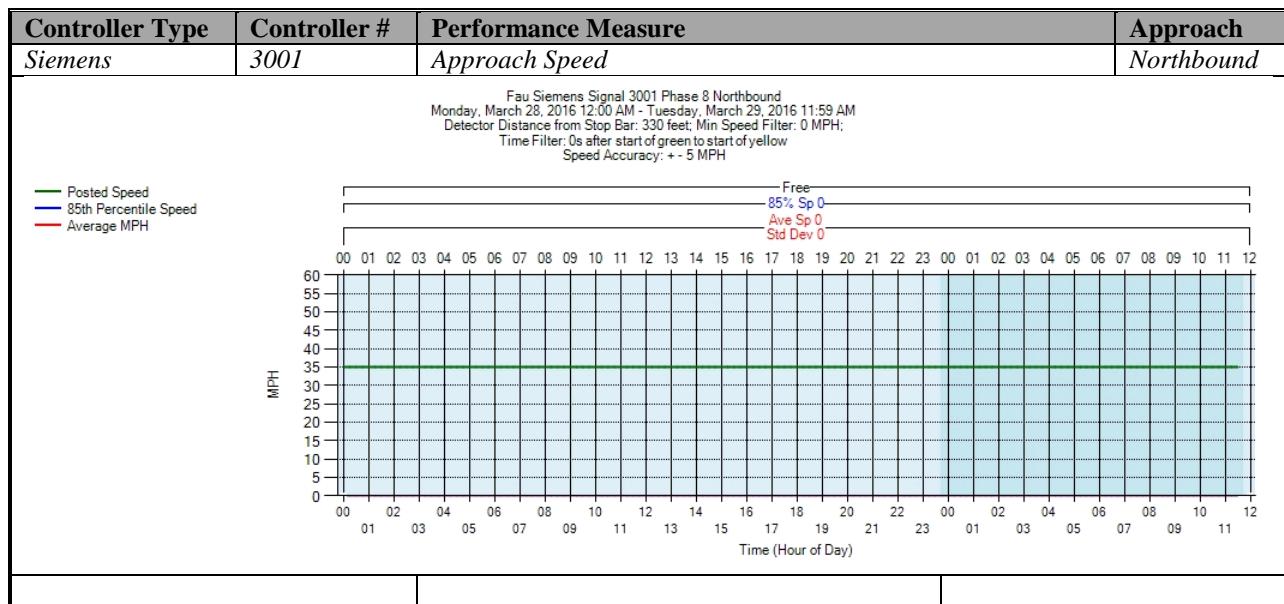


Figure A-48. Siemens – Approach Speed – NB

j) Split Monitor – Siemens

(C:\Installs\Deeptistuff\SPMWebFiles\SPMWebFiles\SPMSourceFiles\v3.2Deepti\Signal Timing Diagrams)

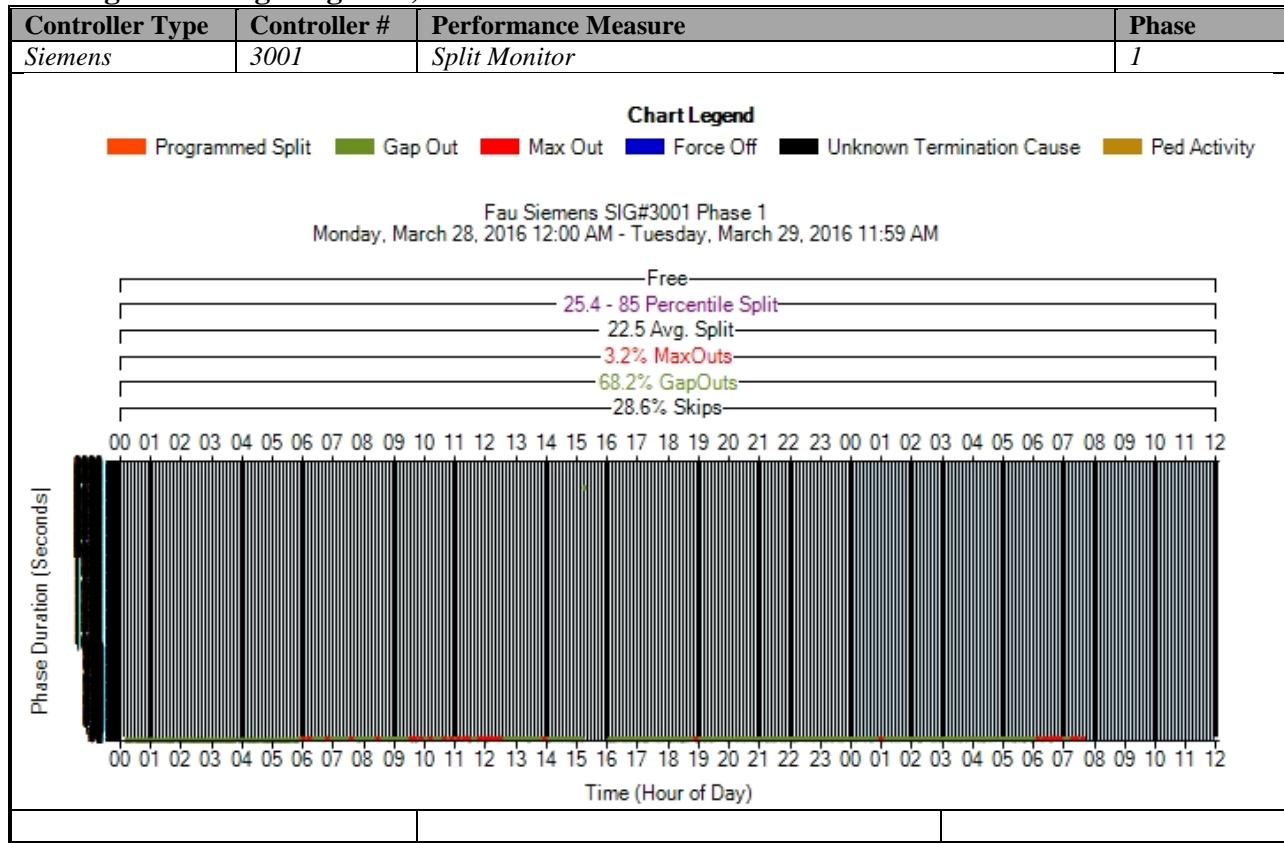


Figure A-49. Siemens – Split Monitor – Phase 1

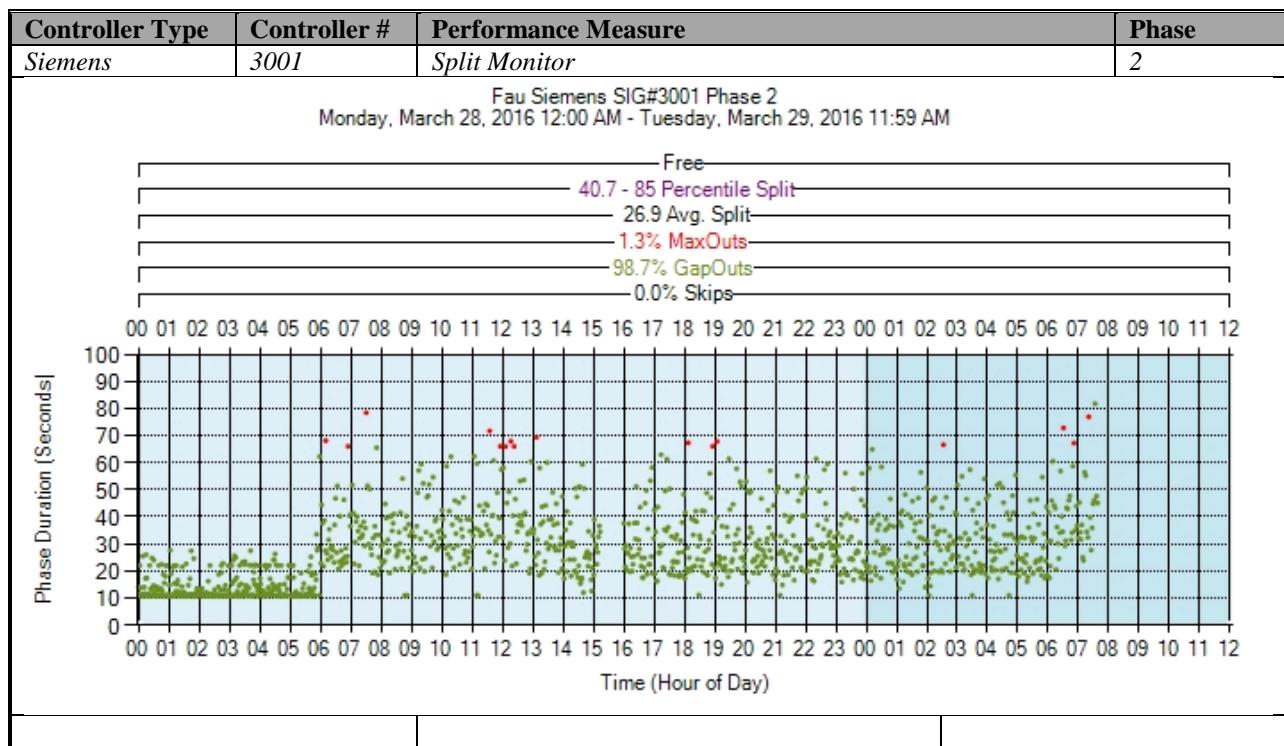


Figure A-50. Siemens – Split Monitor – Phase 2

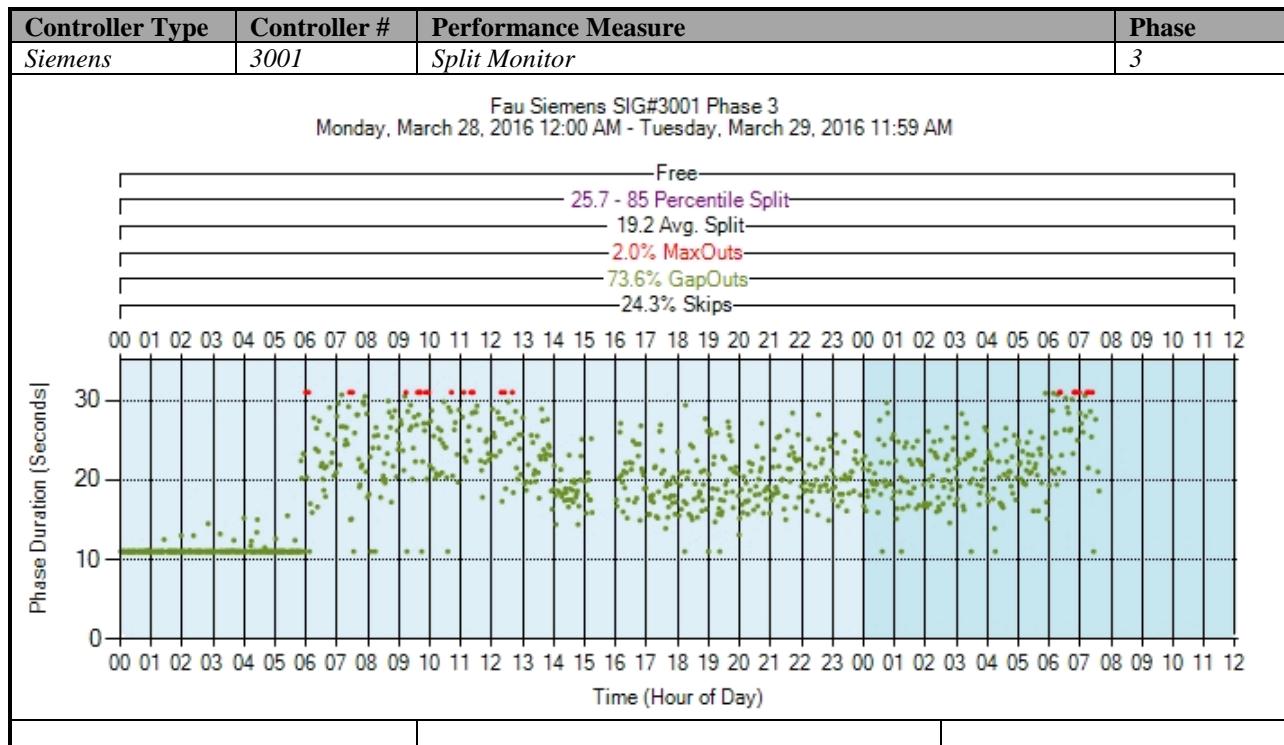


Figure A-51. Siemens – Split Monitor – Phase 3

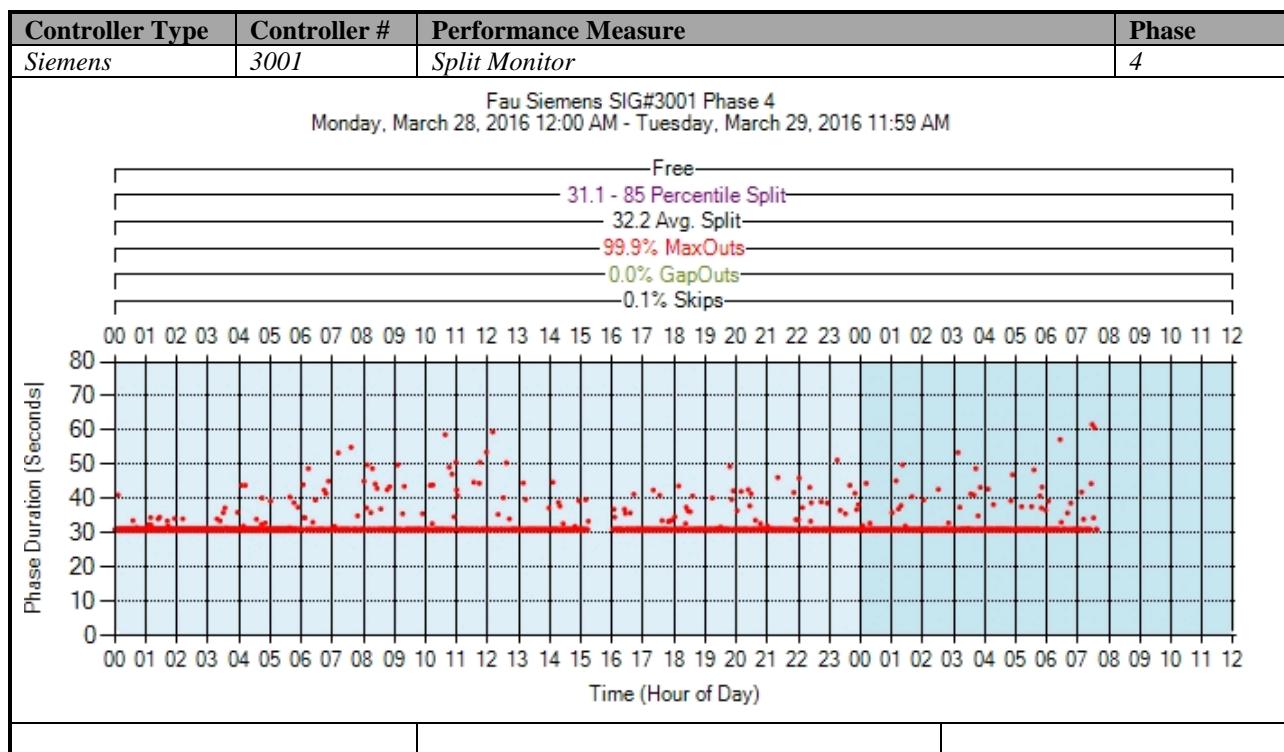


Figure A-52. Siemens – Split Monitor – Phase 4

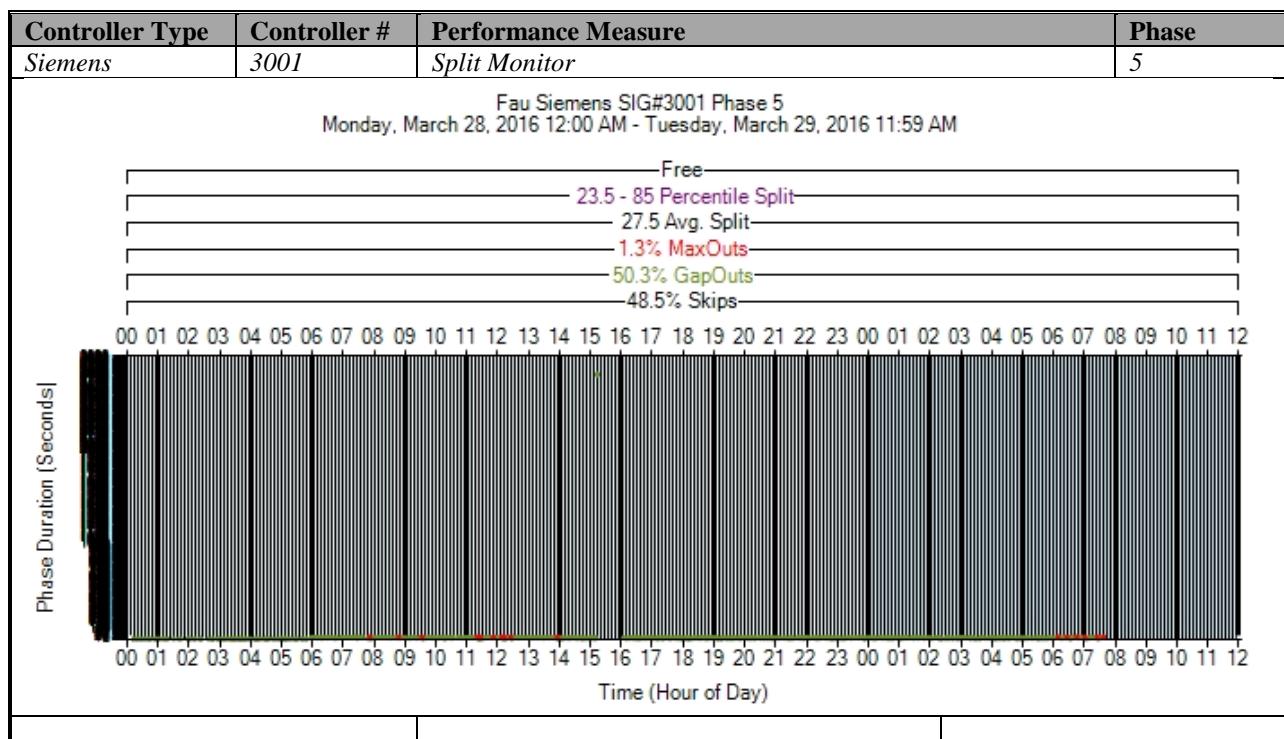


Figure A-53. Siemens – Split Monitor – Phase 5

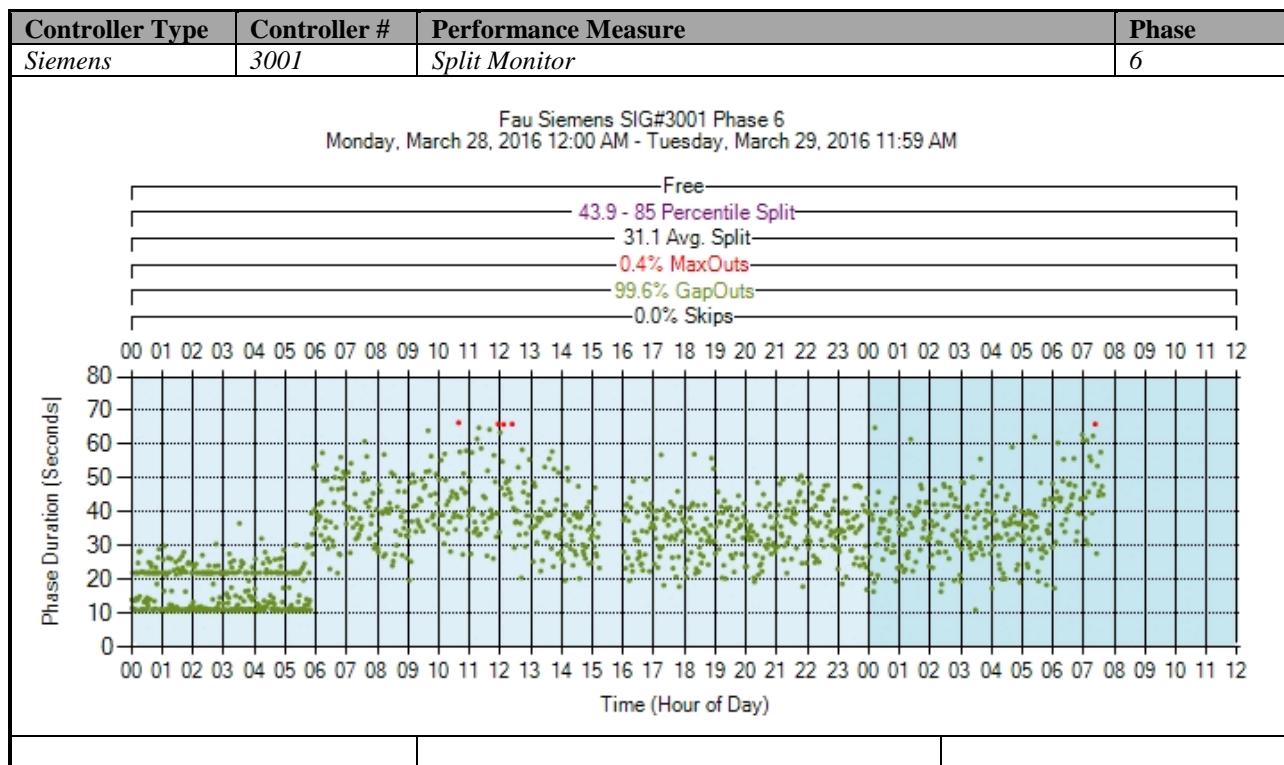


Figure A-54. Siemens – Split Monitor – Phase 6

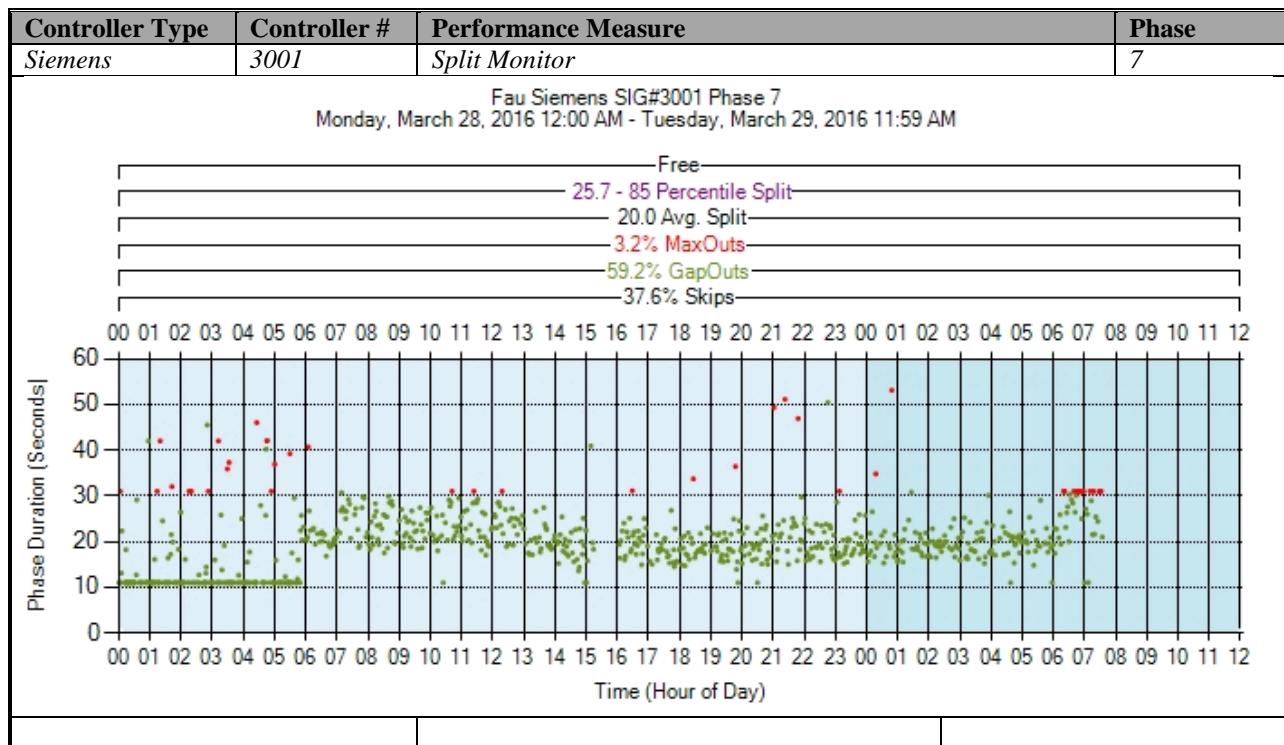


Figure A-55. Siemens – Split Monitor – Phase 7

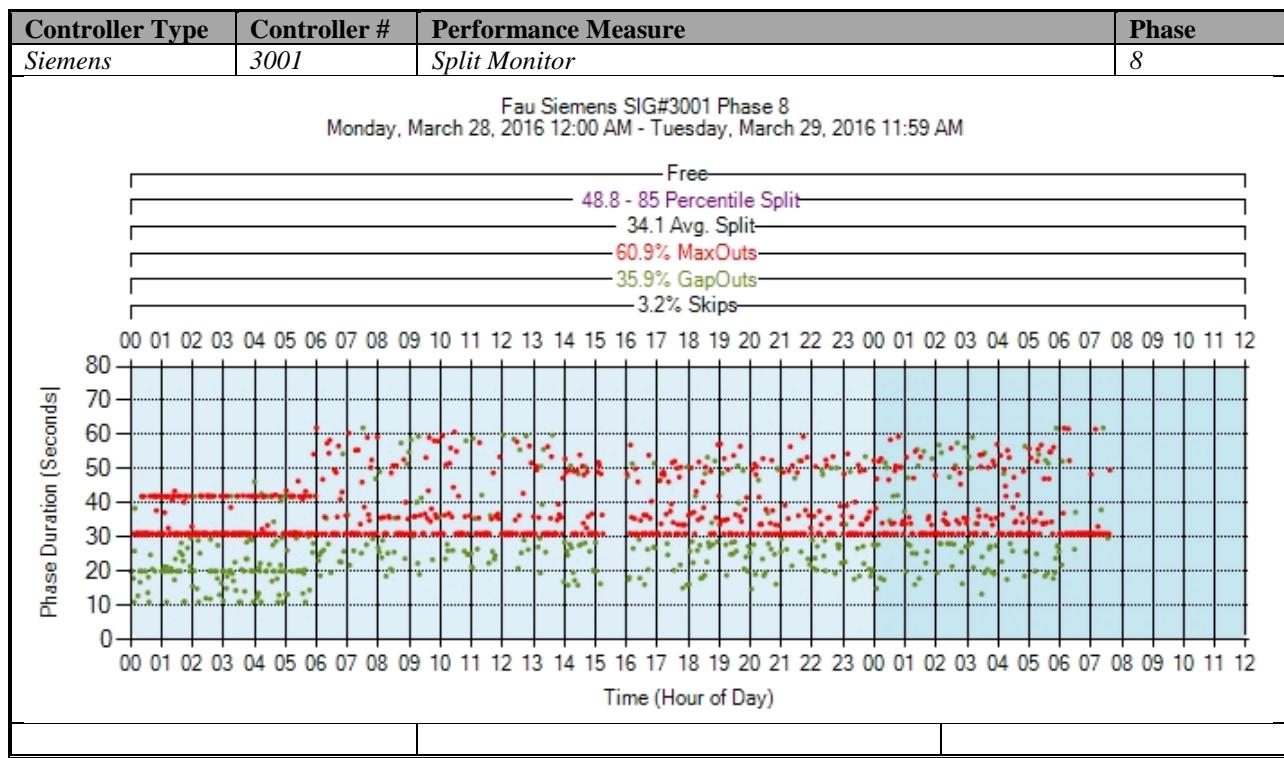


Figure A-56. Siemens – Split Monitor – Phase 8

k) Turning Movement Counts

No graphs – Need to add new detectors after the stop bar. To be accomplished later.

l) Yellow and Red Actuations

No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.

A.3 PEEK (ATC-1000) High Resolution Data Performance Metrics

a) Approach Delay – PEEK (C:\inetpub\wwwroot\SignalPerformanceMetrics)

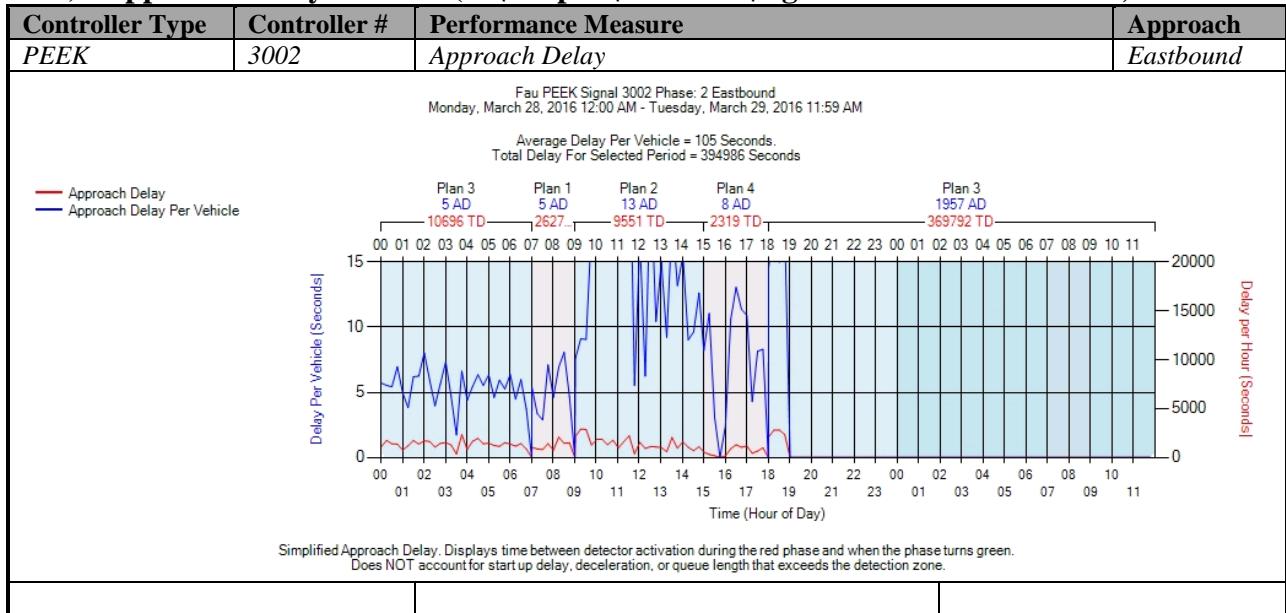


Figure A-57. PEEK – Approach Delay – EB

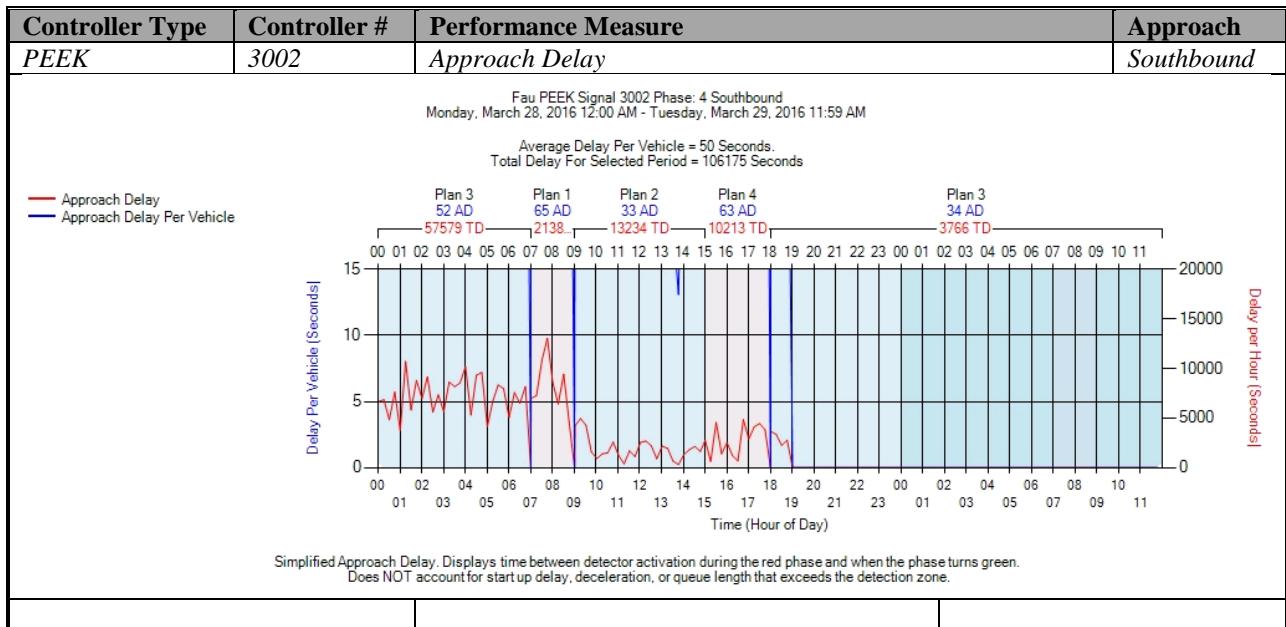


Figure A-58. PEEK – Approach Delay – SB

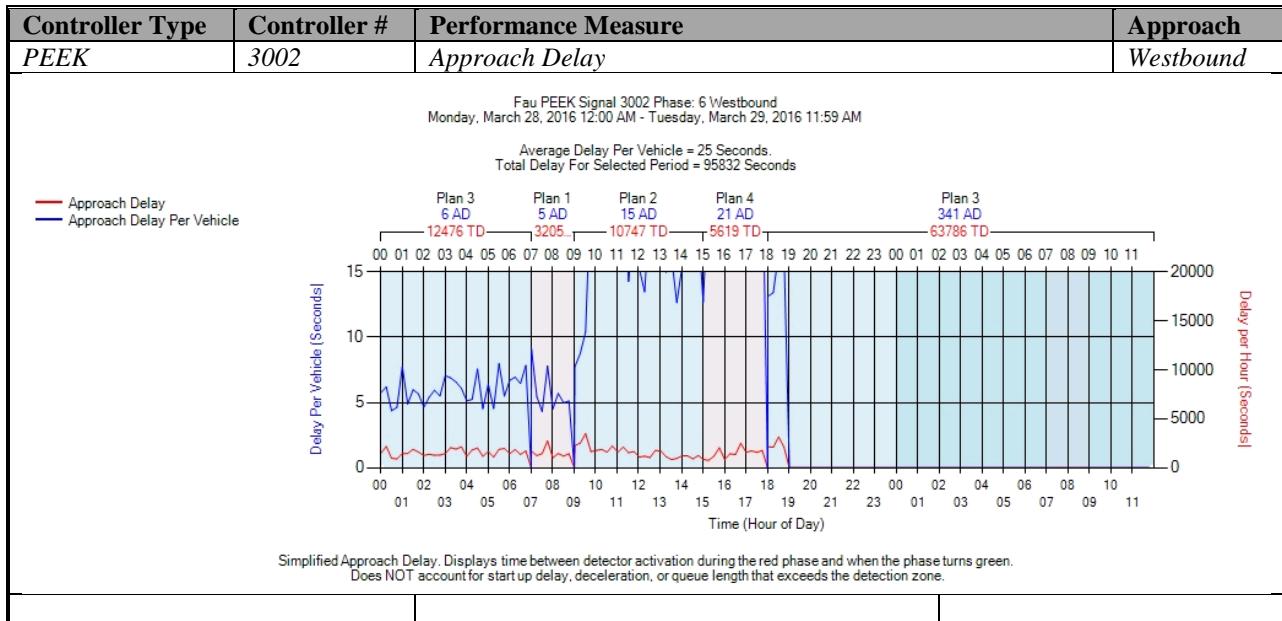


Figure A-59. PEEK – Approach Delay – WB

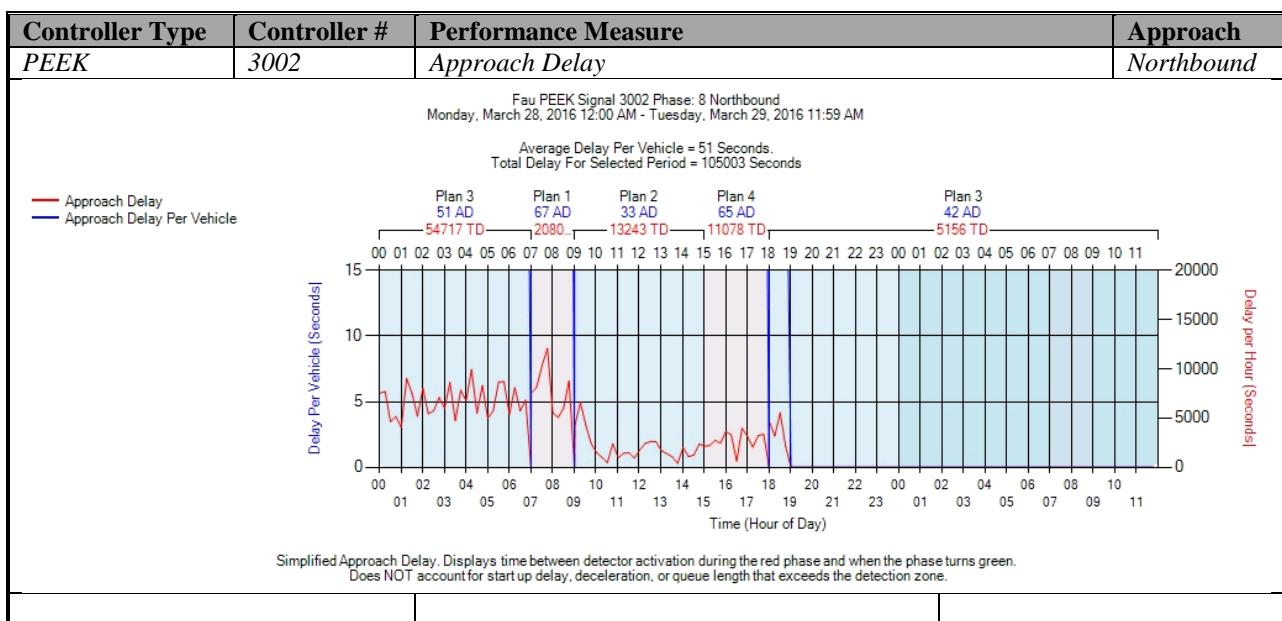


Figure A-60. PEEK – Approach Delay – NB

b) Approach Volume - PEEK (C:\inetpub\wwwroot\SignalPerformanceMetrics)

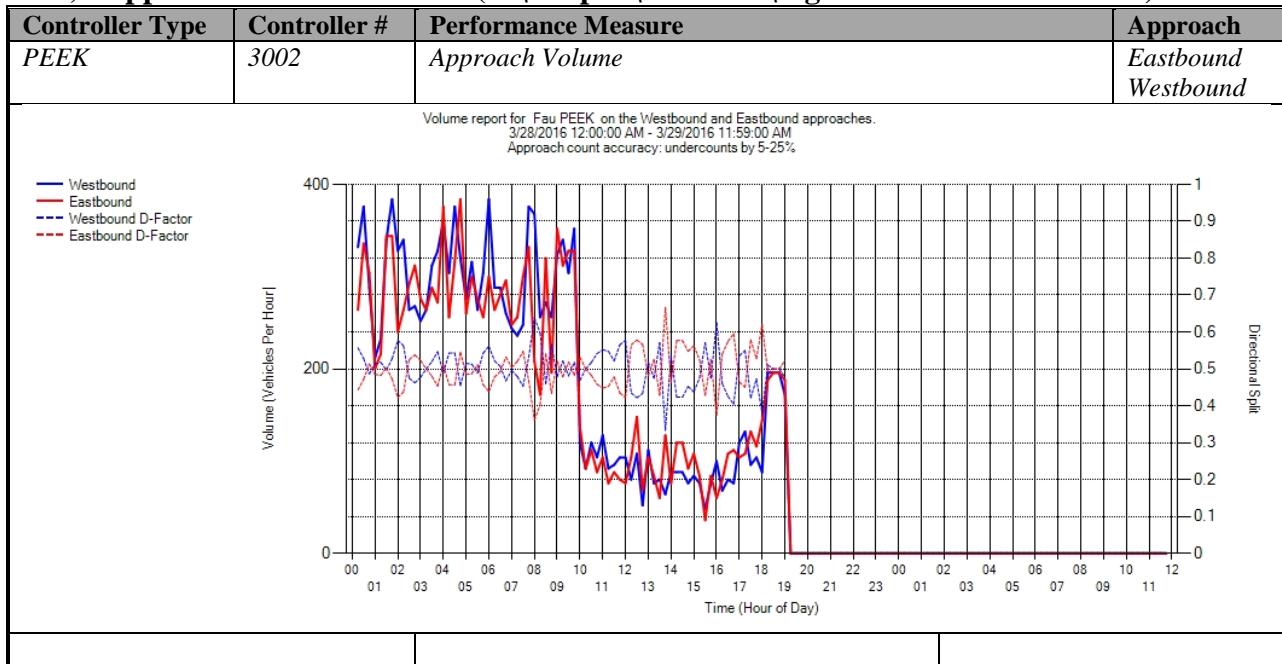


Figure A-61. PEEK – Approach Delay – WB & EB

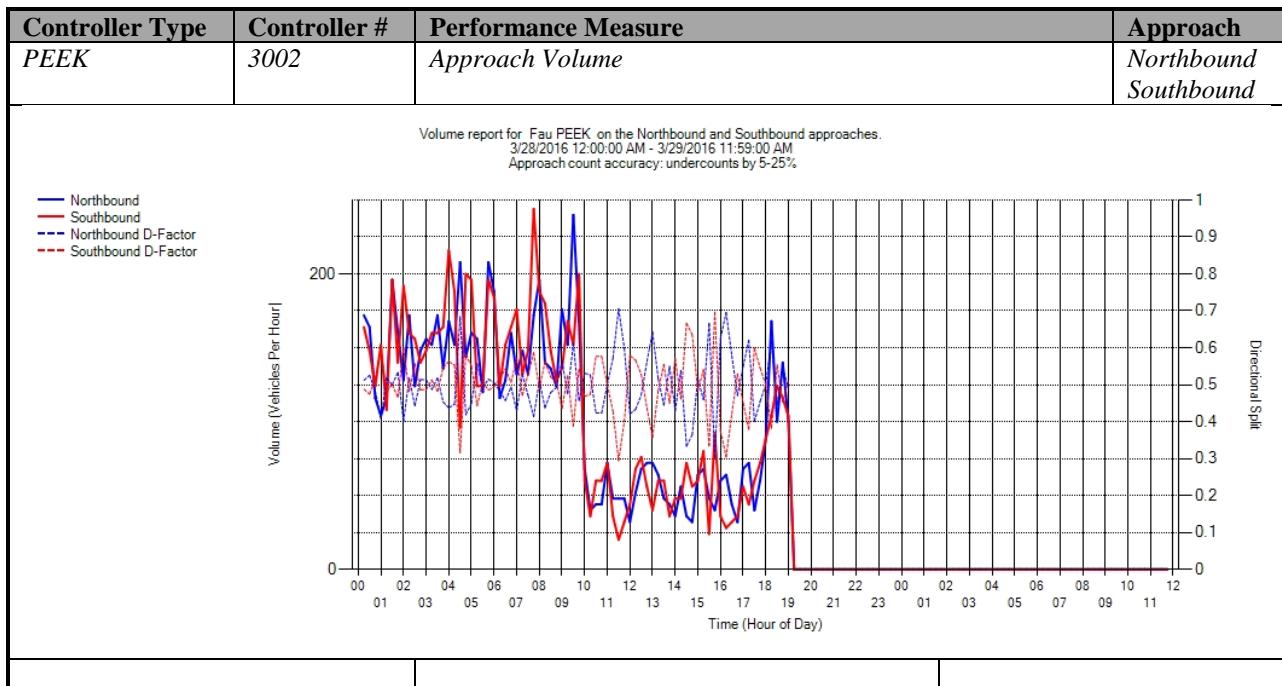


Figure A-62. PEEK – Approach Delay – NB & SB

Controller Type	Controller #	Performance Measure	Approach																																								
PEEK	3002	Approach Volume	Total																																								
<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>4,198</td></tr> <tr> <td>Peak Hour</td><td>7:45 AM - 8:45 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>351</td></tr> <tr> <td>PHF</td><td>0.844</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Northbound Total Volume</td><td>2,080</td></tr> <tr> <td>Northbound Peak Hour</td><td>9:00 AM - 10:00 AM</td></tr> <tr> <td>Northbound Peak Hour Volume</td><td>184</td></tr> <tr> <td>Northbound PHF</td><td>0.767</td></tr> <tr> <td>Northbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Northbound Peak-Hour D-factor</td><td>0.891</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Southbound Total Volume</td><td>2,118</td></tr> <tr> <td>Southbound Peak Hour</td><td>7:30 AM - 8:30 AM</td></tr> <tr> <td>Southbound Peak Hour Volume</td><td>190</td></tr> <tr> <td>Southbound PHF</td><td>1</td></tr> <tr> <td>Southbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Southbound Peak-Hour D-factor</td><td>0.842</td></tr> </tbody> </table>				Metric	Value	Total Volume	4,198	Peak Hour	7:45 AM - 8:45 AM	Peak Hour Volume	351	PHF	0.844	Peak-Hour K-factor	NA			Northbound Total Volume	2,080	Northbound Peak Hour	9:00 AM - 10:00 AM	Northbound Peak Hour Volume	184	Northbound PHF	0.767	Northbound Peak-Hour K-factor	NA	Northbound Peak-Hour D-factor	0.891			Southbound Total Volume	2,118	Southbound Peak Hour	7:30 AM - 8:30 AM	Southbound Peak Hour Volume	190	Southbound PHF	1	Southbound Peak-Hour K-factor	NA	Southbound Peak-Hour D-factor	0.842
Metric	Value																																										
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<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>7,687</td></tr> <tr> <td>Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>673</td></tr> <tr> <td>PHF</td><td>0.914</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Westbound Total Volume</td><td>3,904</td></tr> <tr> <td>Westbound Peak Hour</td><td>1:30 AM - 2:30 AM</td></tr> <tr> <td>Westbound Peak Hour Volume</td><td>348</td></tr> <tr> <td>Westbound PHF</td><td>0.906</td></tr> <tr> <td>Westbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Westbound Peak-Hour D-factor</td><td>0.856</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Eastbound Total Volume</td><td>3,783</td></tr> <tr> <td>Eastbound Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Eastbound Peak Hour Volume</td><td>333</td></tr> <tr> <td>Eastbound PHF</td><td>1</td></tr> <tr> <td>Eastbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Eastbound Peak-Hour D-factor</td><td>1.02</td></tr> </tbody> </table>				Metric	Value	Total Volume	7,687	Peak Hour	4:00 AM - 5:00 AM	Peak Hour Volume	673	PHF	0.914	Peak-Hour K-factor	NA			Westbound Total Volume	3,904	Westbound Peak Hour	1:30 AM - 2:30 AM	Westbound Peak Hour Volume	348	Westbound PHF	0.906	Westbound Peak-Hour K-factor	NA	Westbound Peak-Hour D-factor	0.856			Eastbound Total Volume	3,783	Eastbound Peak Hour	4:00 AM - 5:00 AM	Eastbound Peak Hour Volume	333	Eastbound PHF	1	Eastbound Peak-Hour K-factor	NA	Eastbound Peak-Hour D-factor	1.02
Metric	Value																																										
Total Volume	7,687																																										
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Eastbound Peak Hour Volume	333																																										
Eastbound PHF	1																																										
Eastbound Peak-Hour K-factor	NA																																										
Eastbound Peak-Hour D-factor	1.02																																										

Figure A-63. PEEK – Approach Volume – WB

c) Arrivals On Red - PEEK (C:\inetpub\wwwroot\SignalPerformanceMetrics)

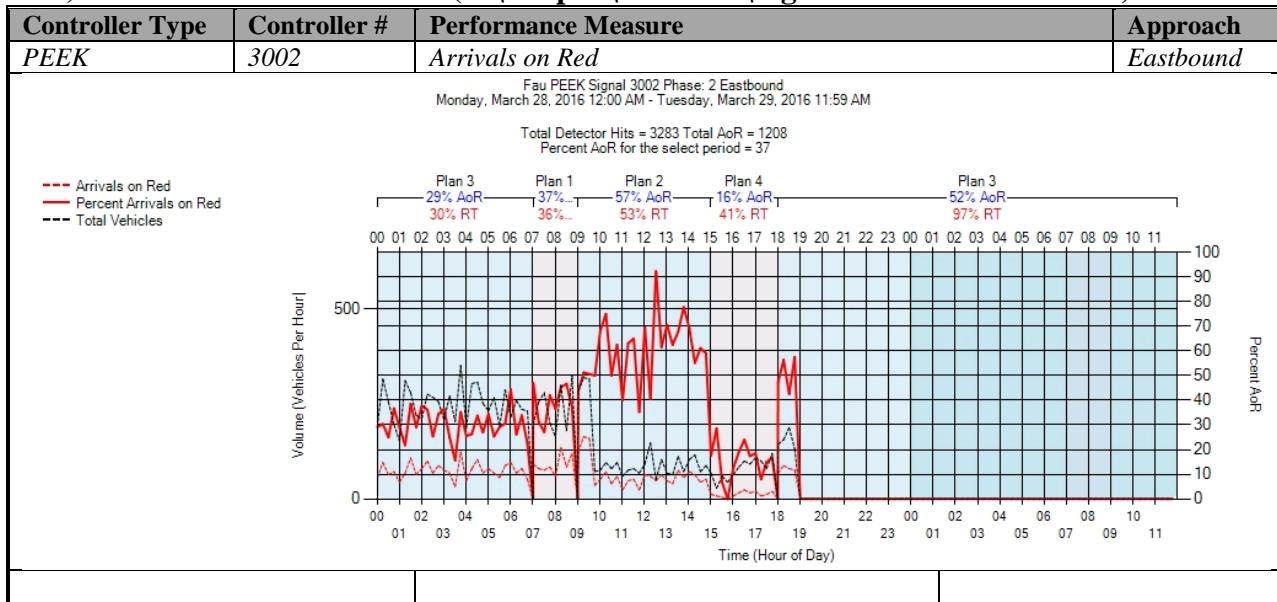


Figure A-64. PEEK – Arrivals on Red – EB

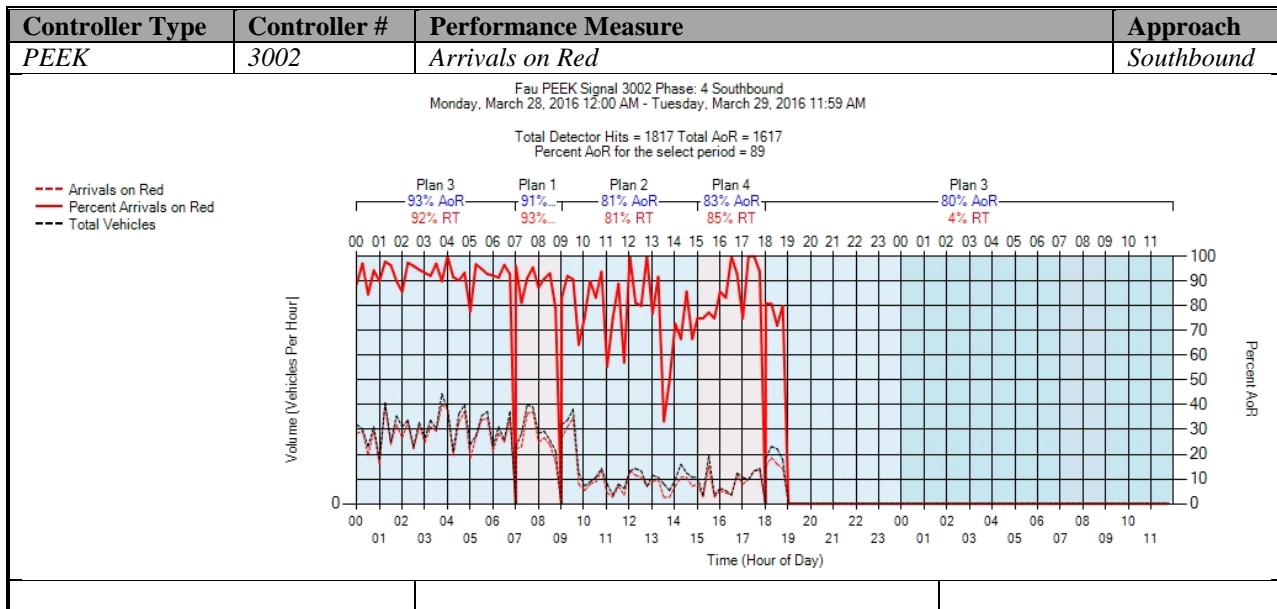


Figure A-65. PEEK – Arrivals on Red – SB

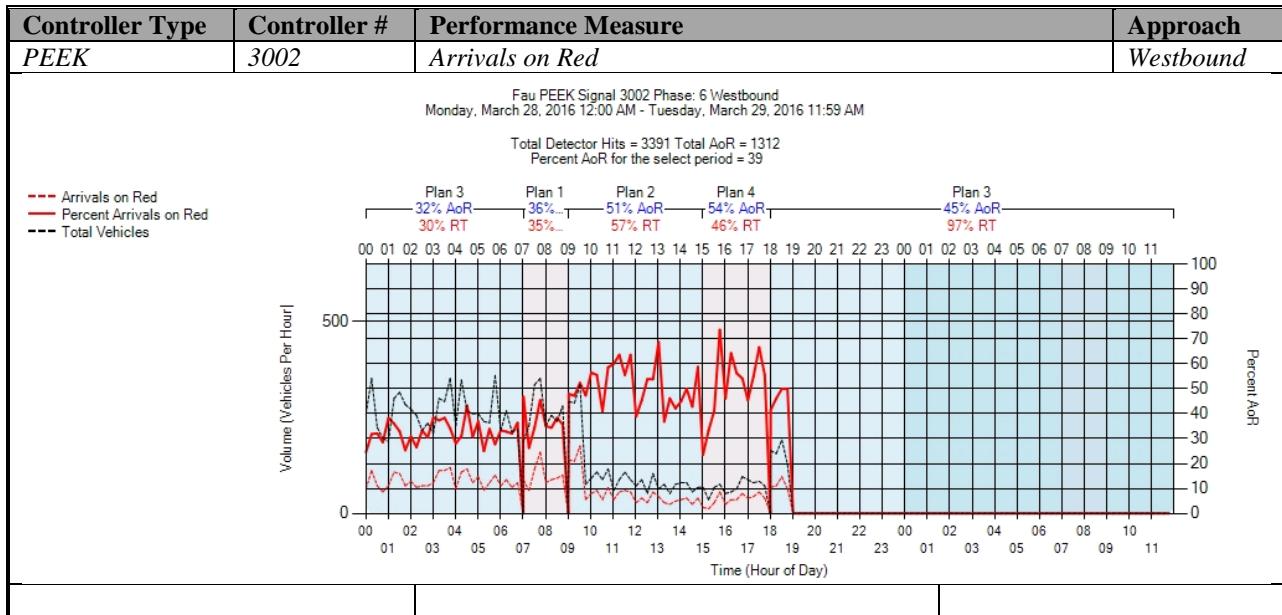


Figure A-66. PEEK – Arrivals on Red – WB

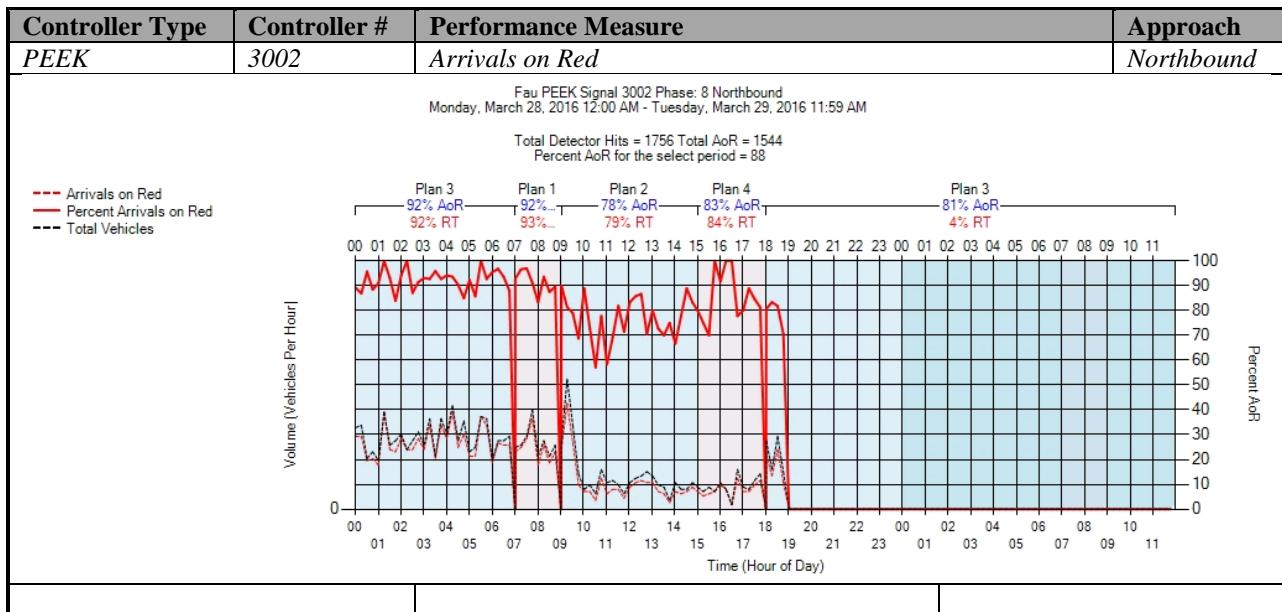


Figure A-67. PEEK – Arrivals on Red – NB

d) Purdue Coordination Diagram – PEEK (C:\inetpub\wwwroot\SPMImages)

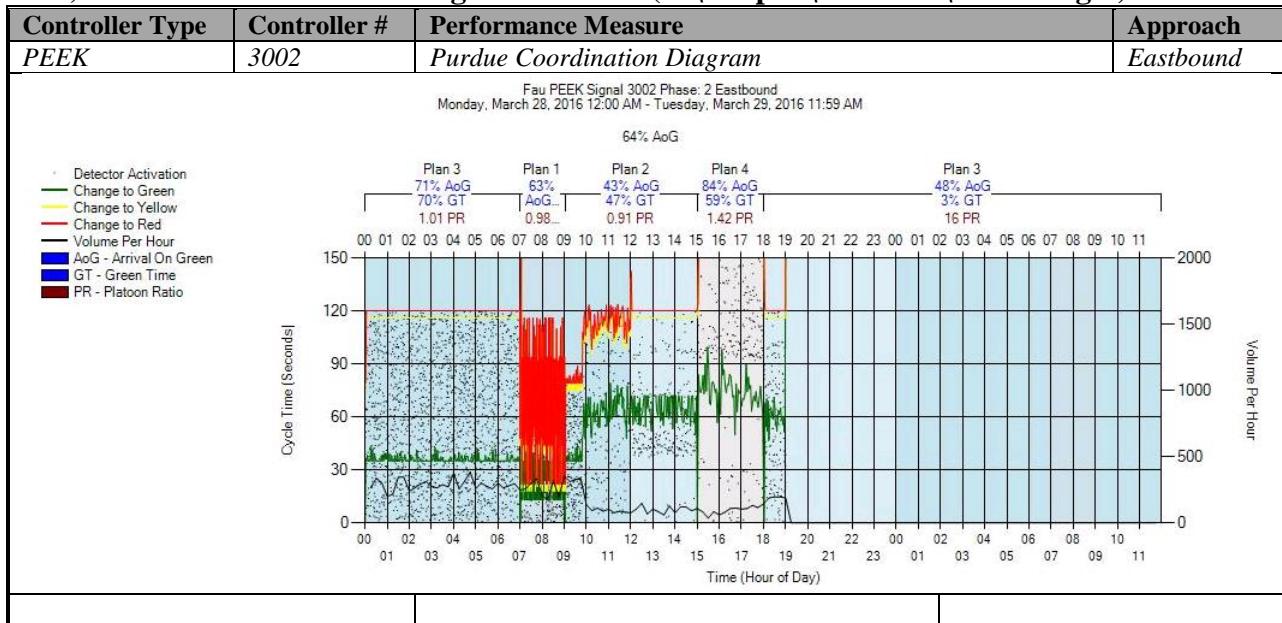


Figure A-68. PEEK – Purdue Coordination Diagram – EB

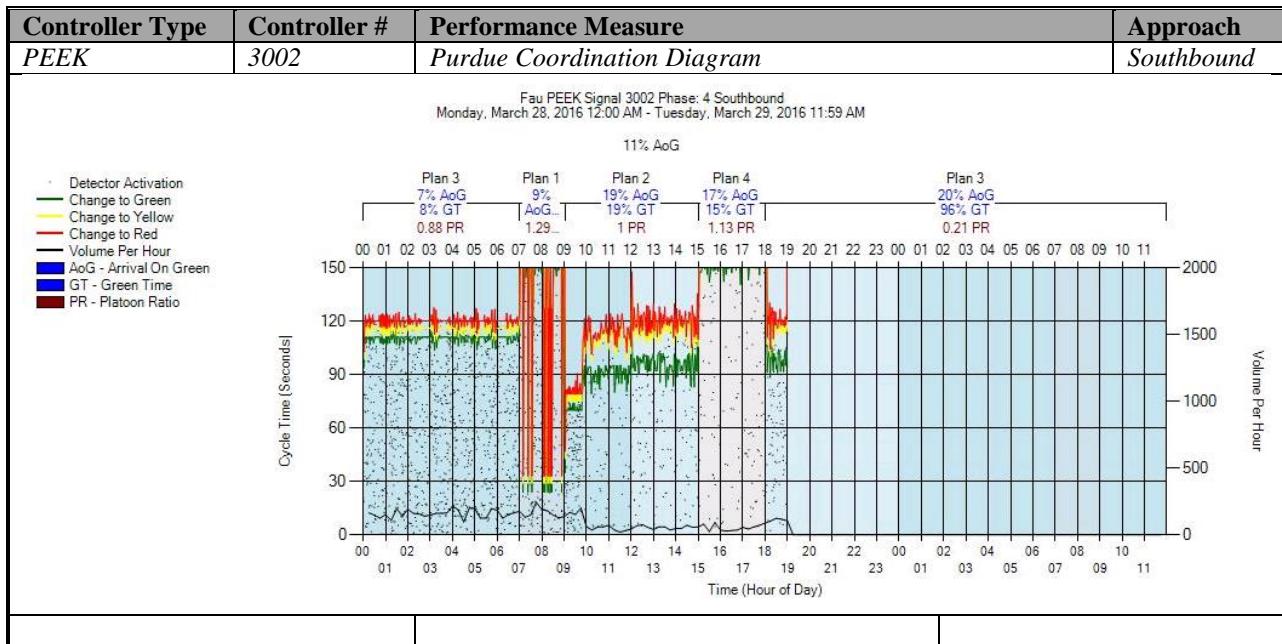


Figure A-69. PEEK – Purdue Coordination Diagram – SB

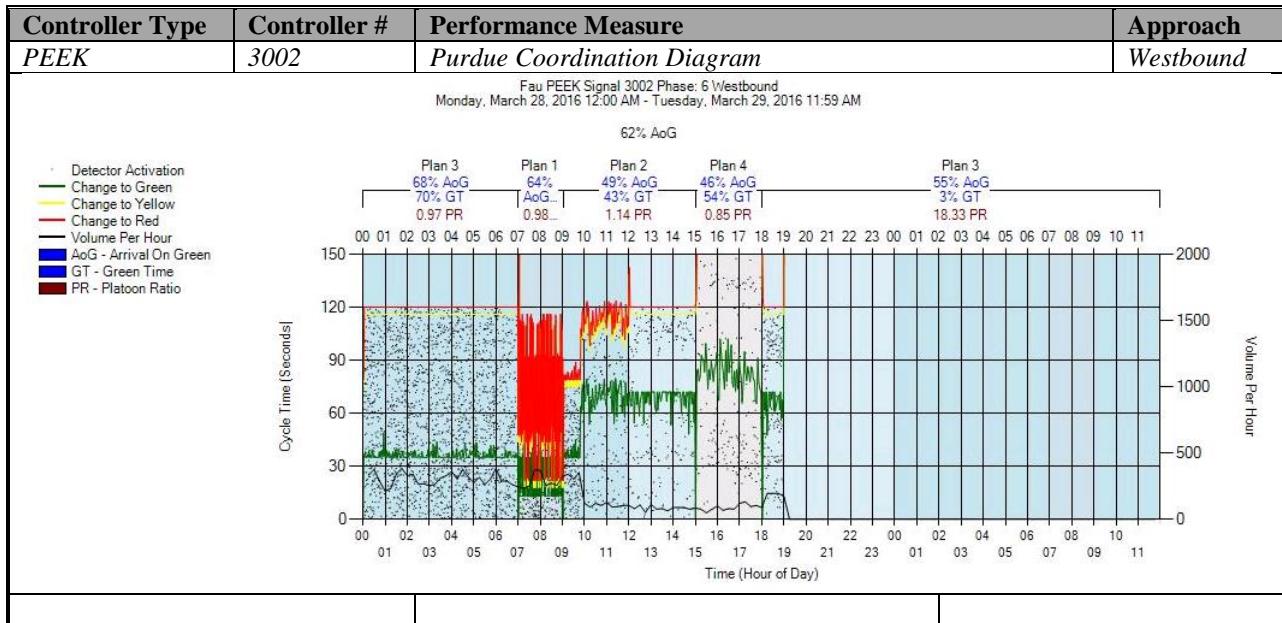


Figure A-70. PEEK – Purdue Coordination Diagram – WB

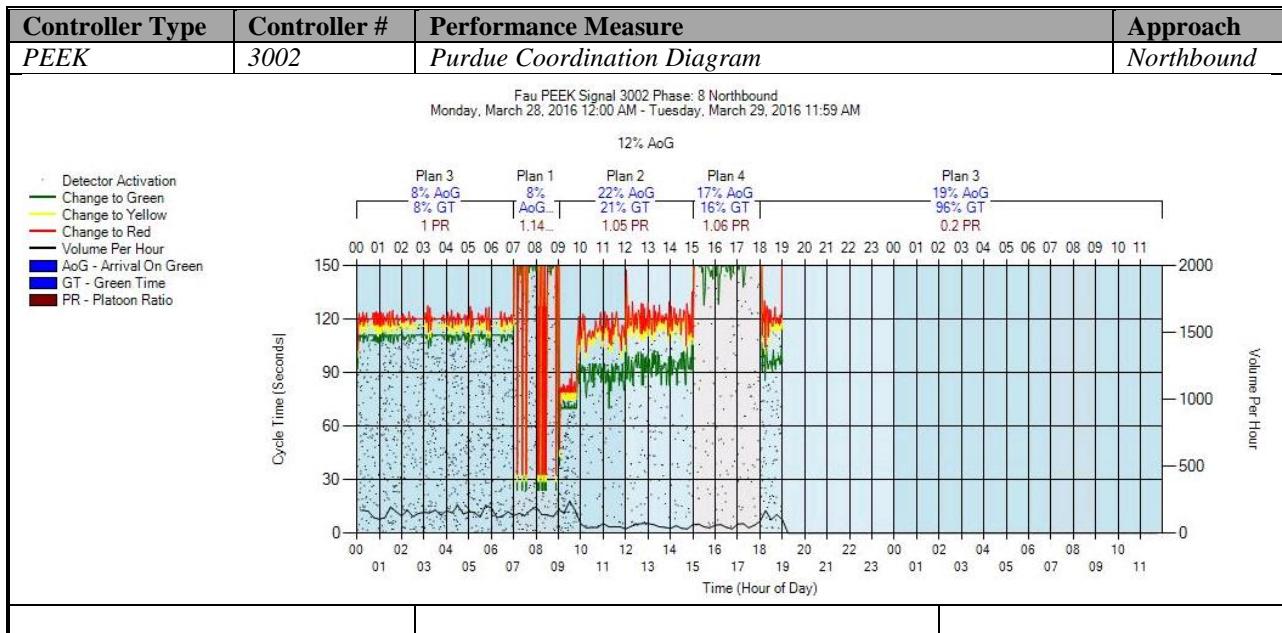


Figure A-71. PEEK – Purdue Coordination Diagram – NB

e) Purdue Split Failure

No graphs – Needs to be configured in the SPM Tool. To be accomplished later.

f) Pedestrian Delay

No graphs – Needs to be configured in the controller. To be accomplished later.

g) Preemption Details

No graphs – Needs to be configured in the controller. To be accomplished later.

h) Purdue Phase Termination

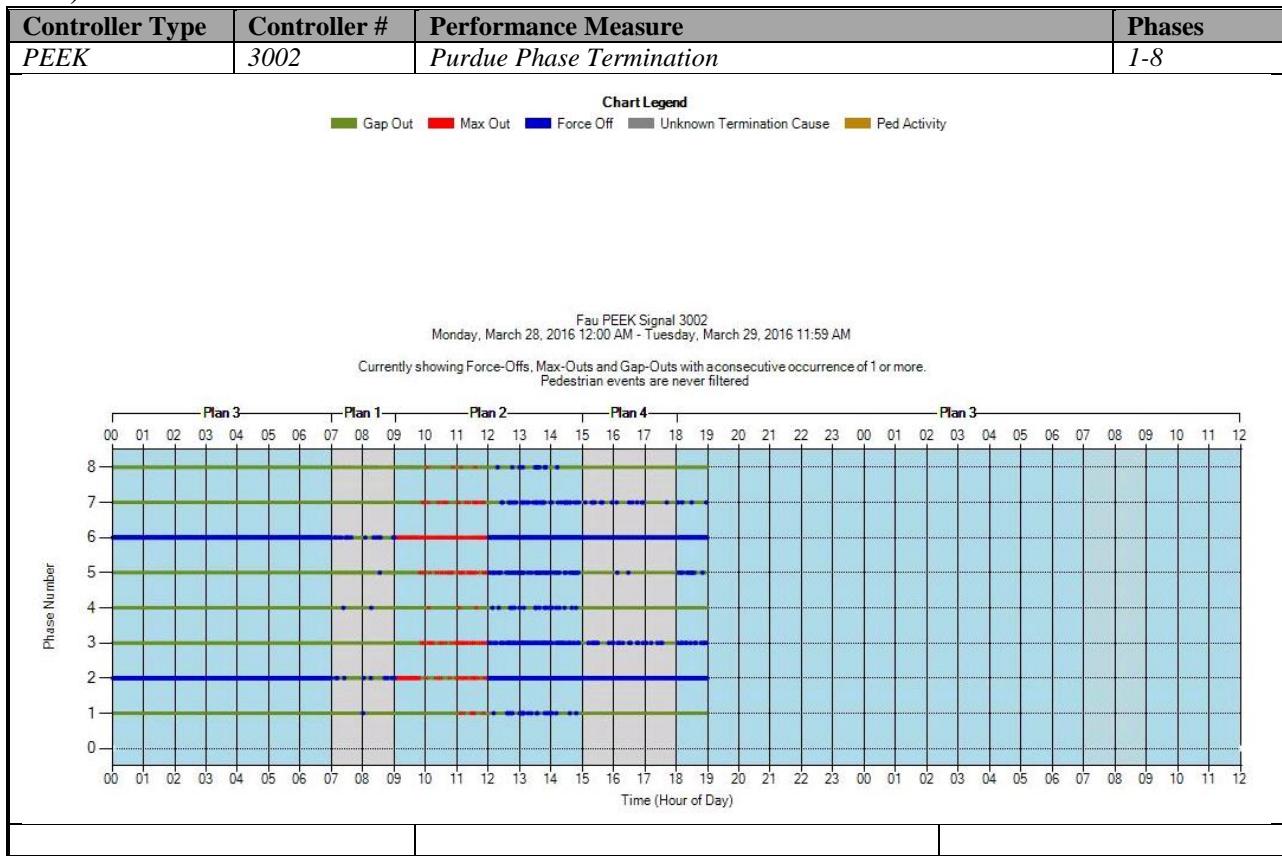


Figure A-72. PEEK – Purdue Phase Termination

i) Speed (Check in C:\inetpub\wwwroot\SignalPerformanceMetrics\misc)

There are graphs, but without data from the controller because speed detectors need to be configured in the controller. To be accomplished later.

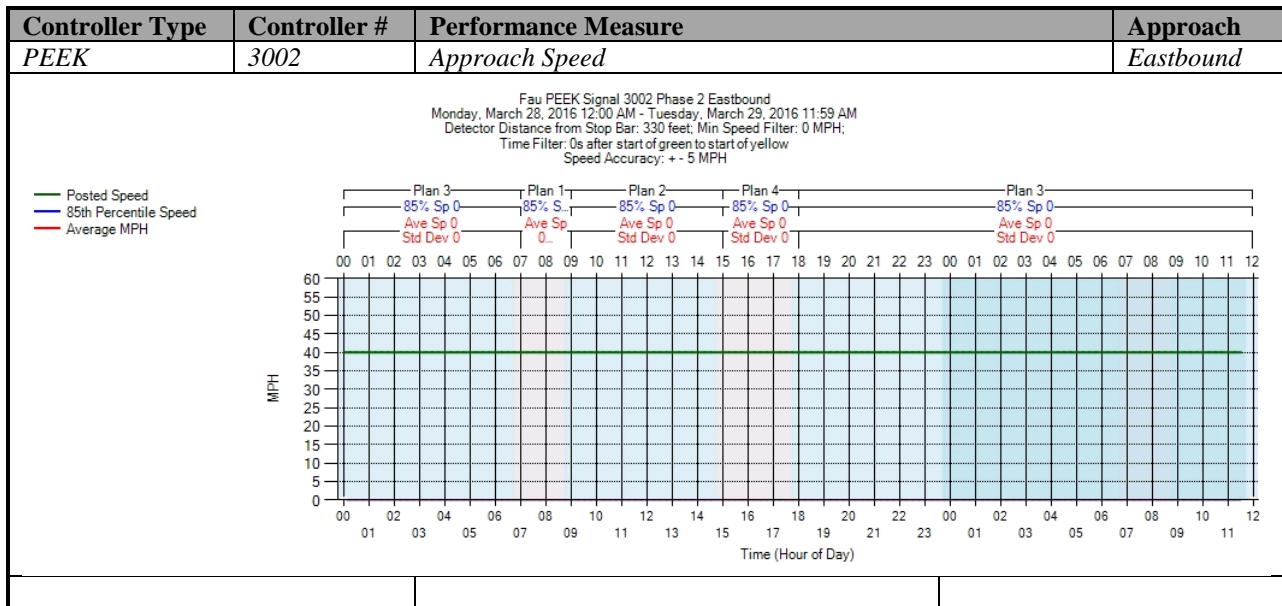


Figure A-73. PEEK – Approach Speed – EB

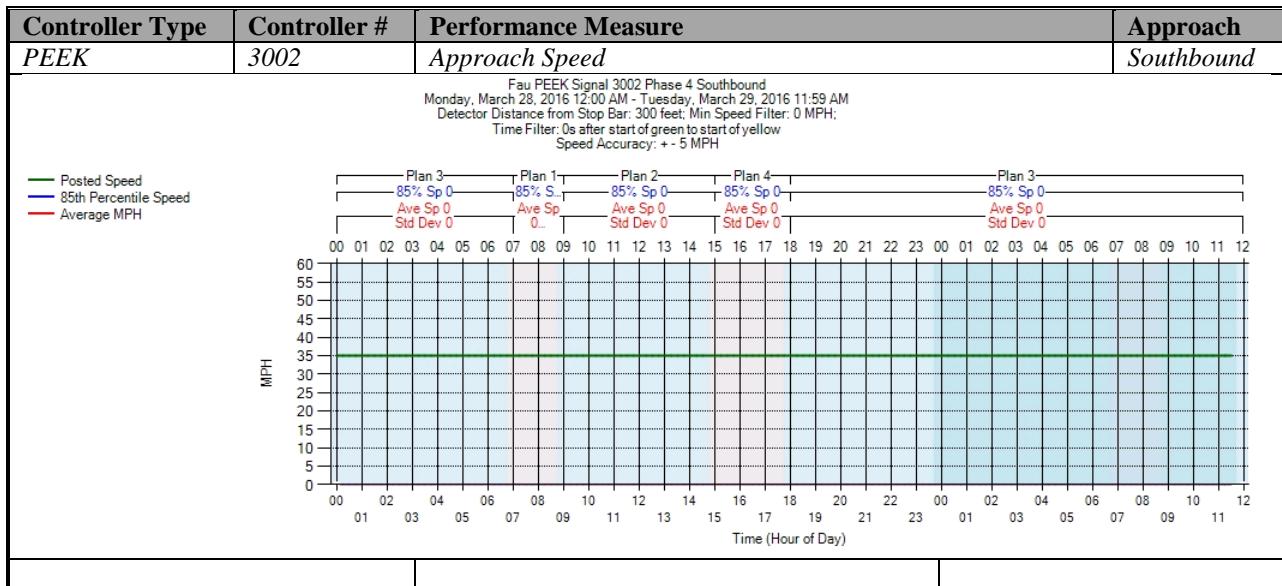


Figure A-74. PEEK – Approach Speed – SB

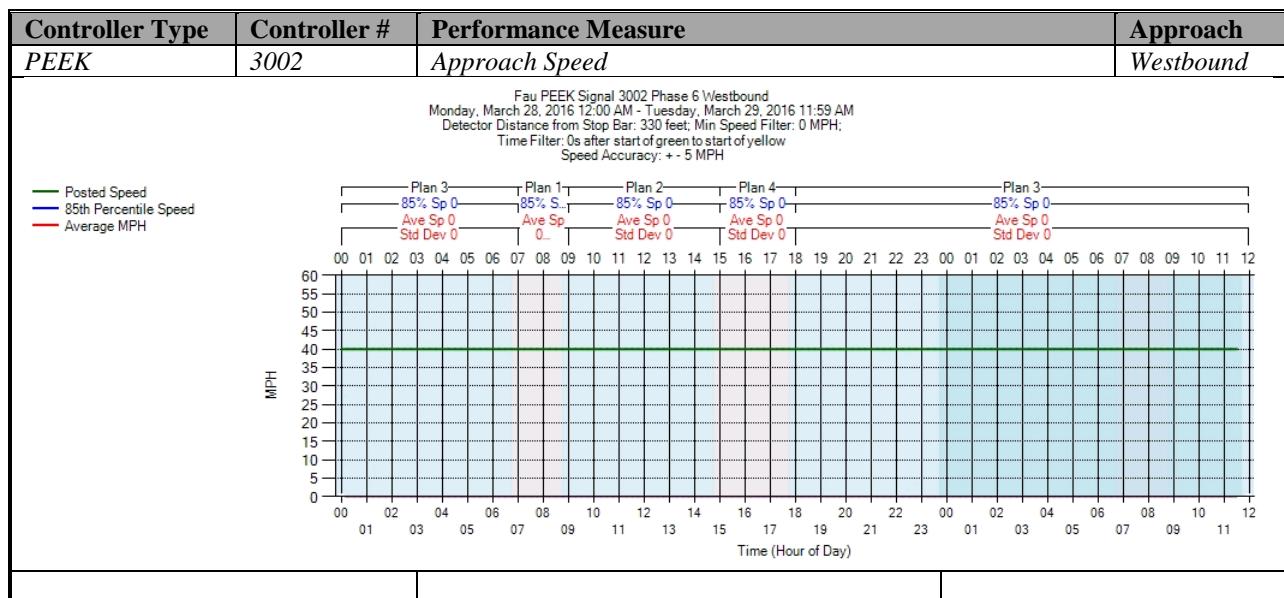


Figure A-75. PEEK – Approach Speed – WB

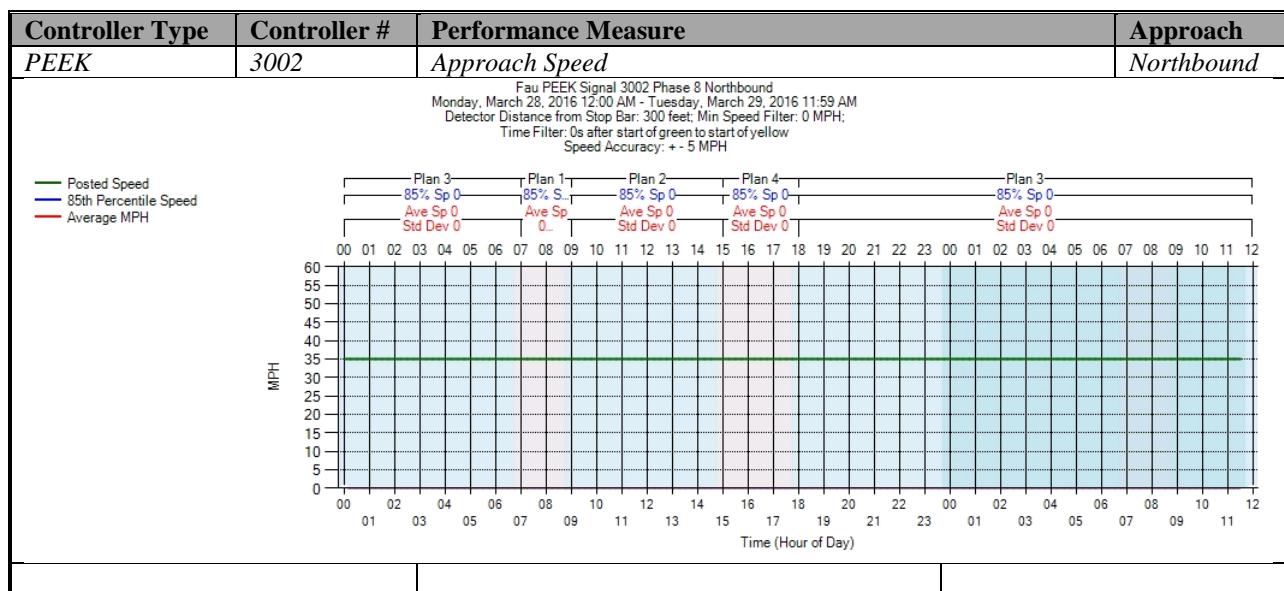


Figure A-76. PEEK – Approach Speed – NB

j) Split Monitor – PEEK

(C:\Installs\Deeptistuff\SPMWebFiles\SPMWebFiles\SPMSourceFiles\v3.2Deepti\Signal Timing Diagrams)

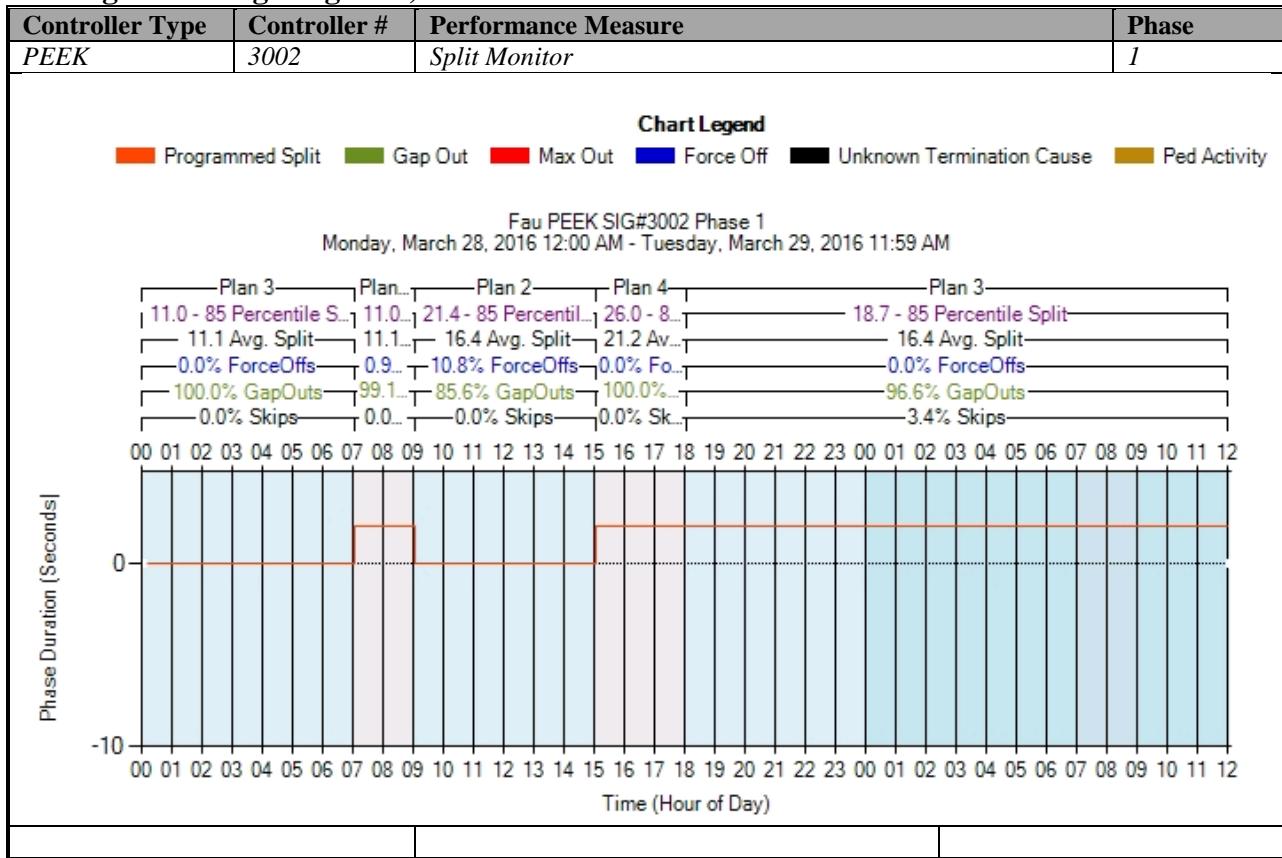


Figure A-77. PEEK – Split Monitor – Phase 1

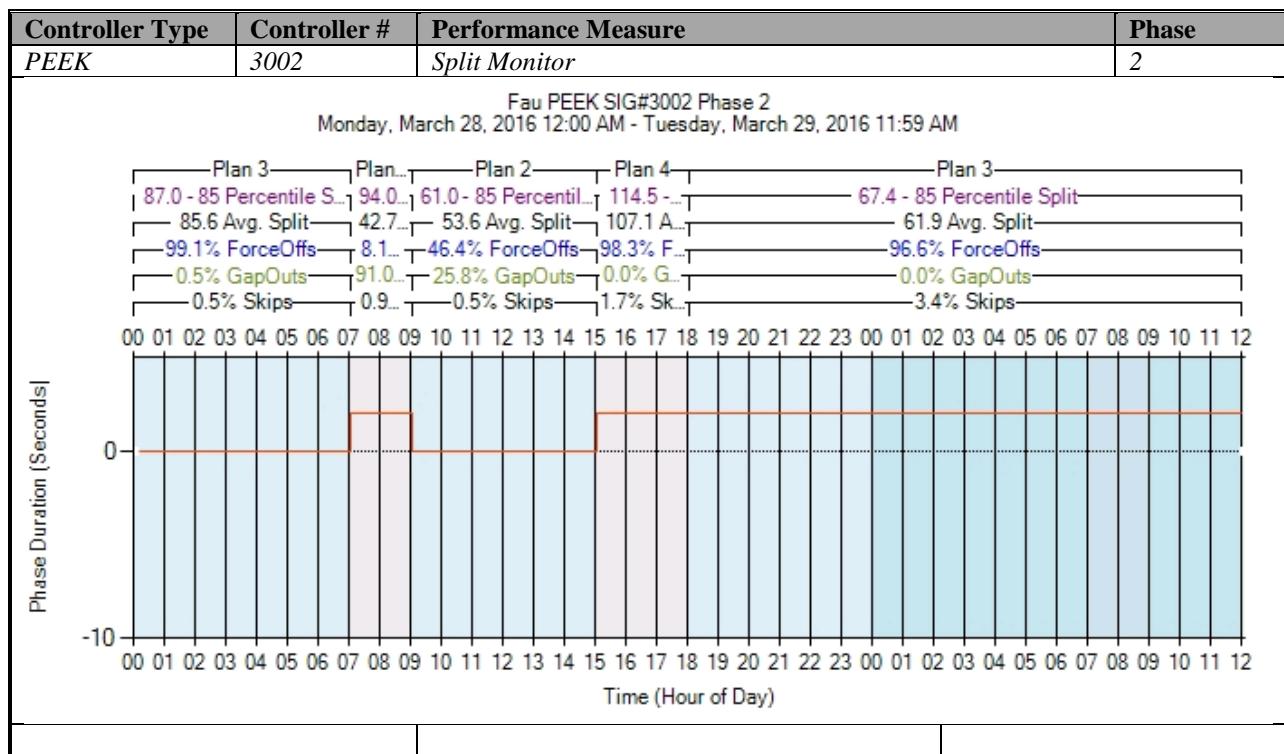


Figure A-78. PEEK – Split Monitor – Phase 2

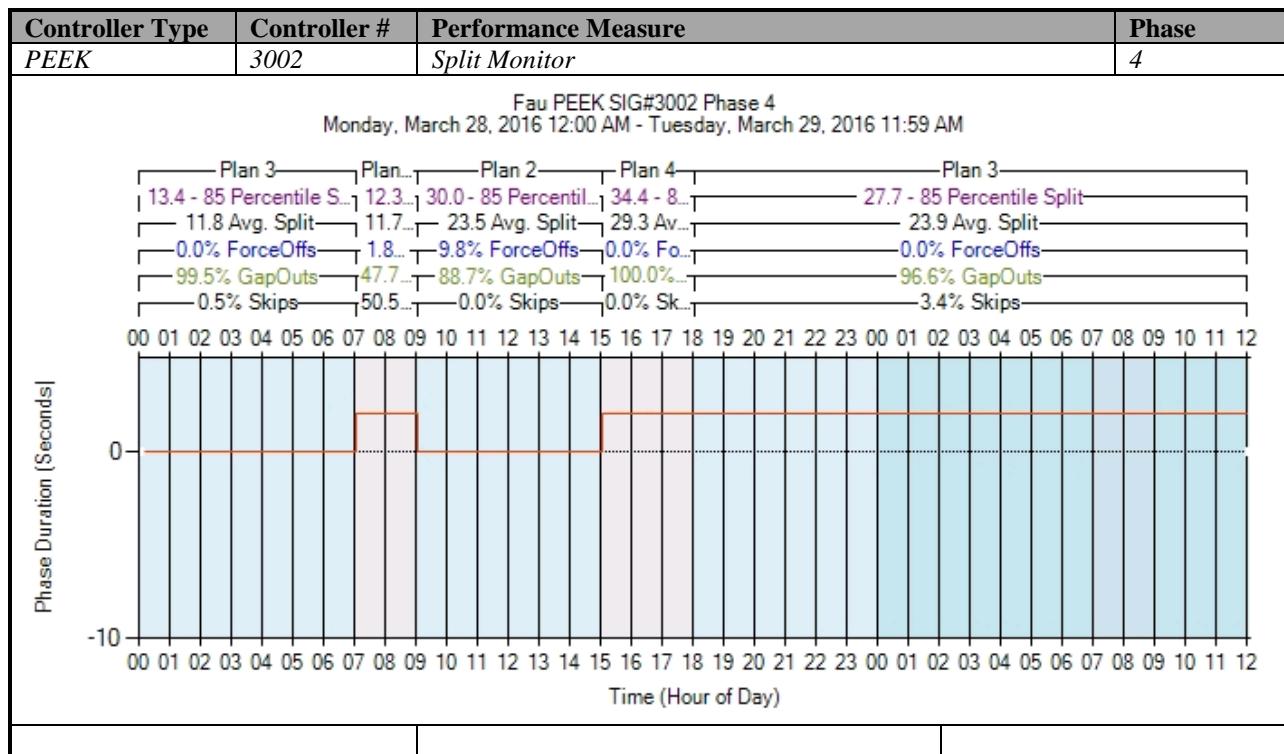


Figure A-79. PEEK – Split Monitor – Phase 4

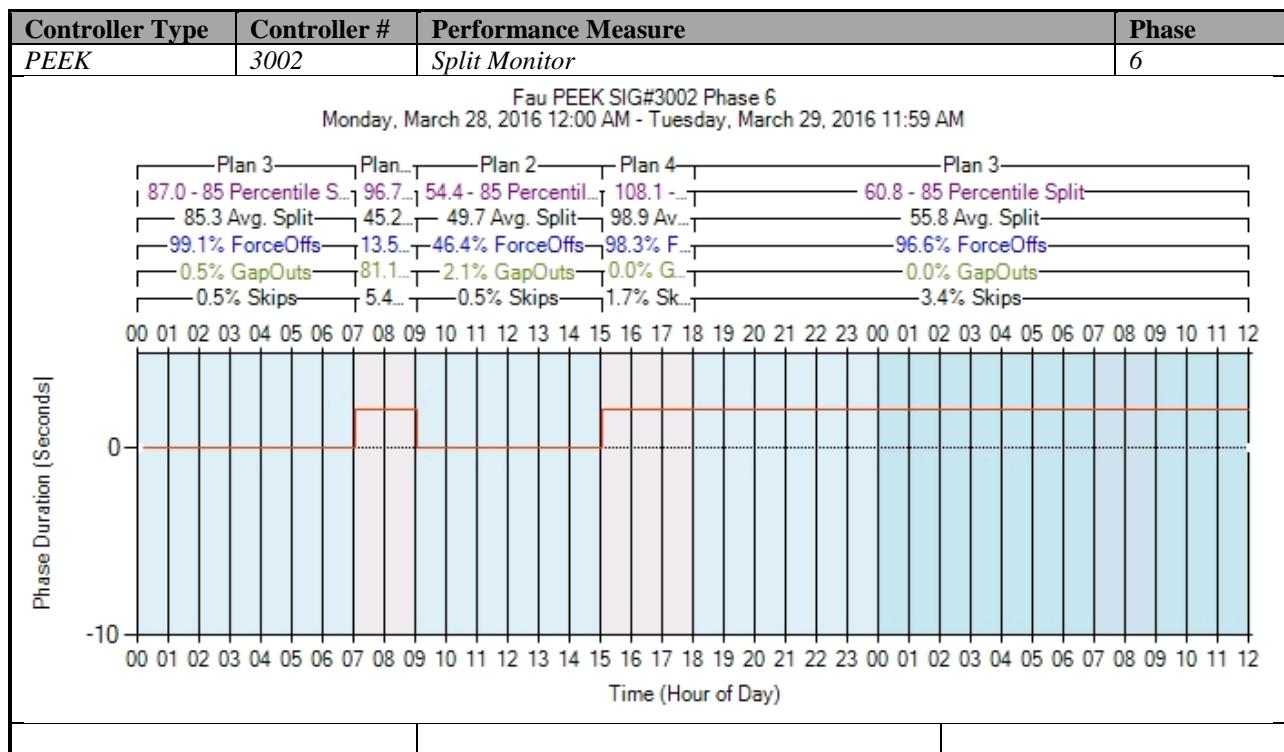


Figure A-80. PEEK – Split Monitor – Phase 6

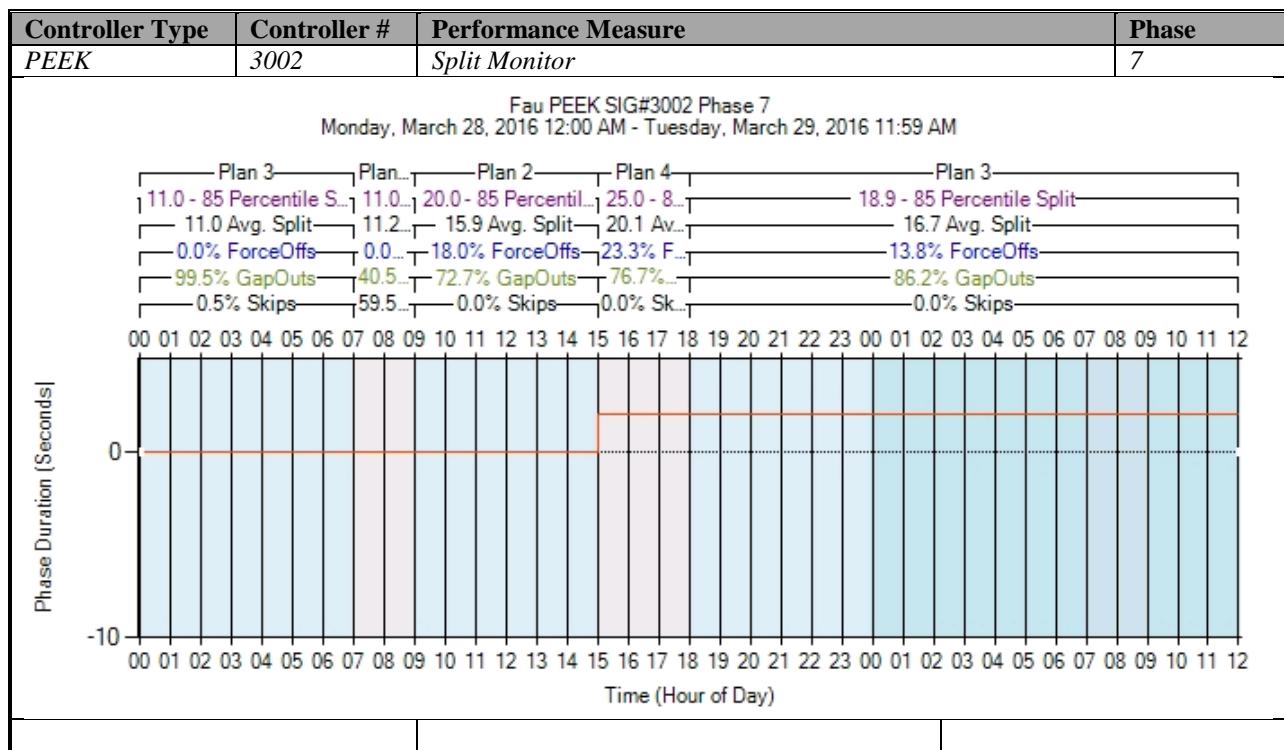


Figure A-81. PEEK – Split Monitor – Phase 7

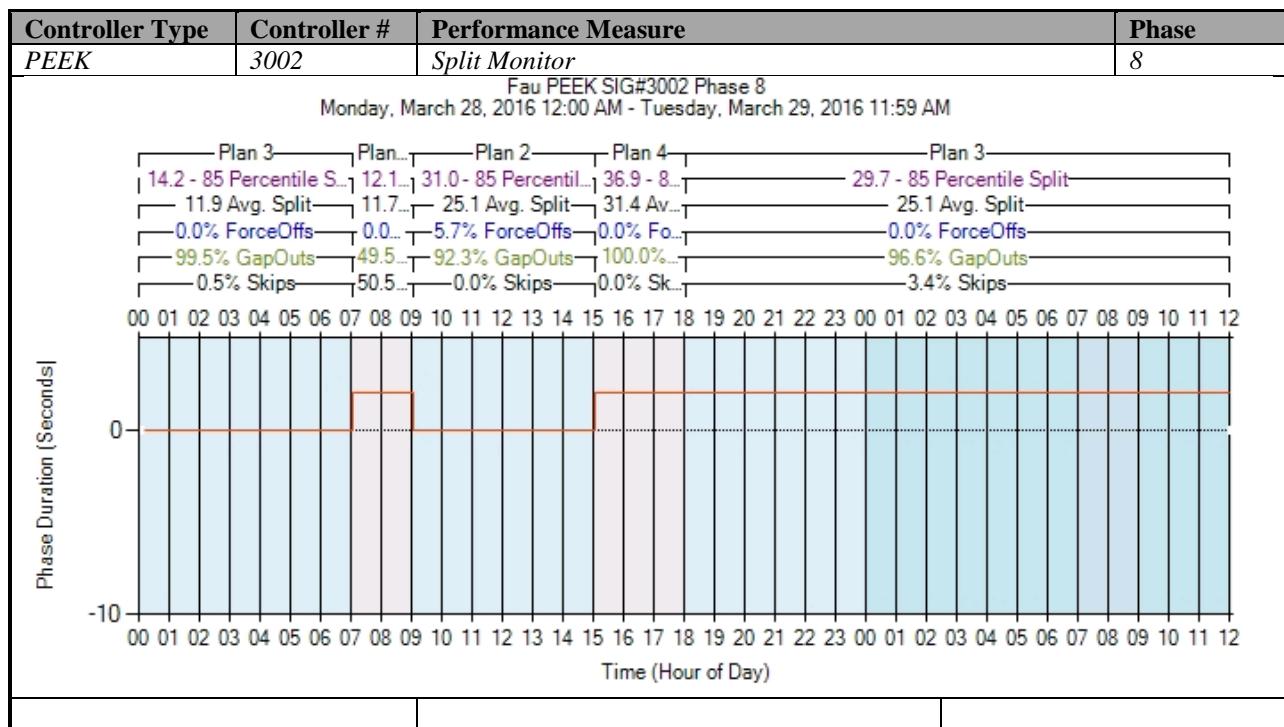


Figure A-82. PEEK – Split Monitor – Phase 8

k) Turning Movement Counts

No graphs – Need to add new detectors after the stop bar. To be accomplished later.

l) Yellow and Red Actuations

No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.

A.4 Trafficware (ATC 900) High Resolution Data Performance Metrics

a) Approach Delay – Trafficware (C:\inetpub\wwwroot\SignalPerformanceMetrics)

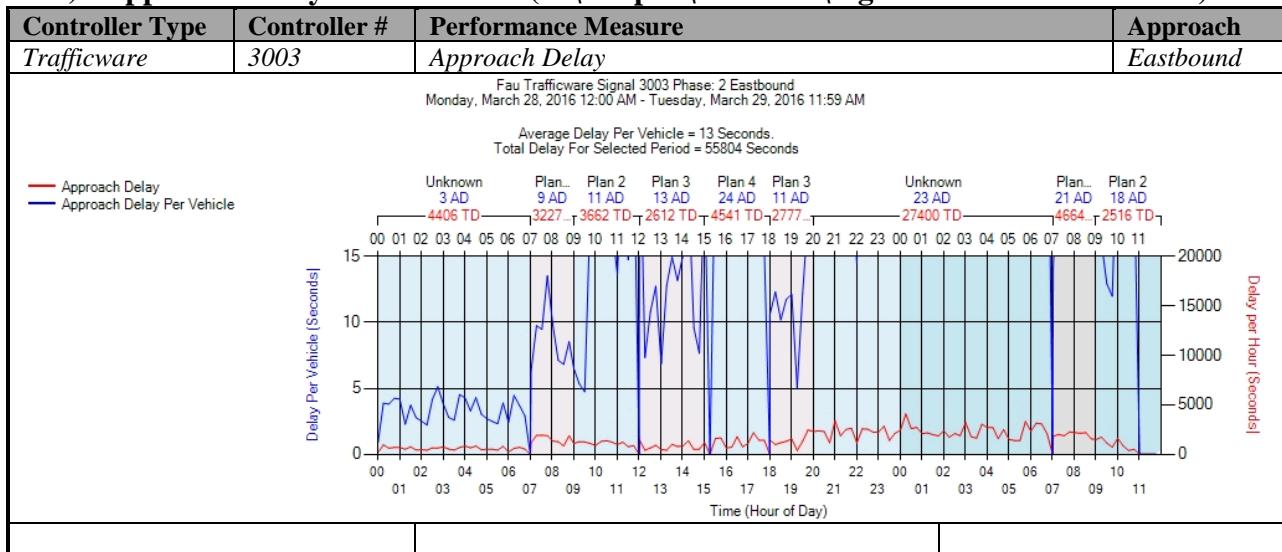


Figure A-83. Trafficware – Approach Delay – EB

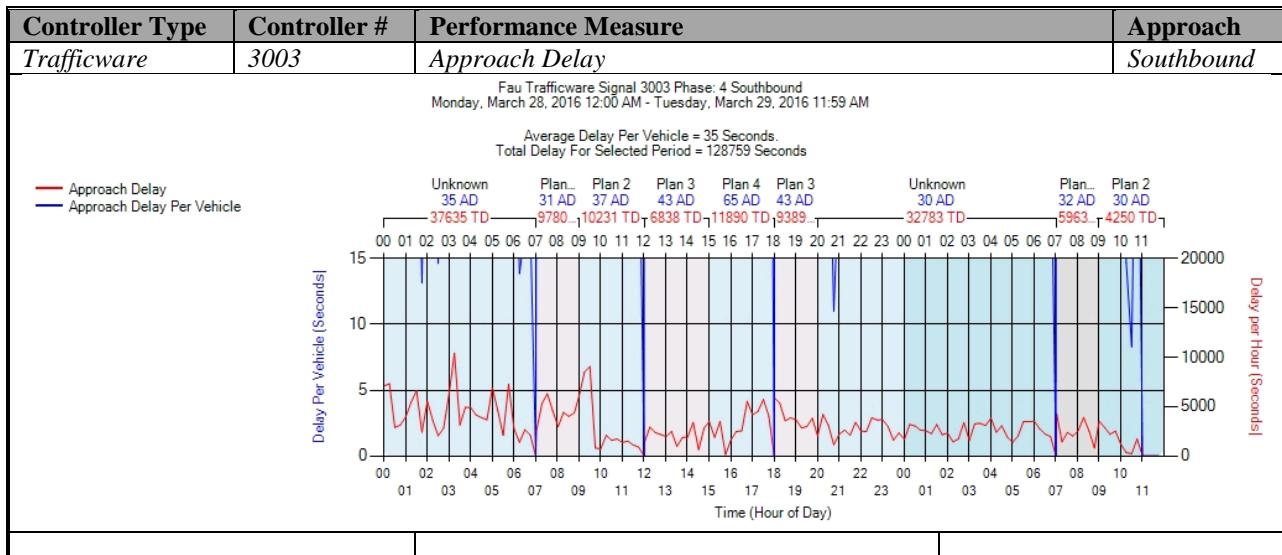


Figure A-84. Trafficware – Approach Delay – SB

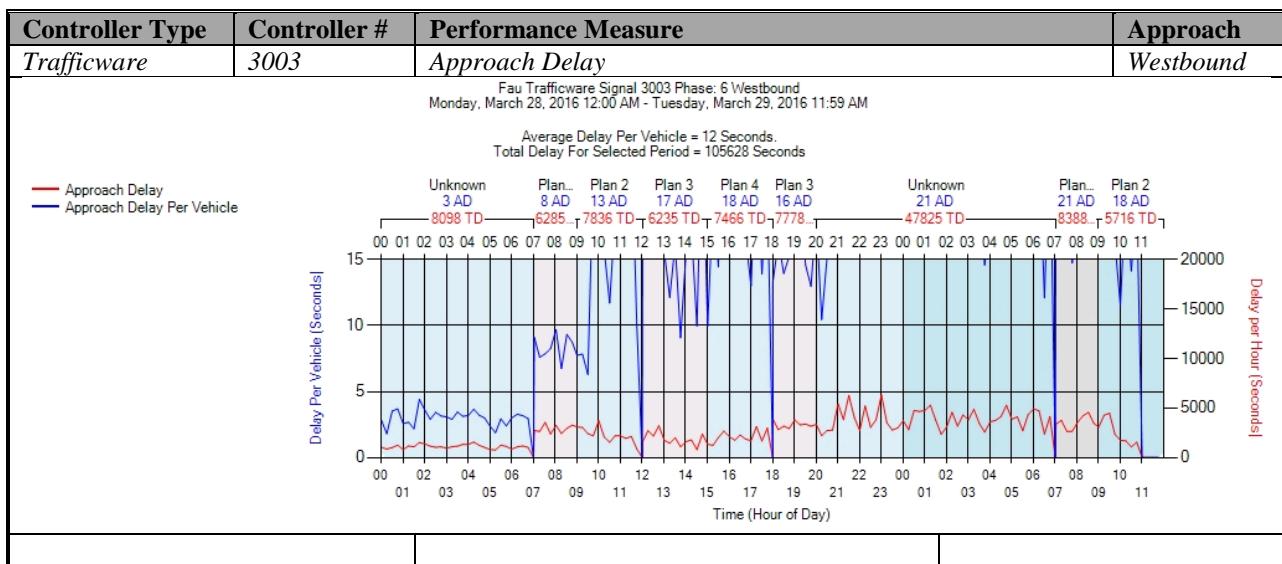


Figure A-85. Trafficware – Approach Delay – WB

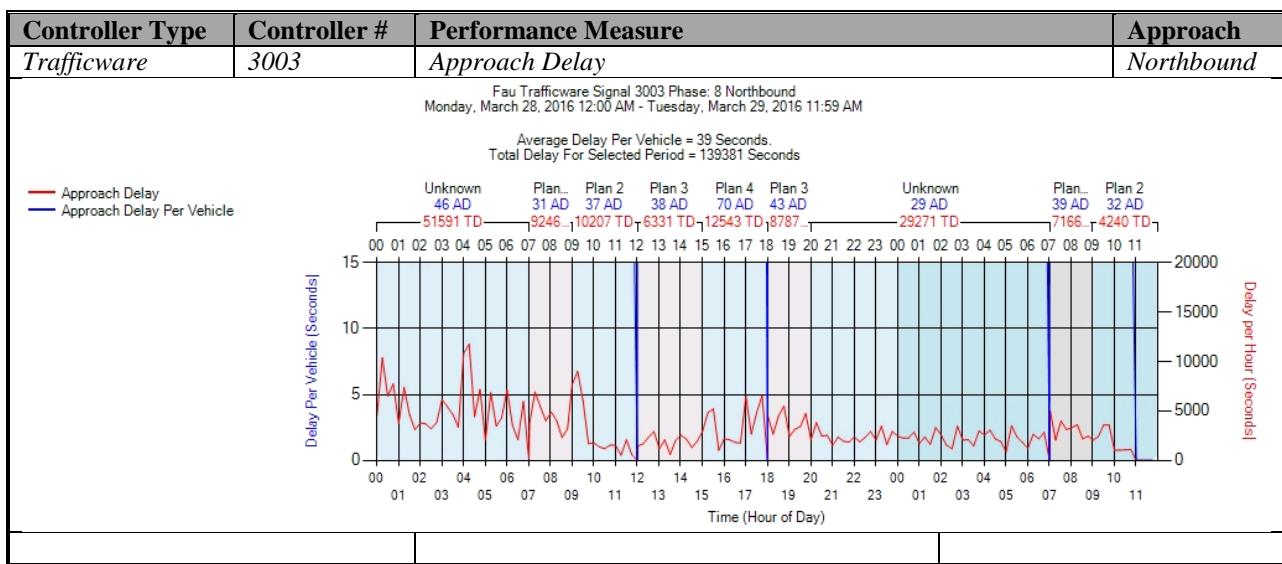


Figure A-86. Trafficware – Approach Delay – NB

b) Approach Volume - Trafficware (C:\inetpub\wwwroot\SignalPerformanceMetrics)

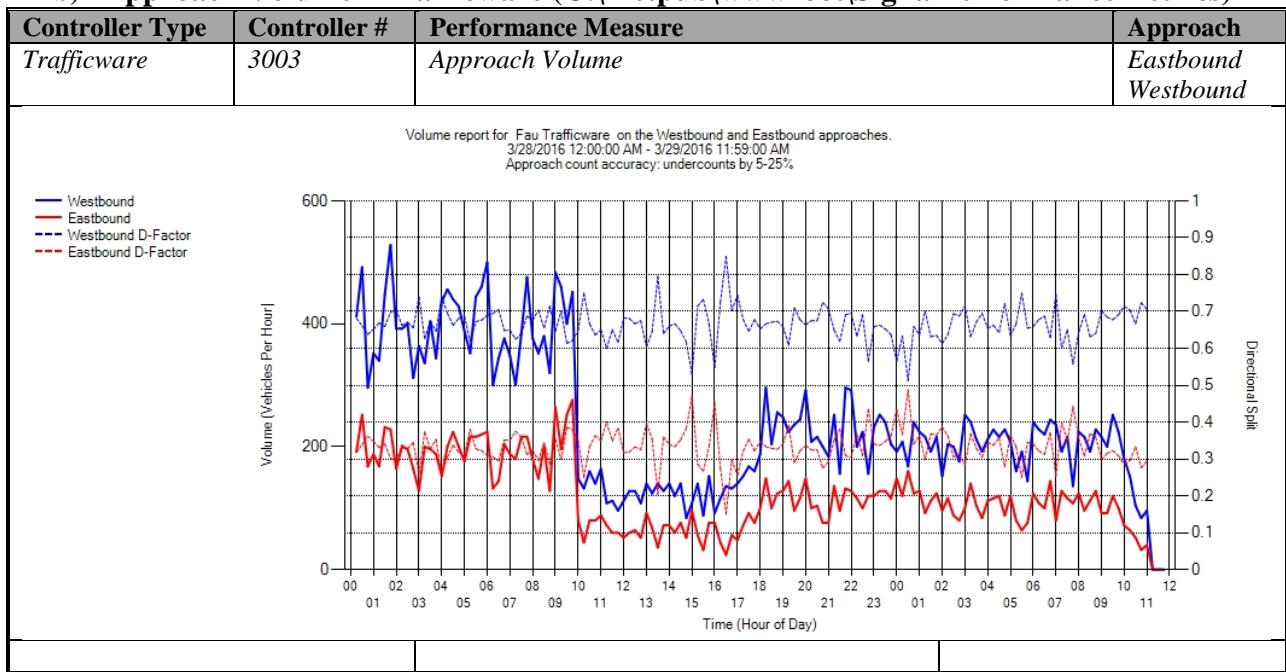


Figure A-87. Trafficware – Approach Delay – WB & EB

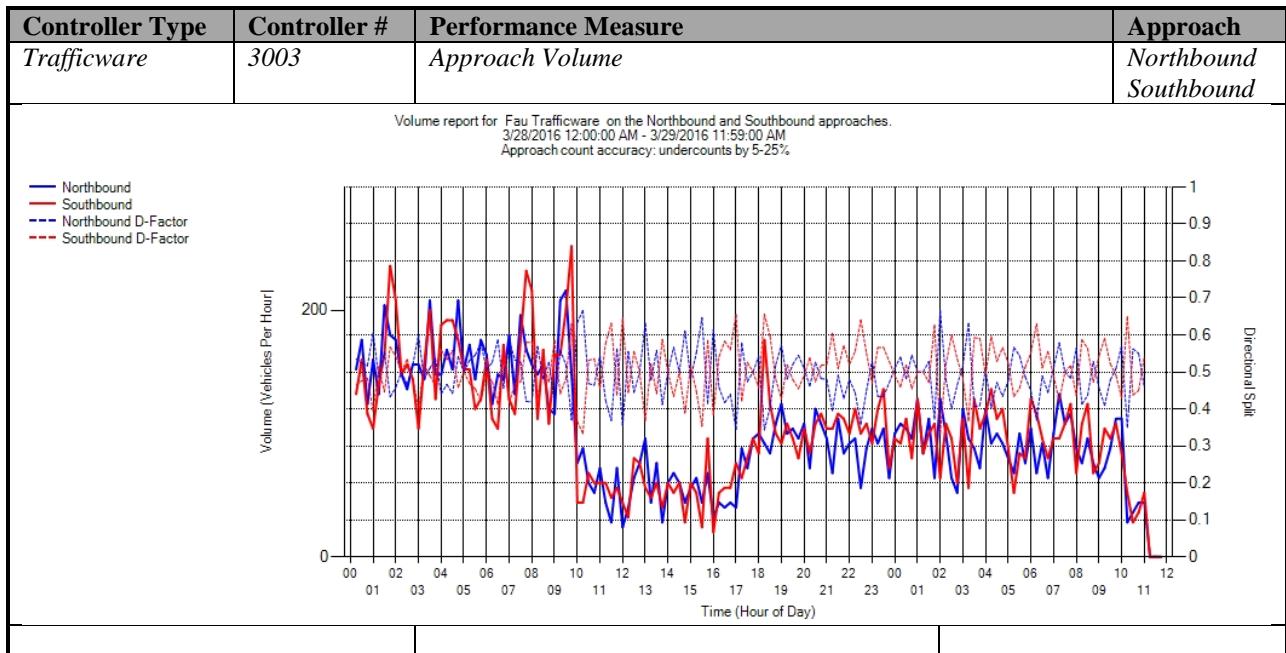


Figure A-88. Trafficware – Approach Delay – NB & SB

Controller Type	Controller #	Performance Measure	Approach
<i>Trafficware</i>	3003	<i>Approach Volume</i>	<i>Total</i>
			Metric Value
			Total Volume 7,262
			Peak Hour 9:00 AM - 10:00 AM
			Peak Hour Volume 367
			PHF 0.882
			Peak-Hour K-factor NA
			Northbound Total Volume 3,585
			Northbound Peak Hour 1:30 AM - 2:30 AM
			Northbound Peak Hour Volume 177
			Northbound PHF 0.868
			Northbound Peak-Hour K-factor NA
			Northbound Peak-Hour D-factor 1.07
			Southbound Total Volume 3,677
			Southbound Peak Hour 9:00 AM - 10:00 AM
			Southbound Peak Hour Volume 195
			Southbound PHF 1
			Southbound Peak-Hour K-factor NA
			Southbound Peak-Hour D-factor 0.882
			Metric Value
			Total Volume 12,786
			Peak Hour 9:00 AM - 10:00 AM
			Peak Hour Volume 696
			PHF 0.93
			Peak-Hour K-factor NA
			Westbound Total Volume 8,514
			Westbound Peak Hour 9:00 AM - 10:00 AM
			Westbound Peak Hour Volume 449
			Westbound PHF 0.928
			Westbound Peak-Hour K-factor NA
			Westbound Peak-Hour D-factor 0.55
			Eastbound Total Volume 4,272
			Eastbound Peak Hour 9:00 AM - 10:00 AM
			Eastbound Peak Hour Volume 247
			Eastbound PHF 1
			Eastbound Peak-Hour K-factor NA
			Eastbound Peak-Hour D-factor 1.82

Figure A-89. Trafficware – Approach Volume – WB

c) Arrivals On Red - Trafficware (C:\inetpub\wwwroot\SignalPerformanceMetrics)

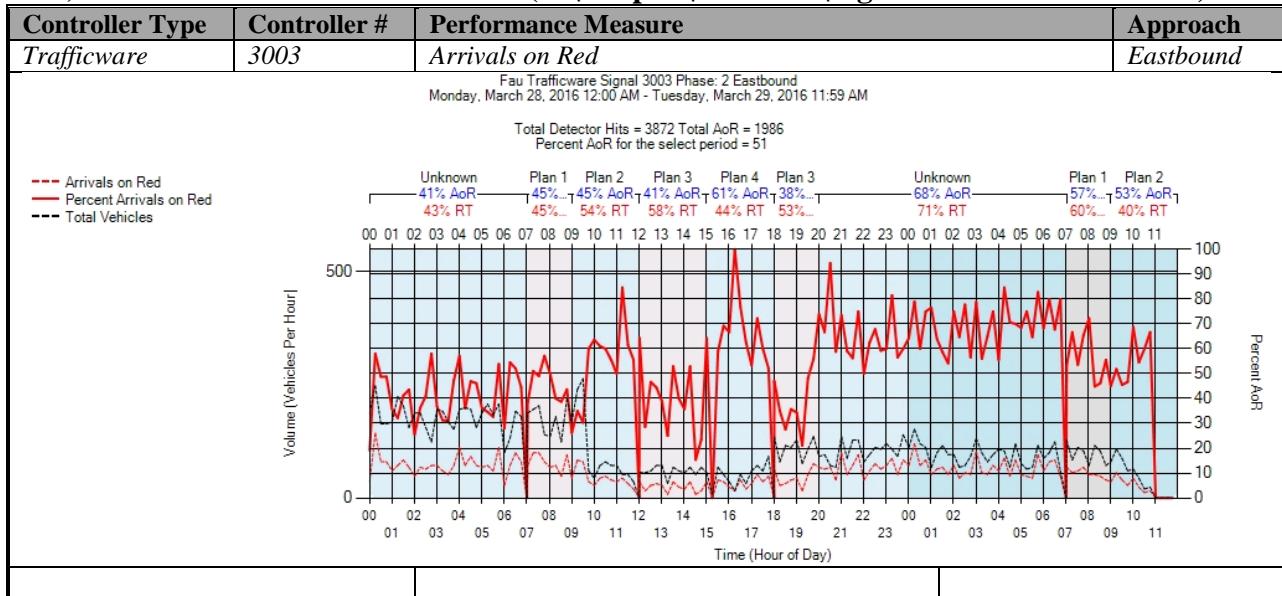


Figure A-90. Trafficware – Arrivals on Red – EB

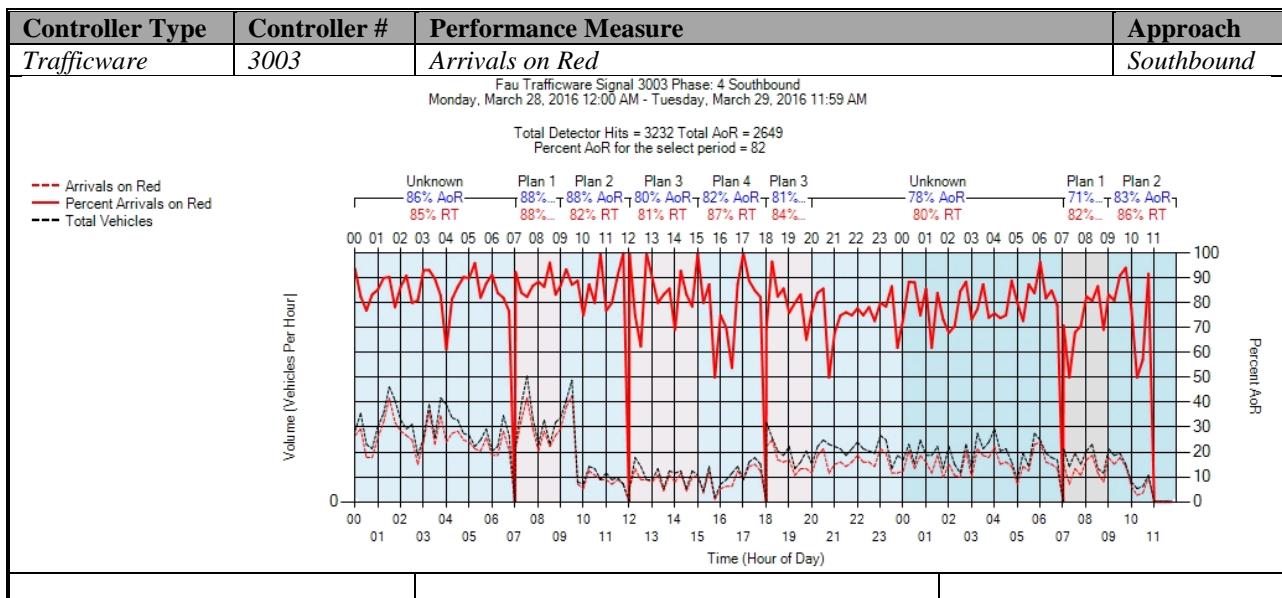


Figure A-91. Trafficware – Arrivals on Red – SB

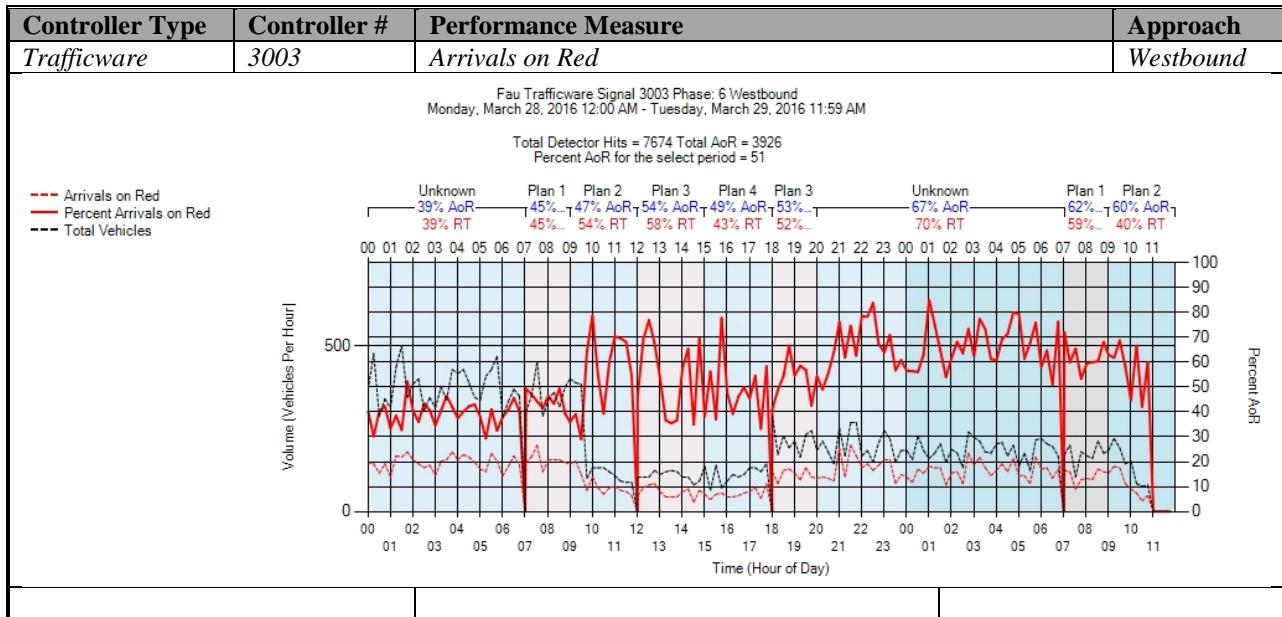


Figure A-92. Trafficware – Arrivals on Red – WB

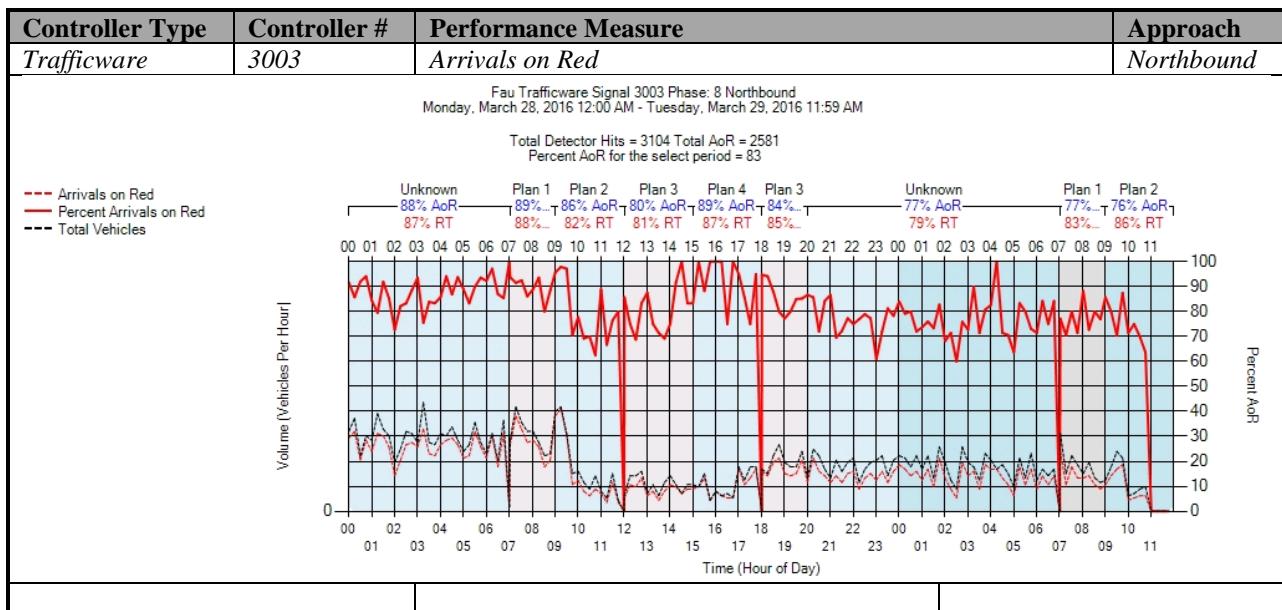


Figure A-93. Trafficware – Arrivals on Red – NB

d) Purdue Coordination Diagram - Trafficware (C:\inetpub\wwwroot\SPMImages)

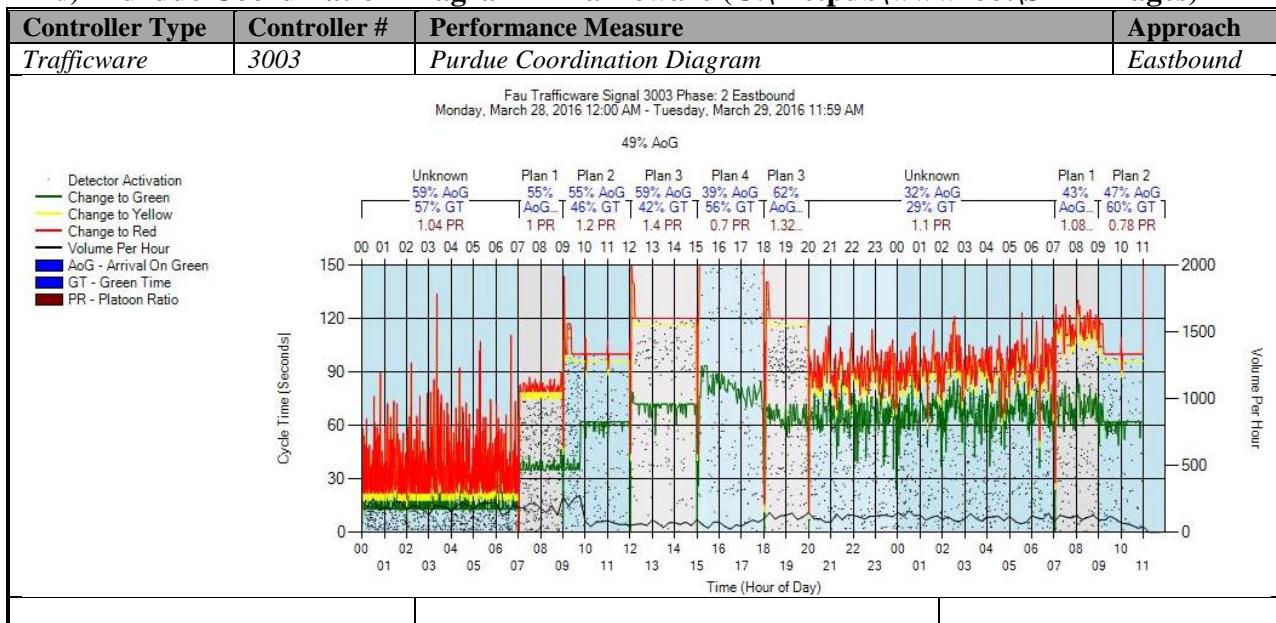


Figure A-94. Trafficware – Purdue Coordination Diagram – EB

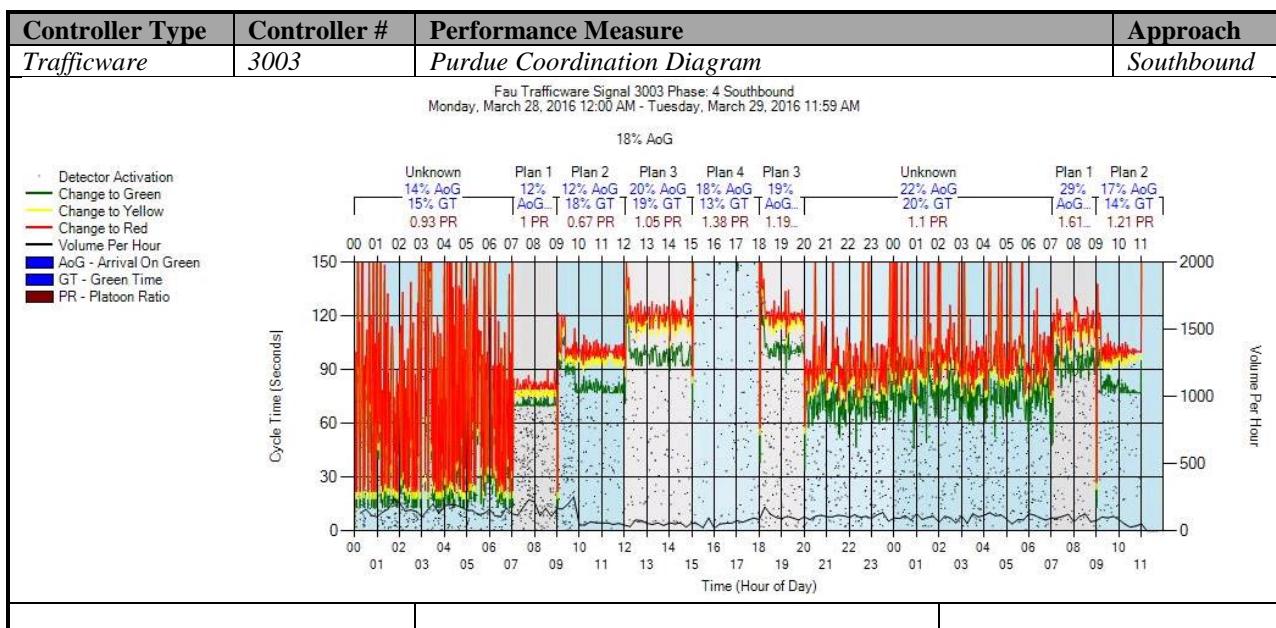


Figure A-95. Trafficware – Purdue Coordination Diagram – SB

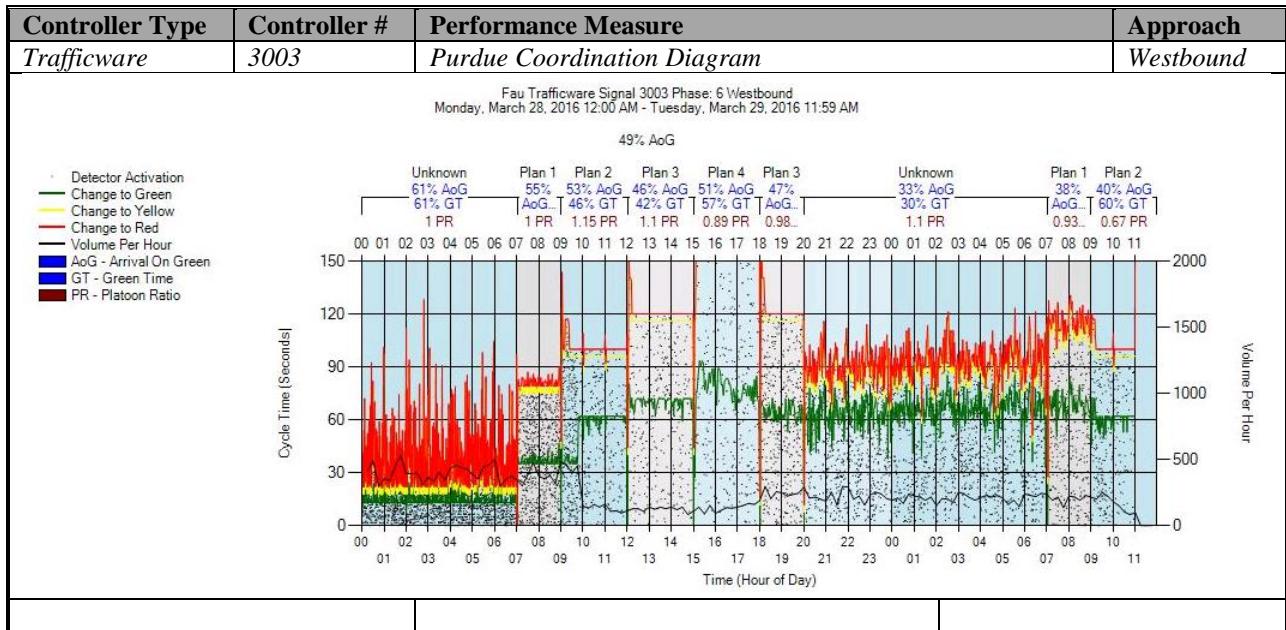


Figure A-96. Trafficware – Purdue Coordination Diagram – WB

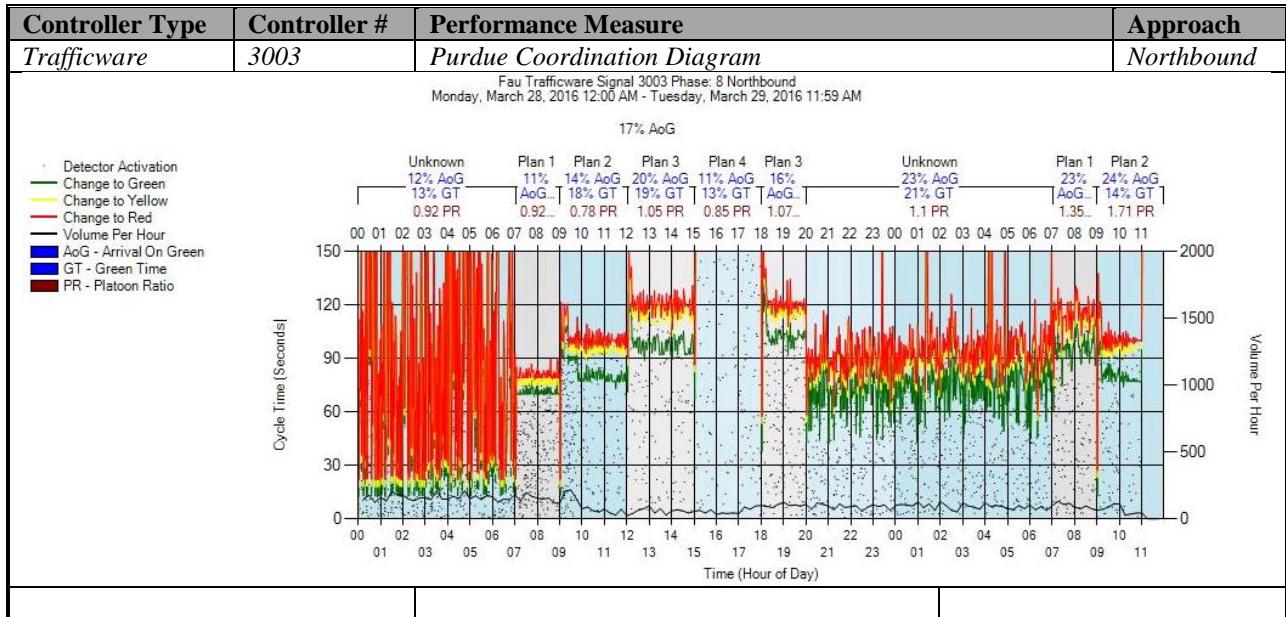


Figure A-97. Trafficware – Purdue Coordination Diagram – NB

e) Purdue Split Failure

No graphs – Needs to be configured in the SPM Tool. To be accomplished later.

f) Pedestrian Delay

No graphs – Needs to be configured in the controller. To be accomplished later.

g) Preemption Details

No graphs – Needs to be configured in the controller. To be accomplished later.

h) Purdue Phase Termination

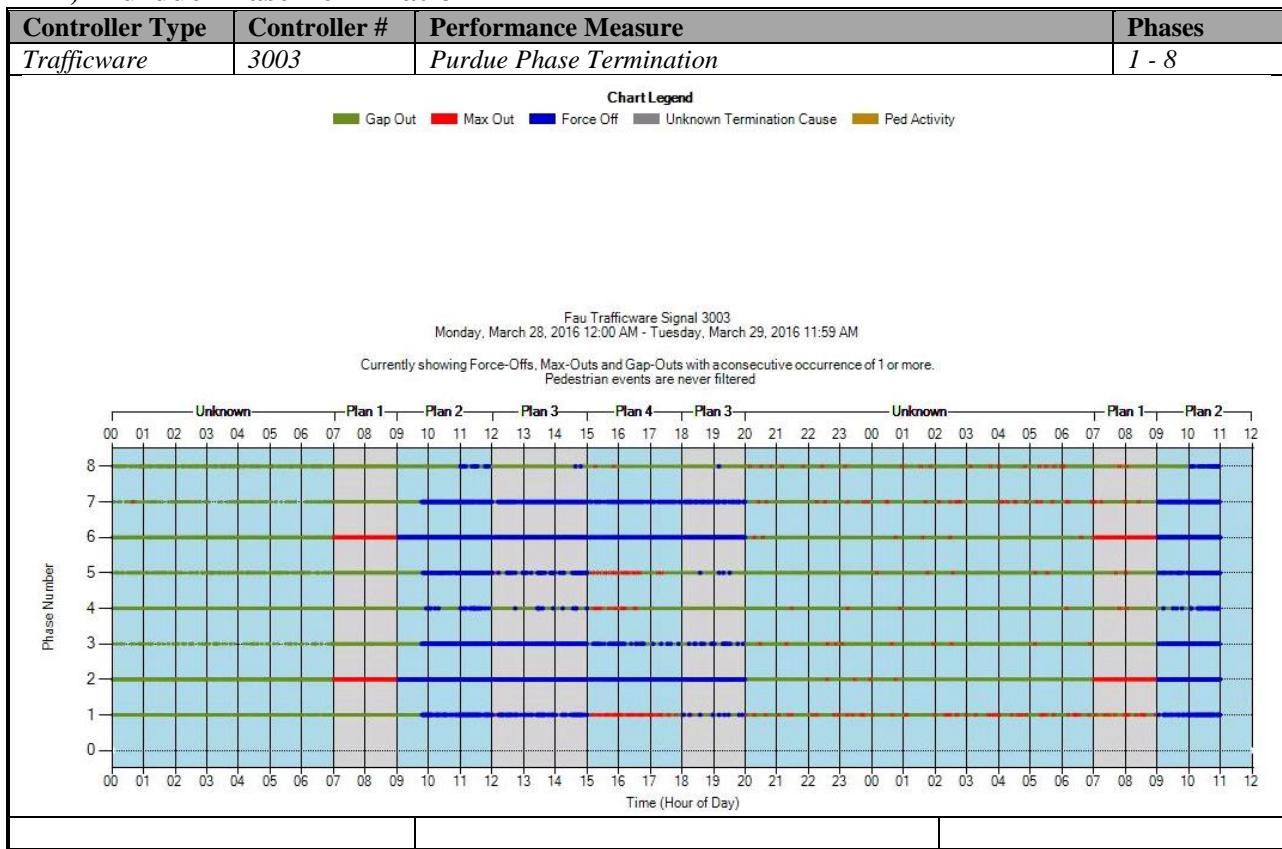


Figure A-98. Trafficware – Purdue Phase Termination

i) Speed (Check in C:\inetpub\wwwroot\SignalPerformanceMetrics\misc)

The graphs are shown below, but without data from the controller because speed detectors need to be configured in the controller. To be accomplished later.

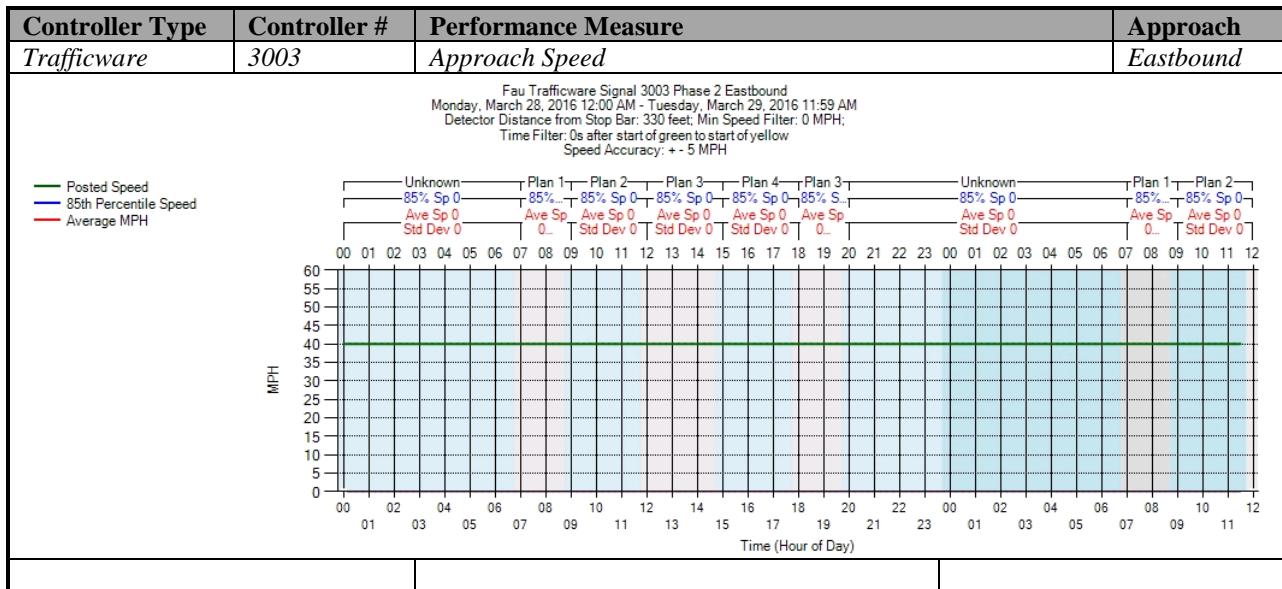


Figure A-99. Trafficware – Approach Speed – EB

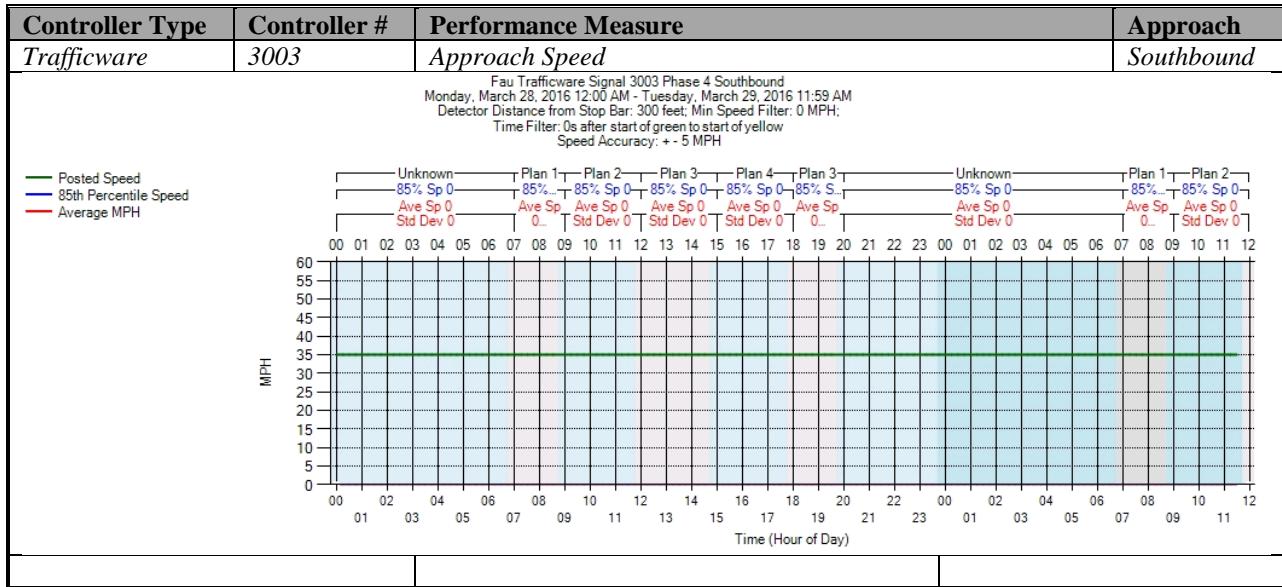


Figure A-100. Trafficware – Approach Speed – SB

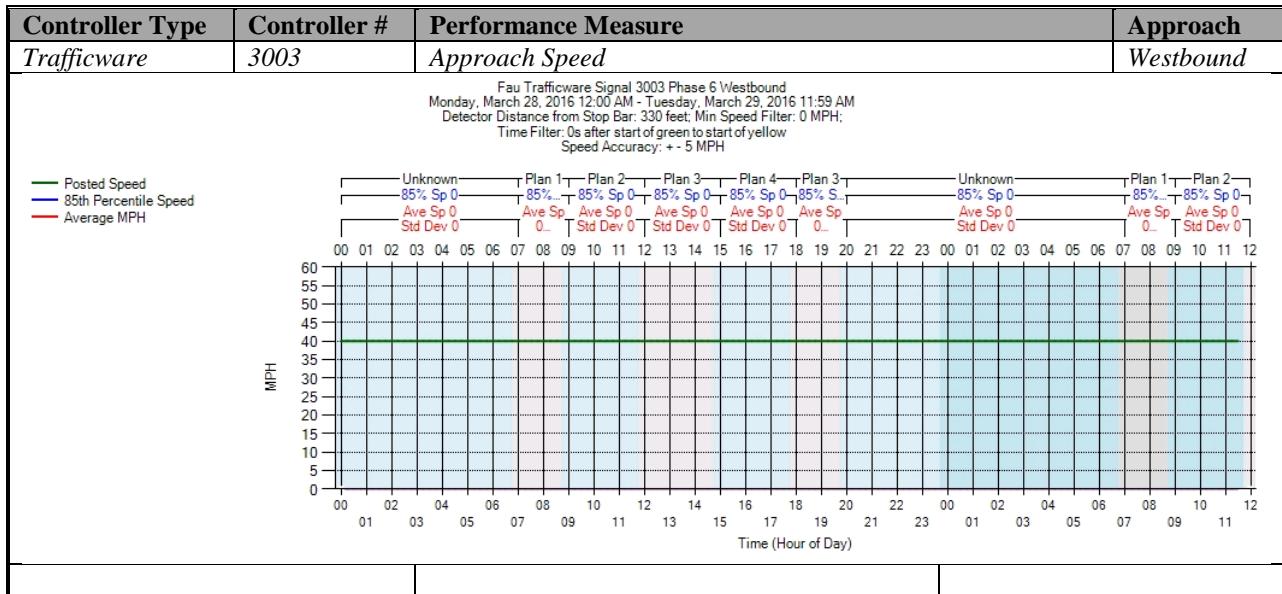


Figure A-101. Trafficware – Approach Speed – WB

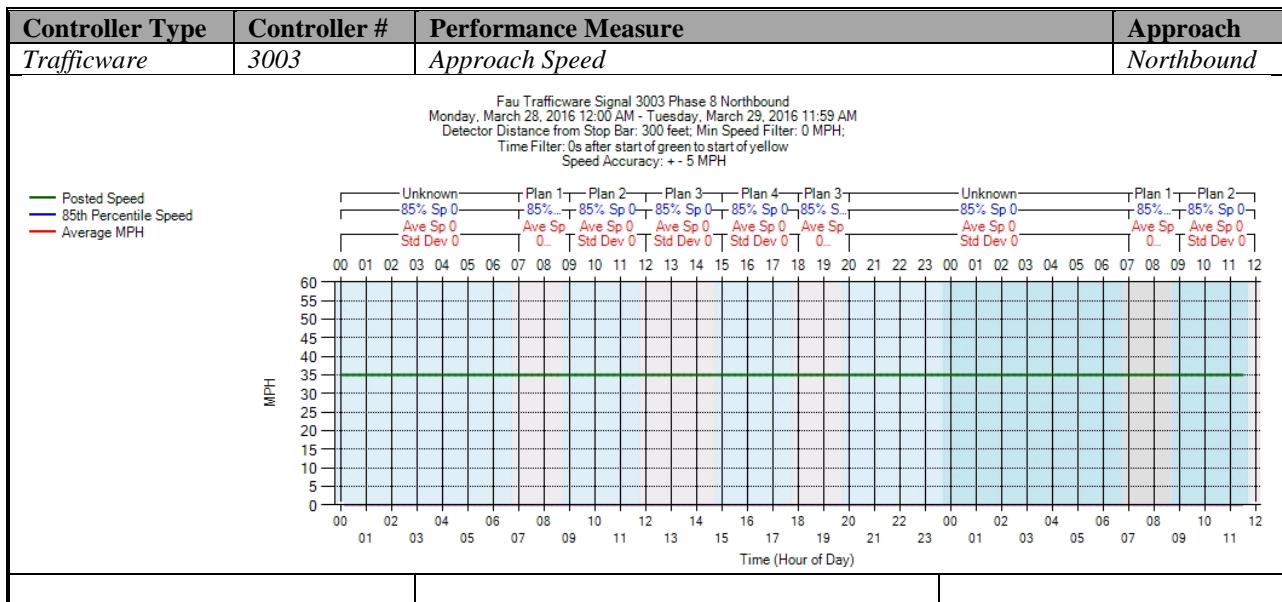


Figure A-102. Trafficware – Approach Speed – NB

j) Split Monitor – Trafficware

(C:\Installs\Deeptistuff\SPMWebFiles\SPMWebFiles\SPMSourceFiles\v3.2Deepti\Signal Timing Diagrams)

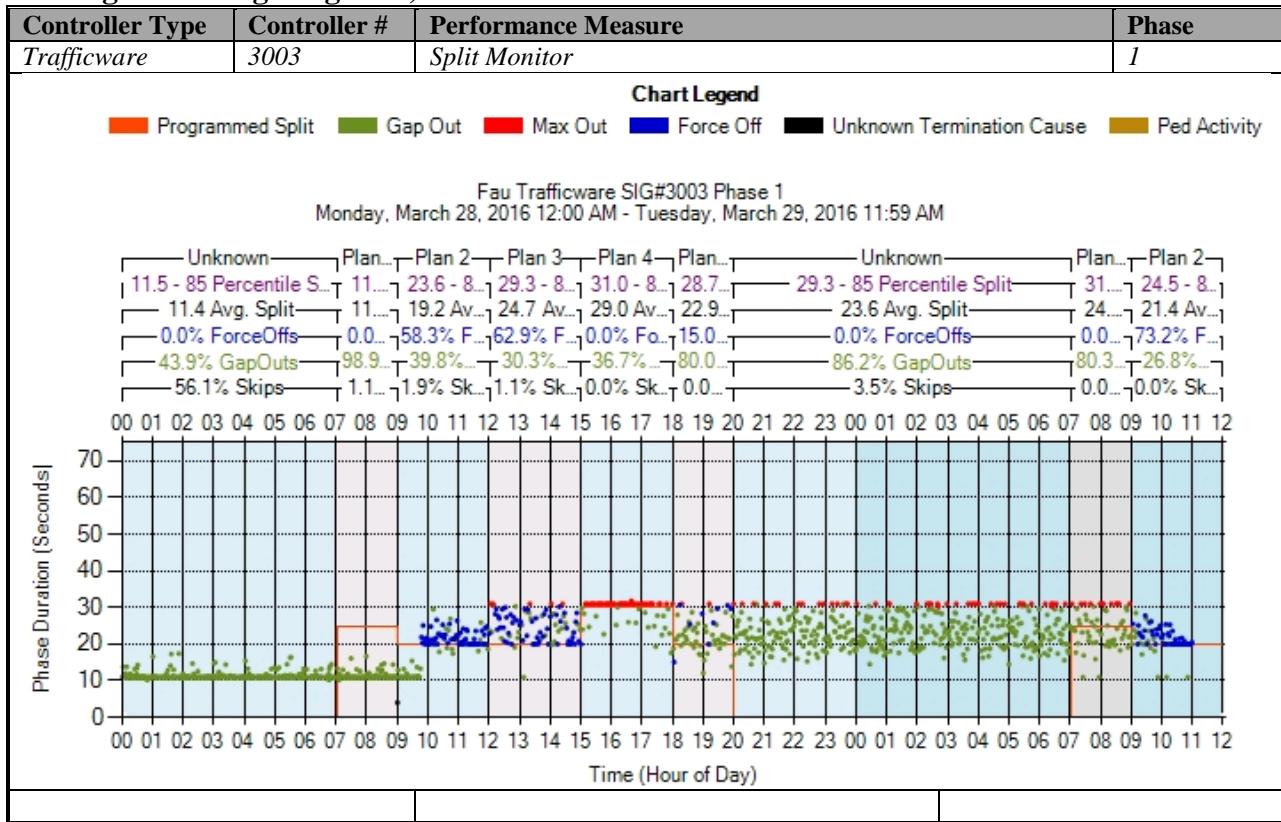


Figure A-103. Trafficware – Split Monitor – Phase 1

Controller Type	Controller #	Performance Measure	Phase
Trafficware	3003	<i>Split Monitor</i>	2

Fau Trafficware SIG#3003 Phase 2
Monday, March 28, 2016 12:00 AM - Tuesday, March 29, 2016 11:59 AM

Legend (Top to Bottom):

- Unknown Plan 1 Plan 2 Plan 3 Plan 4 Plan 5 Unknown Plan 1 Plan 2
- 34.5 - 85 Percentile Split 46.1 - 8.1 65.9 - 8.1 54.8 - 8.1 110.7 - 8.1 62.5 - 8.1 36.8 - 85 Percentile Split 50.1 - 8.1 46.4 - 8.1
- 21.9 Avg. Split 46.1 - 8.1 47.8 Avg. 52.1 Avg. 101.8 Avg. 58.0 - 8.1 28.5 Avg. Split 47.1 - 8.1 42.3 Avg. 1
- 0.0% ForceOffs 0.0% 98.1% F 98.9% F 96.7% F 96.7% 0.0% ForceOffs 0.0% 98.6% F 0.0% 98.6% F 1
- 99.9% GapOuts 0.0% 0.0% G 0.0% G 0.0% G 0.0% 98.8% GapOuts 0.0% 0.0% G 0.0% 0.0% G 1
- 0.0% Skips 1.1% 0.9% Sk. 0.0% Sk. 0.0% Sk. 1.7% 0.0% Skips 0.0% 1.4% Sk. 0.0% 1.4% Sk. 1

Phase Duration [Seconds]

Time (Hour of Day)

Figure A-104. Trafficware – Split Monitor – Phase 2

Controller Type	Controller #	Performance Measure	Phase
Trafficware	3003	Split Monitor	3

Fau Trafficware SIG#3003 Phase 3
 Monday, March 28, 2016 12:00 AM - Tuesday, March 29, 2016 11:59 AM

Legend (Top):

- Unknown: Plan 1, Plan 2, Plan 3, Plan 4, Plan 5, Plan 6, Plan 7, Plan 8, Plan 9, Plan 10, Plan 11, Plan 12
- 12.8 - 85 Percentile Split: 11.0 - 8.1, 15.0 - 8.1, 20.0 - 8.1, 25.0 - 8.1, 20.0, 24.3 - 85 Percentile Split, 23.1, 15.0 - 8.1
- 11.8 Avg. Split: 11.0, 14.1 Av., 20.0 Av., 23.6 Av., 18.8, 21.1 Avg. Split, 20.0, 15.2 Av.
- 0.0% ForceOffs: 0.0, 75.0% F., 89.9% F., 46.7% F., 30.0, 0.0% ForceOffs, 0.0, 95.8% F.
- 14.6% GapOuts: 100.0, 25.0%, 10.1%, 51.7%, 68.3, 96.0% GapOuts, 100.0, 2.8% G.
- 85.4% Skips: 0.0, 0.0% Sk., 0.0% Sk., 1.7% Sk., 1.7, 1.6% Skips, 0.0, 1.4% Sk.

Y-axis: Phase Duration [Seconds]

X-axis: Time (Hour of Day)

Figure A-105. Trafficware – Split Monitor – Phase 3

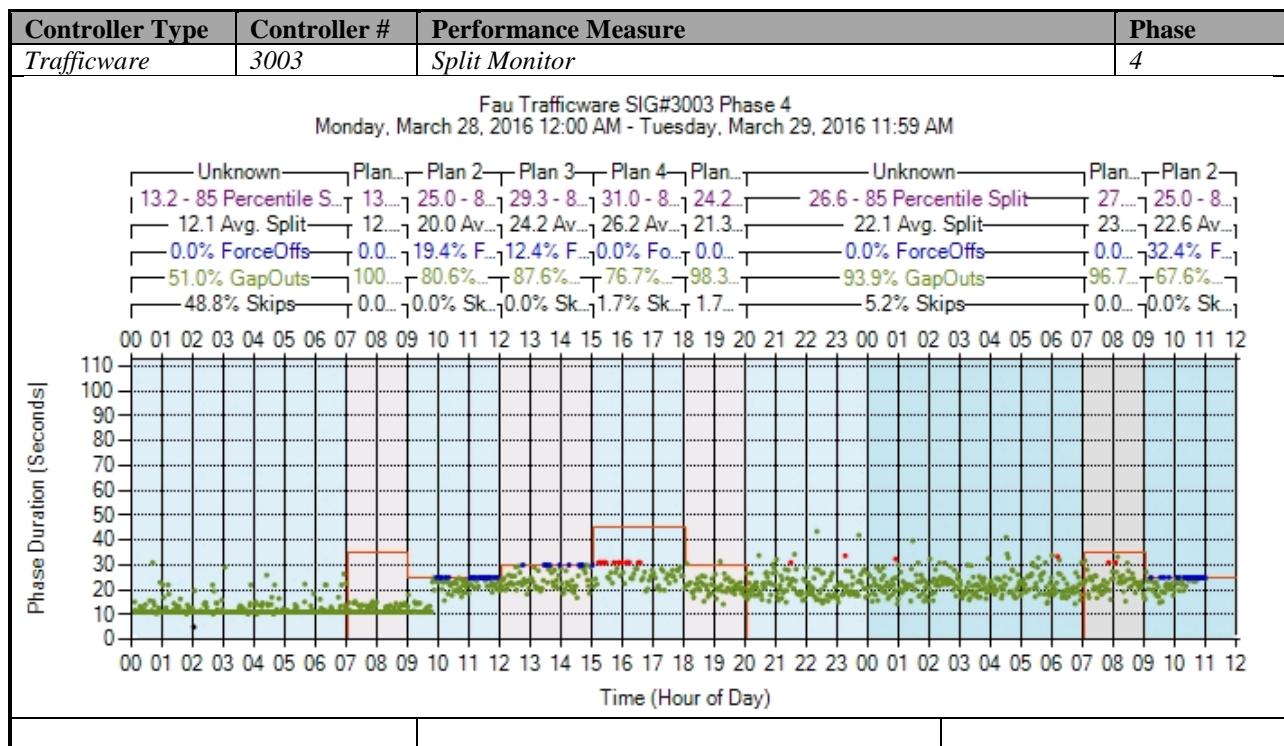


Figure A-106. Trafficware – Split Monitor – Phase 4

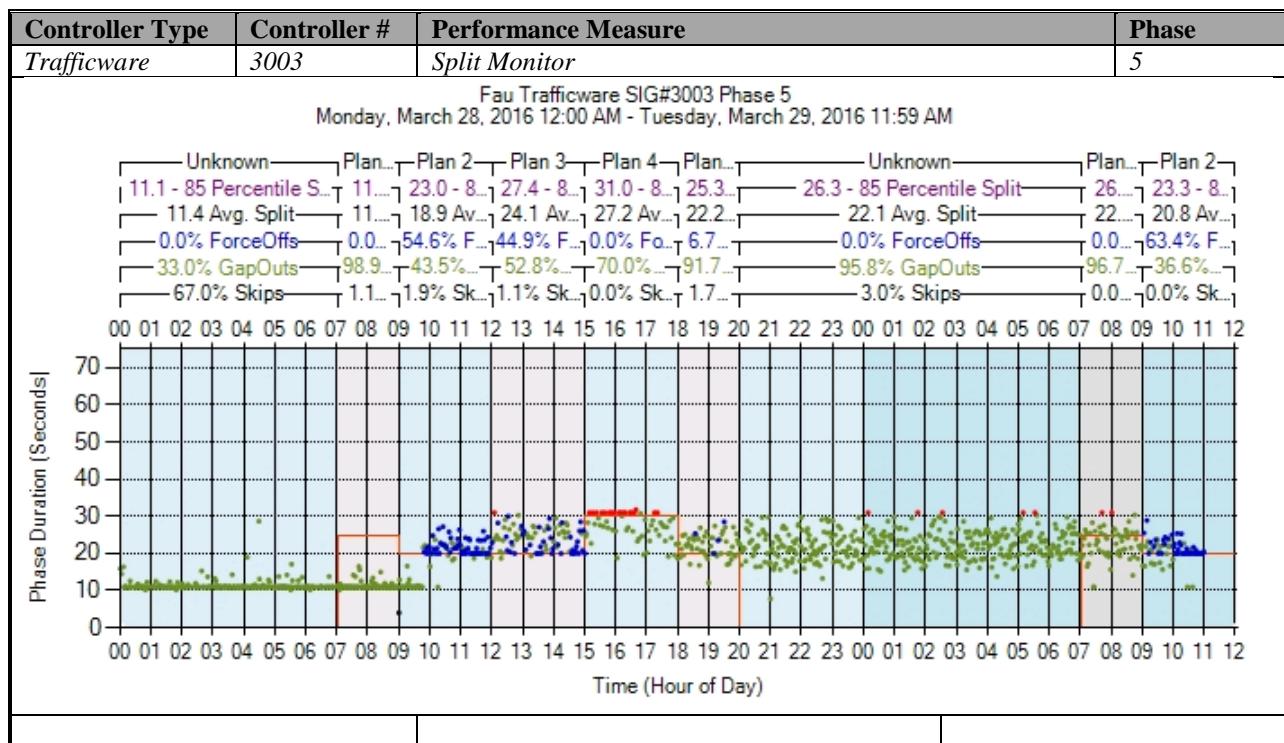


Figure A-107. Trafficware – Split Monitor – Phase 5

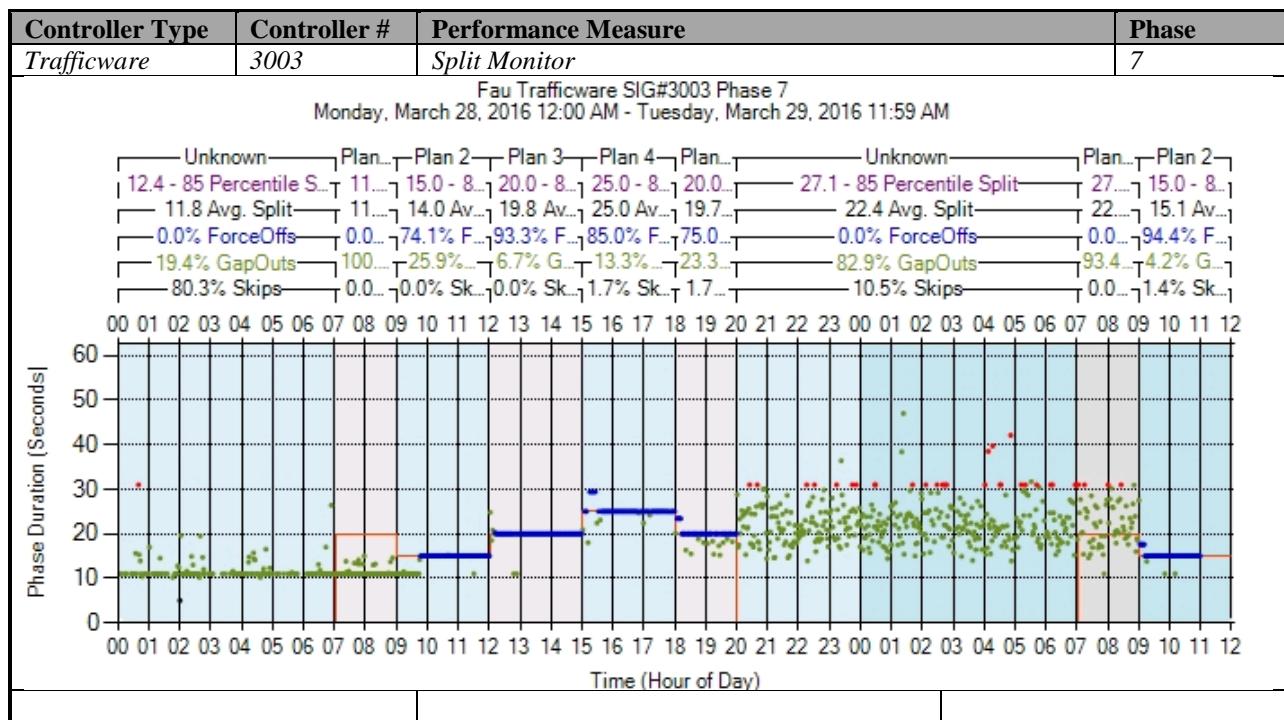


Figure A-108. Trafficware – Split Monitor – Phase 7

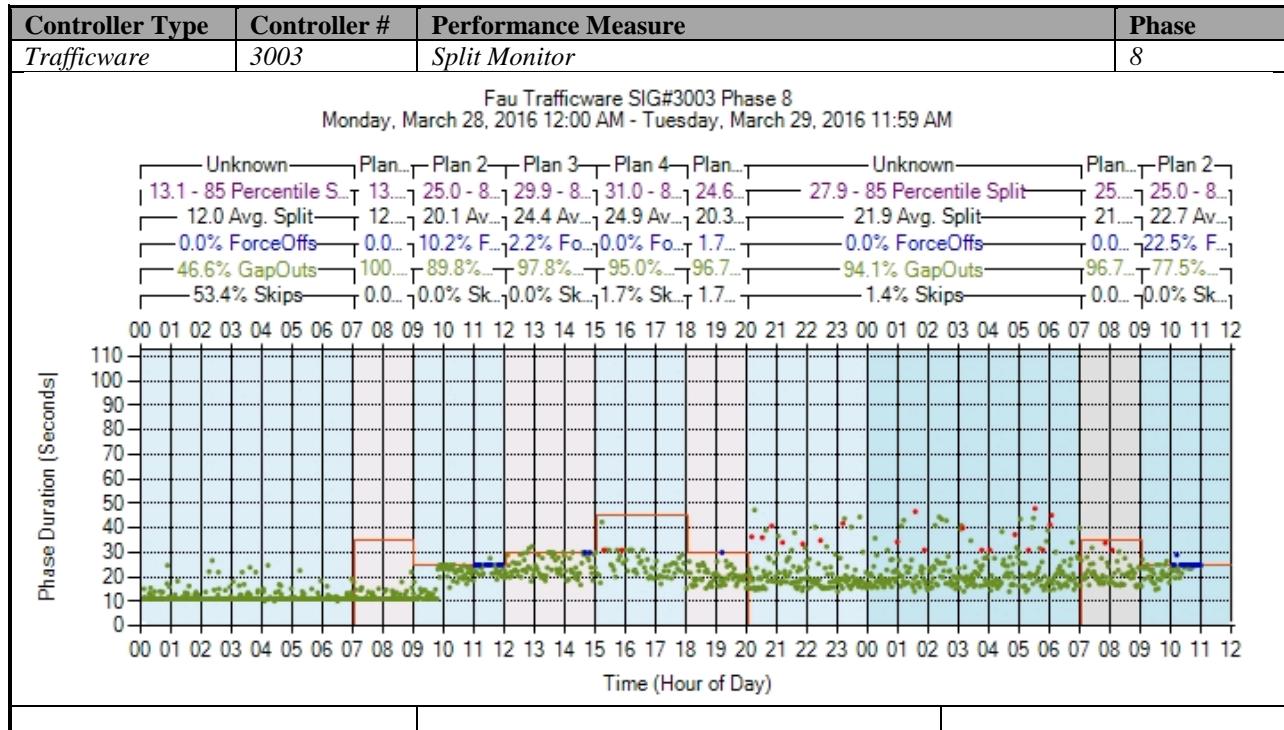


Figure A-109. Trafficware – Split Monitor – Phase 8

k) Turning Movement Counts

No graphs – Need to add new detectors after the stop bar. To be accomplished later.

I) Yellow and Red Actuations

No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.

A.5 McCain (ATC eX) High Resolution Data Performance Metrics

a) Approach Delay – McCain (C:\inetpub\wwwroot\SignalPerformanceMetrics)

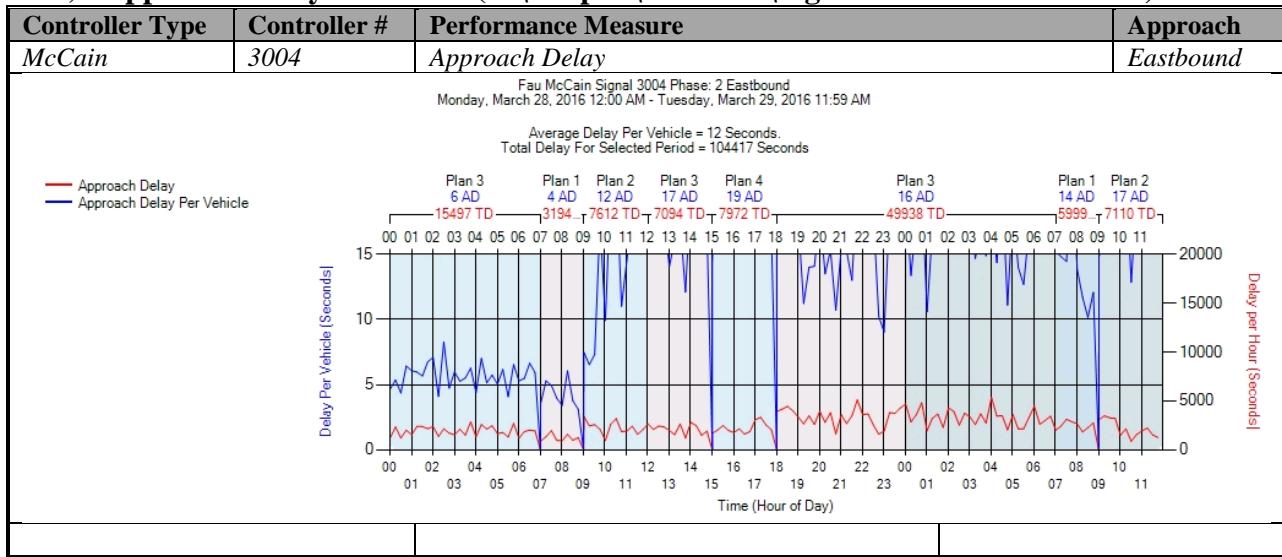


Figure A-110. McCain – Approach Delay – EB

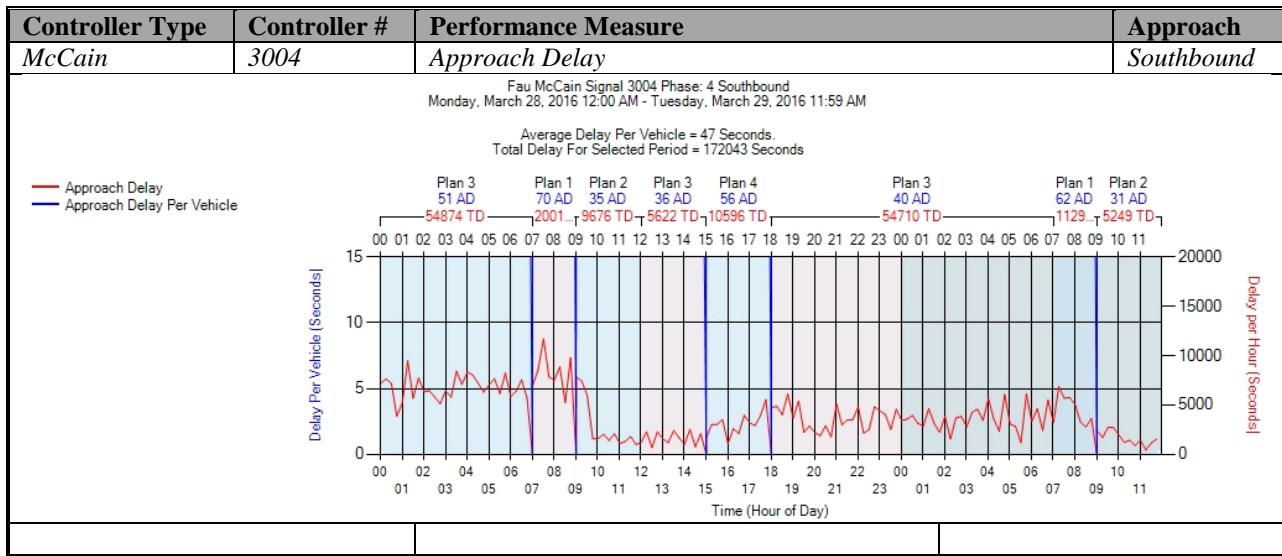


Figure A-111. McCain – Approach Delay – SB

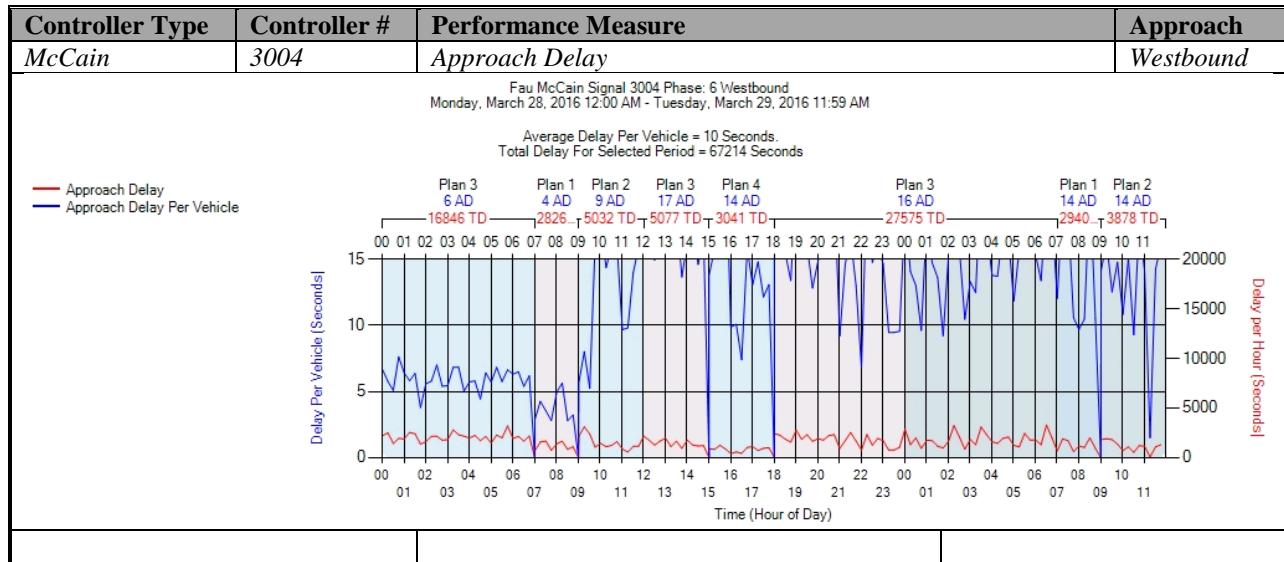


Figure A-112. McCain – Approach Delay – WB

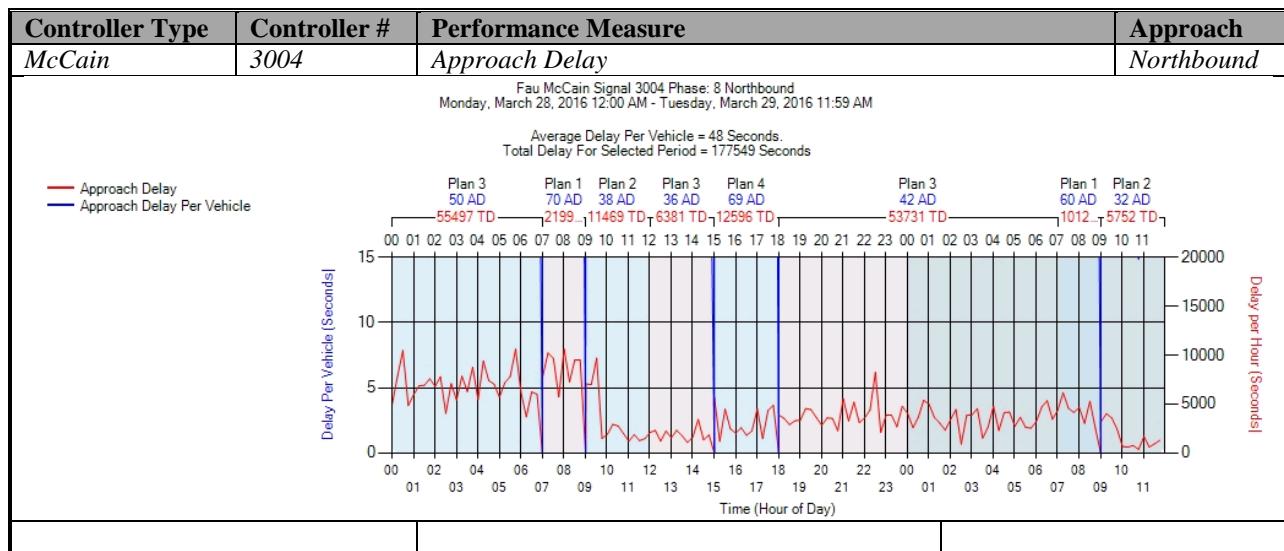


Figure A-113. McCain – Approach Delay – NB

b) Approach Volume - McCain (C:\inetpub\wwwroot\SignalPerformanceMetrics)

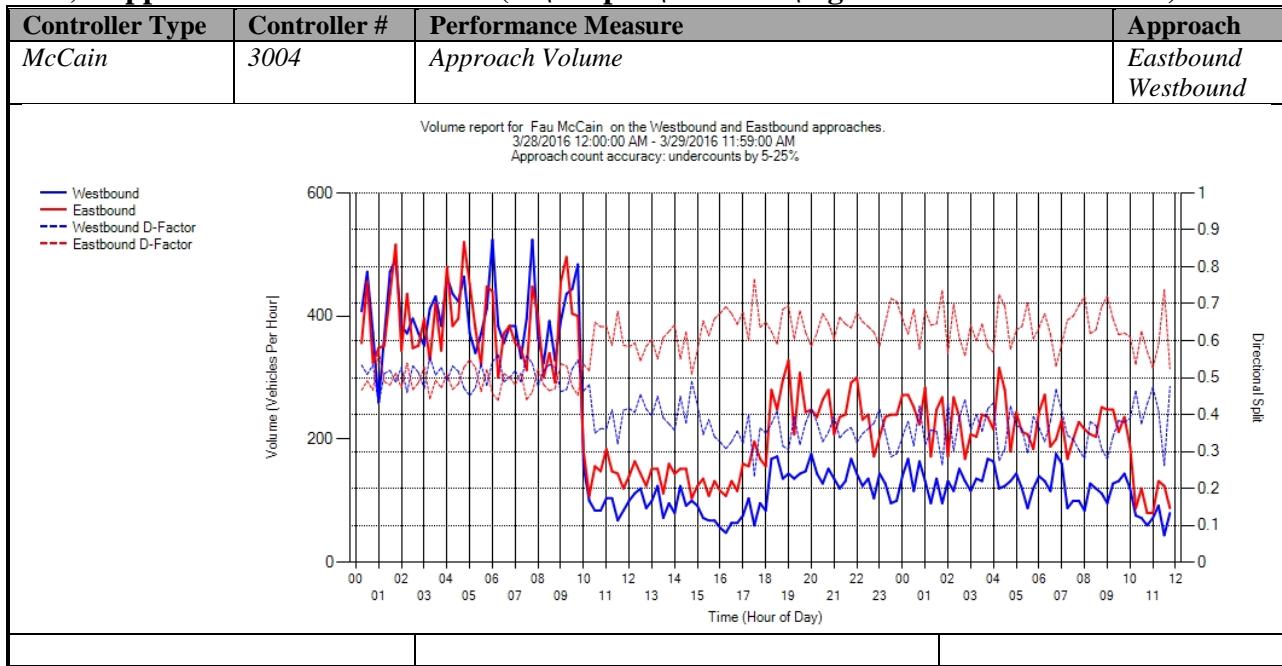


Figure A-114. McCain – Approach Delay – WB & EB

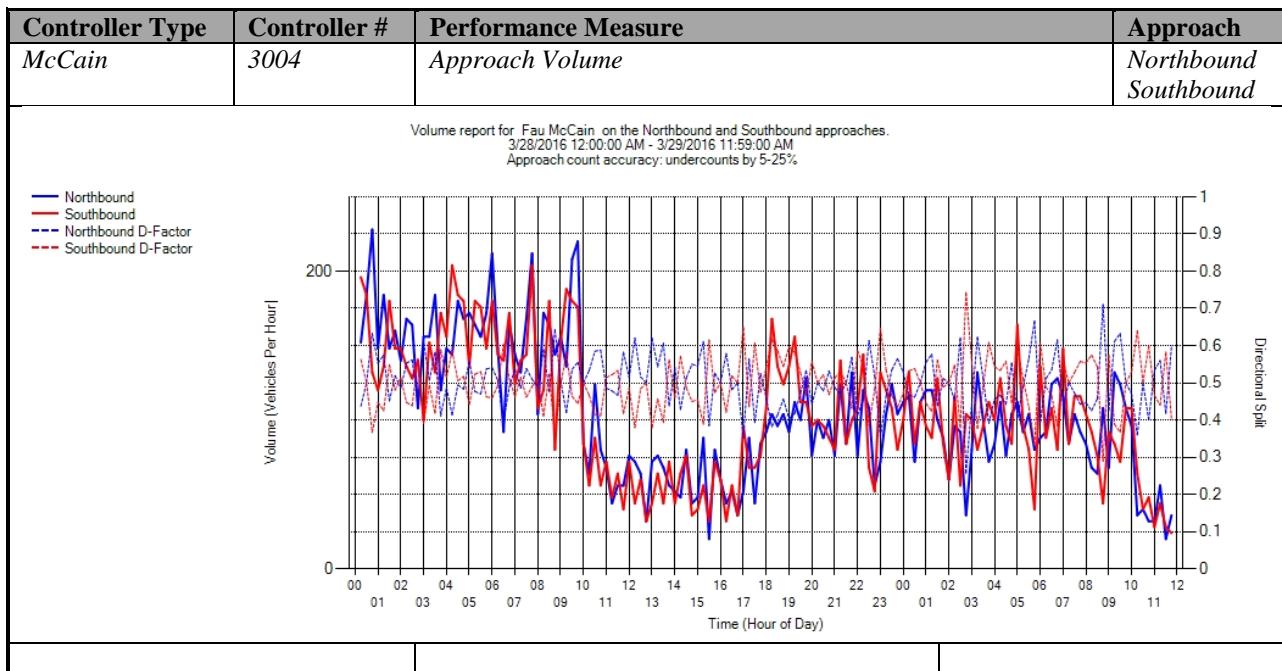


Figure A-115. McCain – Approach Delay – NB & SB

Controller Type	Controller #	Performance Measure	Approach																																								
<i>McCain</i>	3004	<i>Approach Volume</i>	<i>Total</i>																																								
			<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>7,409</td></tr> <tr> <td>Peak Hour</td><td>9:00 AM - 10:00 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>354</td></tr> <tr> <td>PHF</td><td>0.894</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Northbound Total Volume</td><td>3,717</td></tr> <tr> <td>Northbound Peak Hour</td><td>12:30 AM - 1:30 AM</td></tr> <tr> <td>Northbound Peak Hour Volume</td><td>186</td></tr> <tr> <td>Northbound PHF</td><td>0.816</td></tr> <tr> <td>Northbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Northbound Peak-Hour D-factor</td><td>0.769</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Southbound Total Volume</td><td>3,692</td></tr> <tr> <td>Southbound Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Southbound Peak Hour Volume</td><td>181</td></tr> <tr> <td>Southbound PHF</td><td>1</td></tr> <tr> <td>Southbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Southbound Peak-Hour D-factor</td><td>0.884</td></tr> </tbody> </table>	Metric	Value	Total Volume	7,409	Peak Hour	9:00 AM - 10:00 AM	Peak Hour Volume	354	PHF	0.894	Peak-Hour K-factor	NA			Northbound Total Volume	3,717	Northbound Peak Hour	12:30 AM - 1:30 AM	Northbound Peak Hour Volume	186	Northbound PHF	0.816	Northbound Peak-Hour K-factor	NA	Northbound Peak-Hour D-factor	0.769			Southbound Total Volume	3,692	Southbound Peak Hour	4:00 AM - 5:00 AM	Southbound Peak Hour Volume	181	Southbound PHF	1	Southbound Peak-Hour K-factor	NA	Southbound Peak-Hour D-factor	0.884
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Southbound Peak-Hour K-factor	NA																																										
Southbound Peak-Hour D-factor	0.884																																										
			<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>15,800</td></tr> <tr> <td>Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>892</td></tr> <tr> <td>PHF</td><td>0.907</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Westbound Total Volume</td><td>6,880</td></tr> <tr> <td>Westbound Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Westbound Peak Hour Volume</td><td>447</td></tr> <tr> <td>Westbound PHF</td><td>0.963</td></tr> <tr> <td>Westbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Westbound Peak-Hour D-factor</td><td>0.996</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Eastbound Total Volume</td><td>8,920</td></tr> <tr> <td>Eastbound Peak Hour</td><td>4:00 AM - 5:00 AM</td></tr> <tr> <td>Eastbound Peak Hour Volume</td><td>445</td></tr> <tr> <td>Eastbound PHF</td><td>1</td></tr> <tr> <td>Eastbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Eastbound Peak-Hour D-factor</td><td>1</td></tr> </tbody> </table>	Metric	Value	Total Volume	15,800	Peak Hour	4:00 AM - 5:00 AM	Peak Hour Volume	892	PHF	0.907	Peak-Hour K-factor	NA			Westbound Total Volume	6,880	Westbound Peak Hour	4:00 AM - 5:00 AM	Westbound Peak Hour Volume	447	Westbound PHF	0.963	Westbound Peak-Hour K-factor	NA	Westbound Peak-Hour D-factor	0.996			Eastbound Total Volume	8,920	Eastbound Peak Hour	4:00 AM - 5:00 AM	Eastbound Peak Hour Volume	445	Eastbound PHF	1	Eastbound Peak-Hour K-factor	NA	Eastbound Peak-Hour D-factor	1
Metric	Value																																										
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Eastbound Peak-Hour D-factor	1																																										

Figure A-116. McCain – Approach Volume – WB

c) Arrivals On Red - McCain (C:\inetpub\wwwroot\SignalPerformanceMetrics)

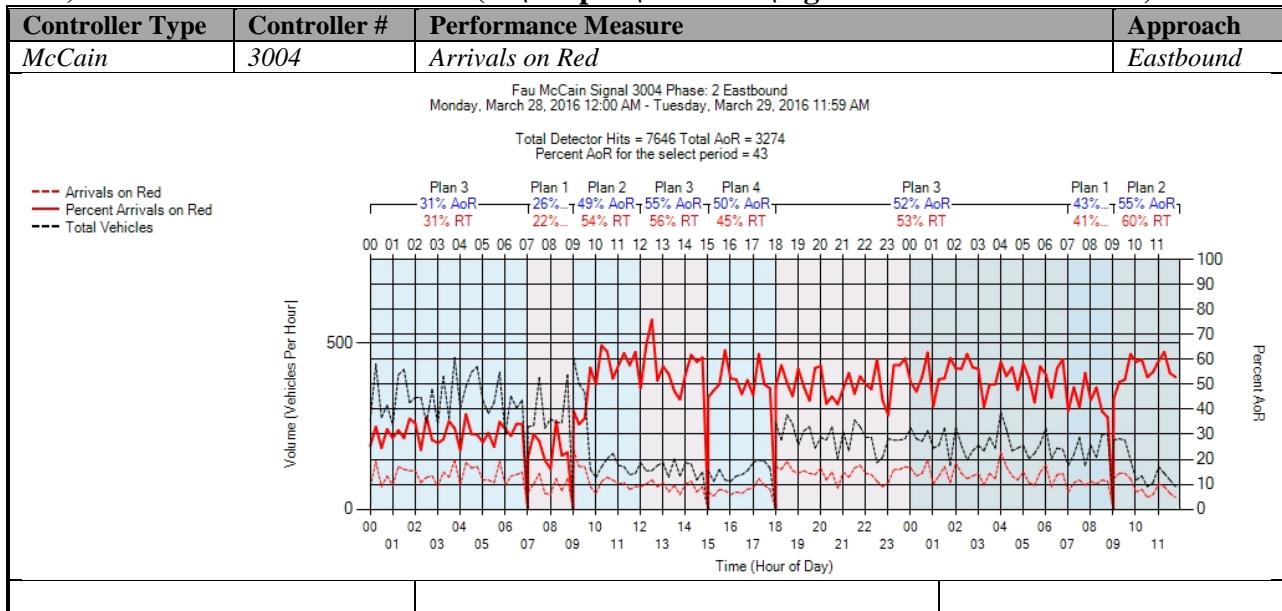


Figure A-117. McCain – Arrivals on Red – EB

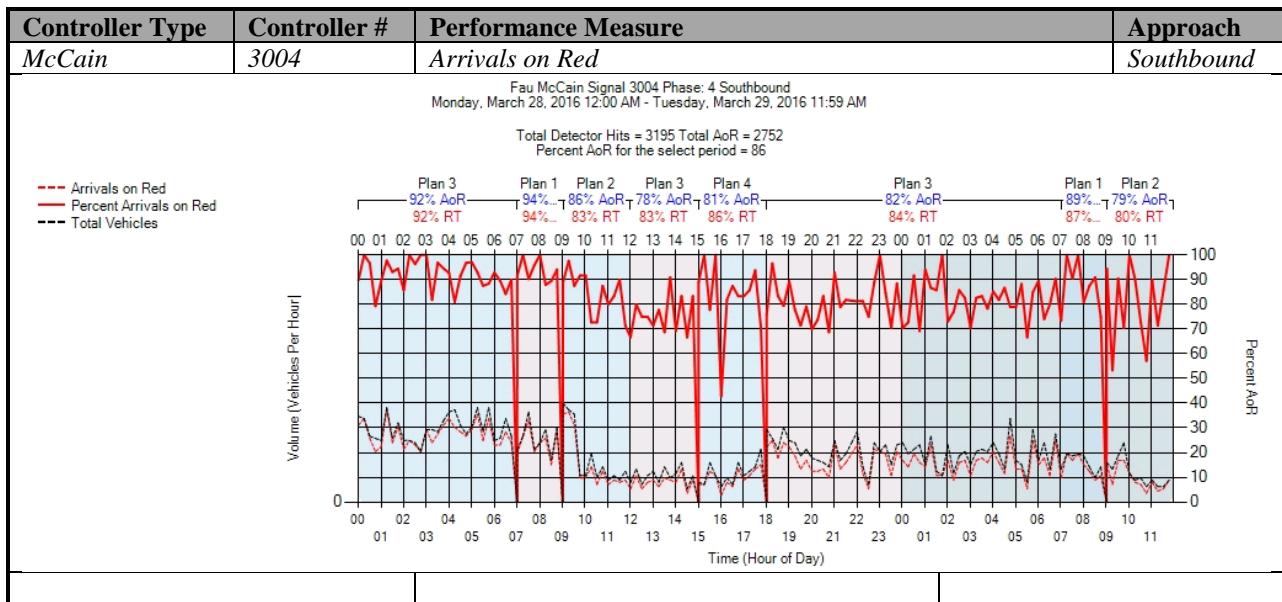


Figure A-118. McCain – Arrivals on Red – SB

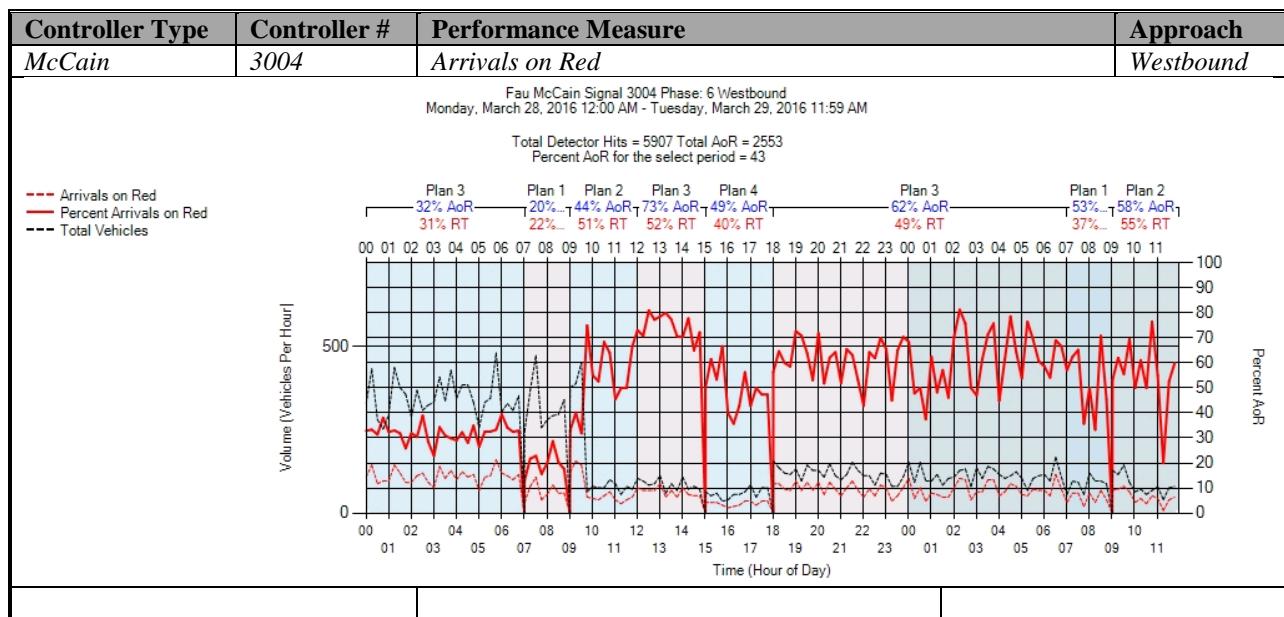


Figure A-119. McCain – Arrivals on Red – WB

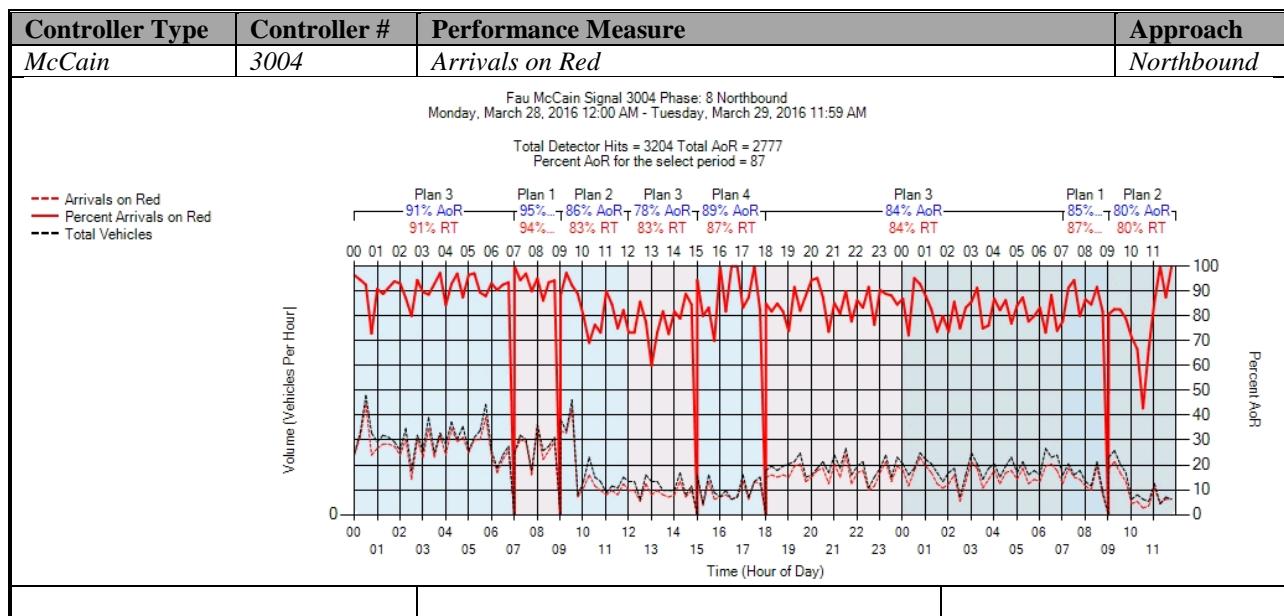


Figure A-120. McCain – Arrivals on Red – NB

d) Purdue Coordination Diagram - McCain (C:\inetpub\wwwroot\SPMImages)

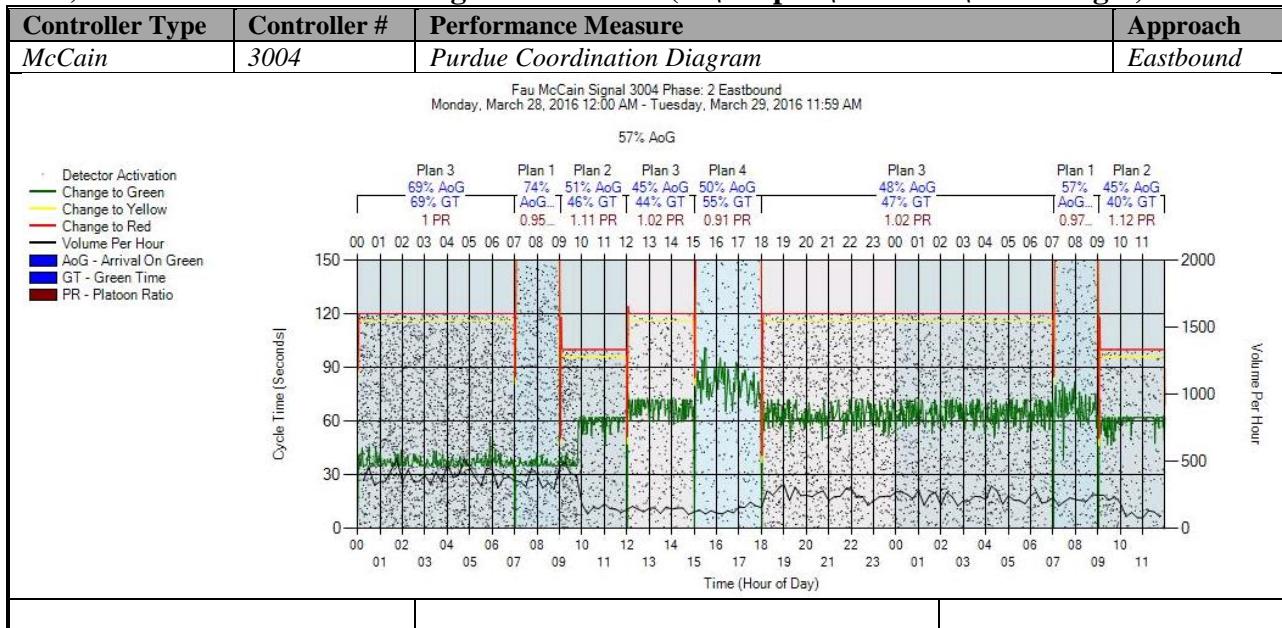


Figure A-121. McCain – Purdue Coordination Diagram – EB

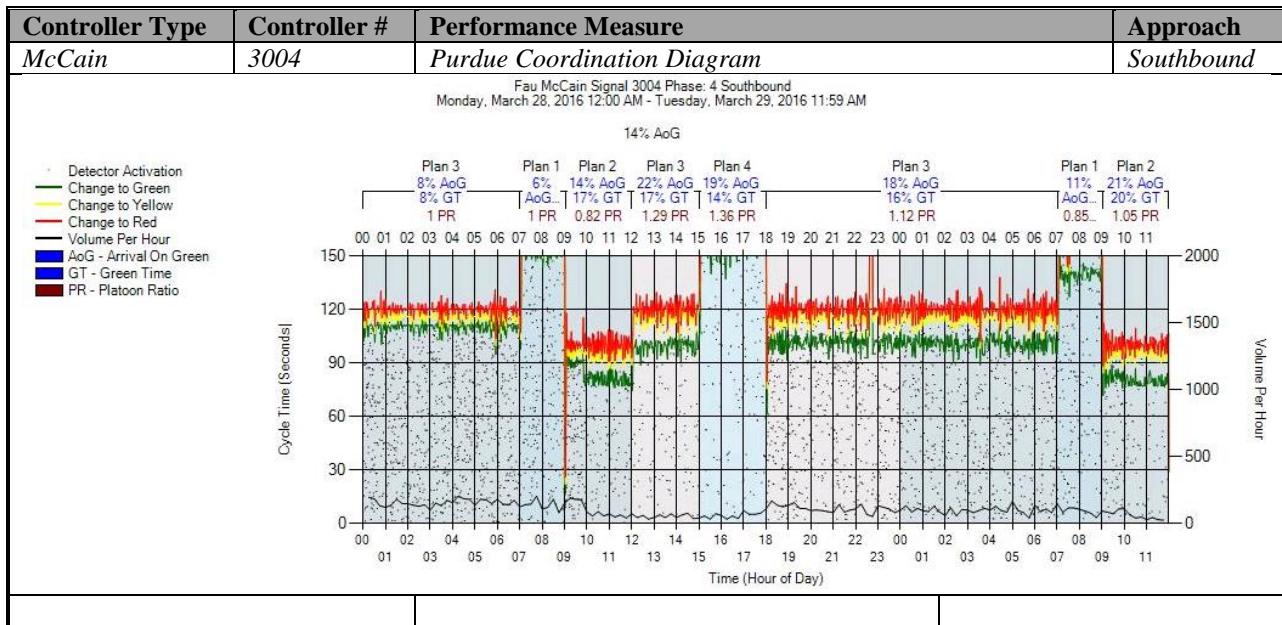


Figure A-122. McCain – Purdue Coordination Diagram – SB

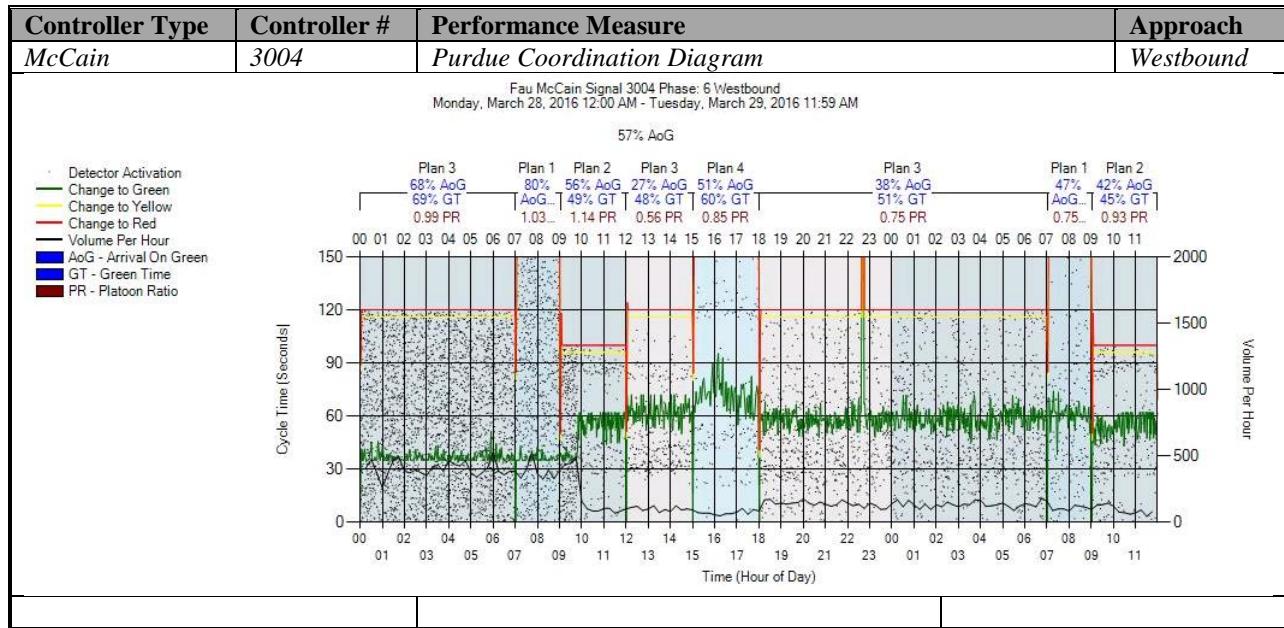


Figure A-123. McCain – Purdue Coordination Diagram – WB

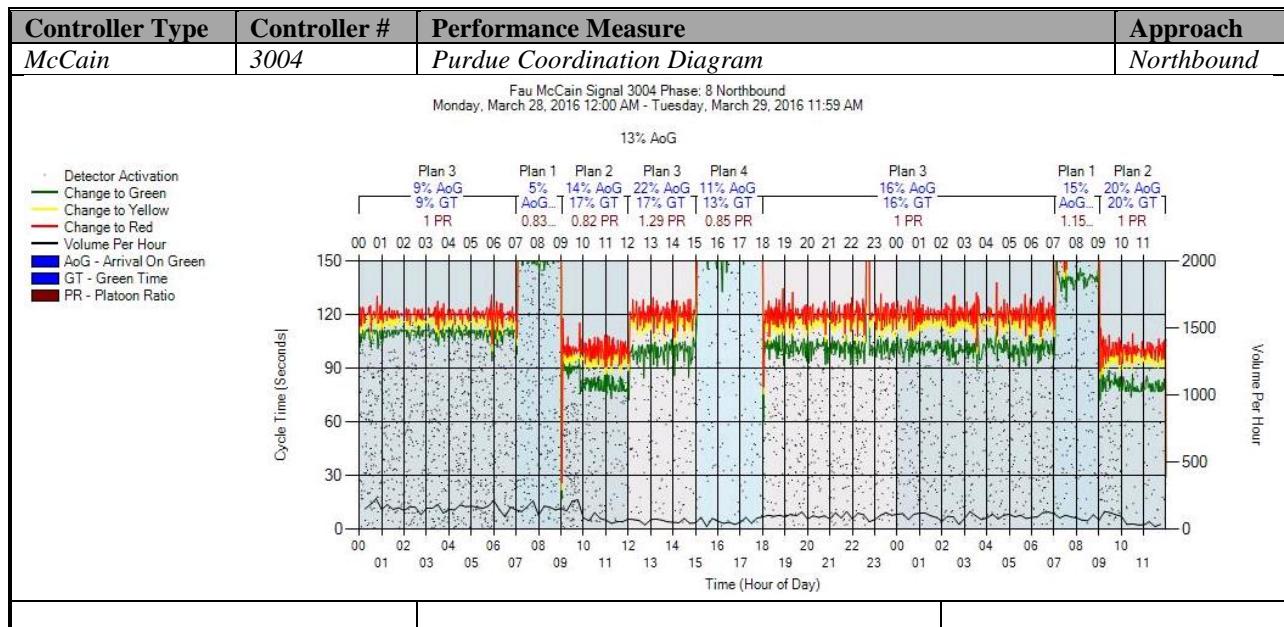


Figure A-124. McCain – Purdue Coordination Diagram – NB

e) Purdue Split Failure

No graphs – Needs to be configured in the SPM Tool. To be accomplished later.

f) Pedestrian Delay

No graphs – Needs to be configured in the controller. To be accomplished later.

g) Preemption Details

No graphs – Needs to be configured in the controller. To be accomplished later.

h) Purdue Phase Termination

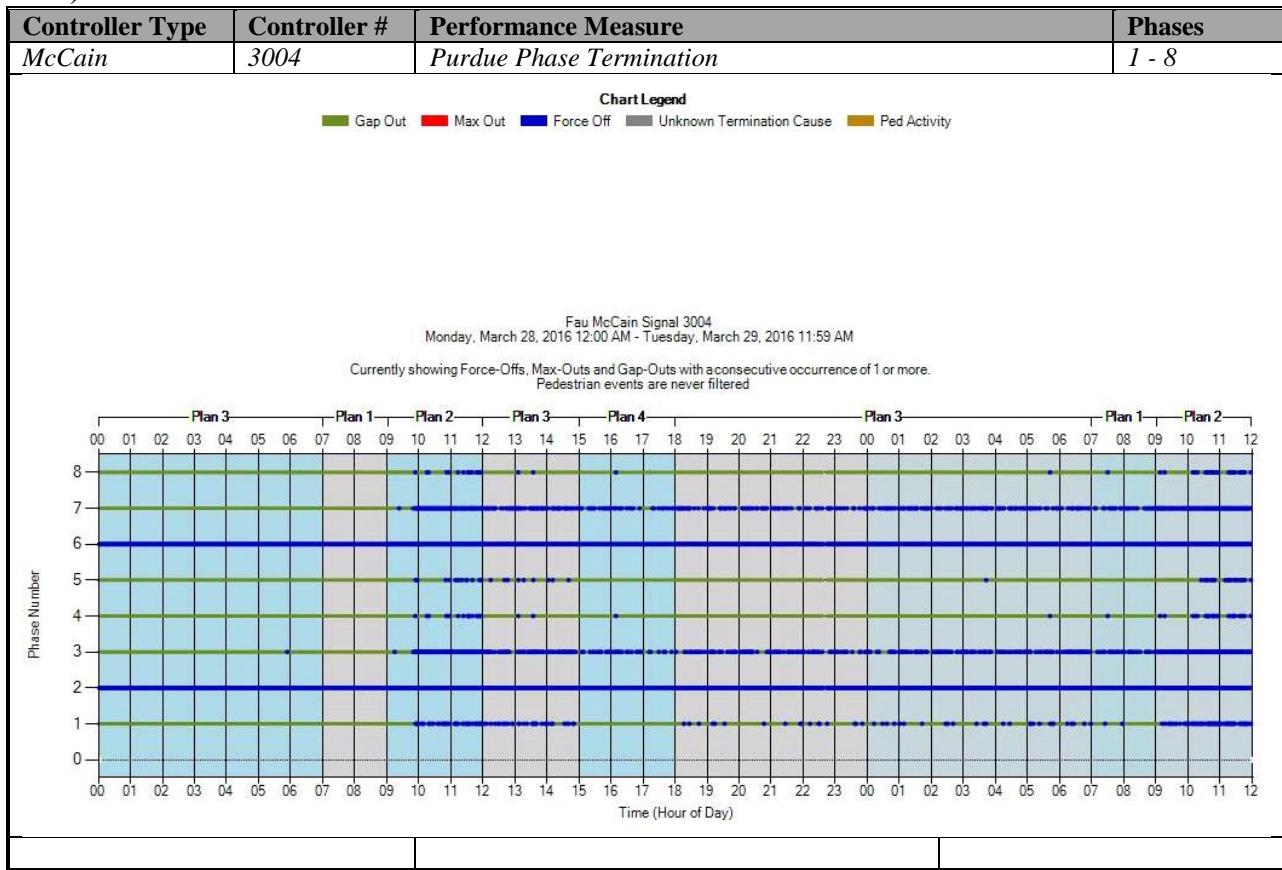


Figure A-125. McCain – Purdue Phase Termination

i) Speed (Check in C:\inetpub\wwwroot\SignalPerformanceMetrics\misc)

The graphs do exist, but without the data from the controller because speed detectors need to be configured in the controller. To be accomplished later.

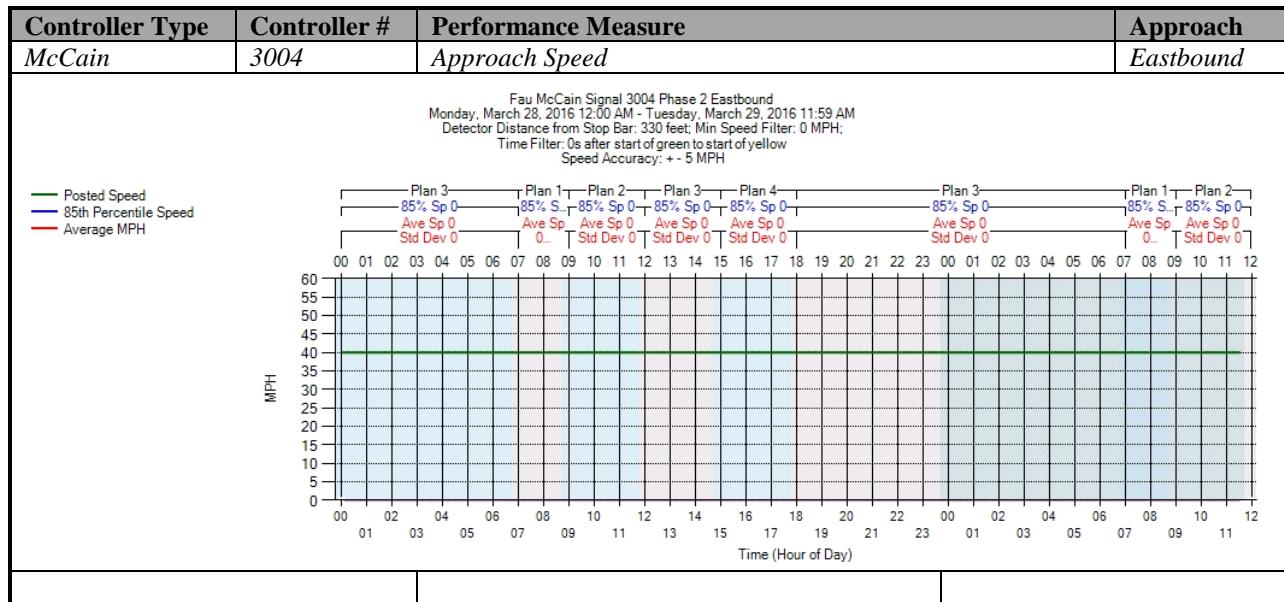


Figure A-126. McCain – Approach Speed – EB

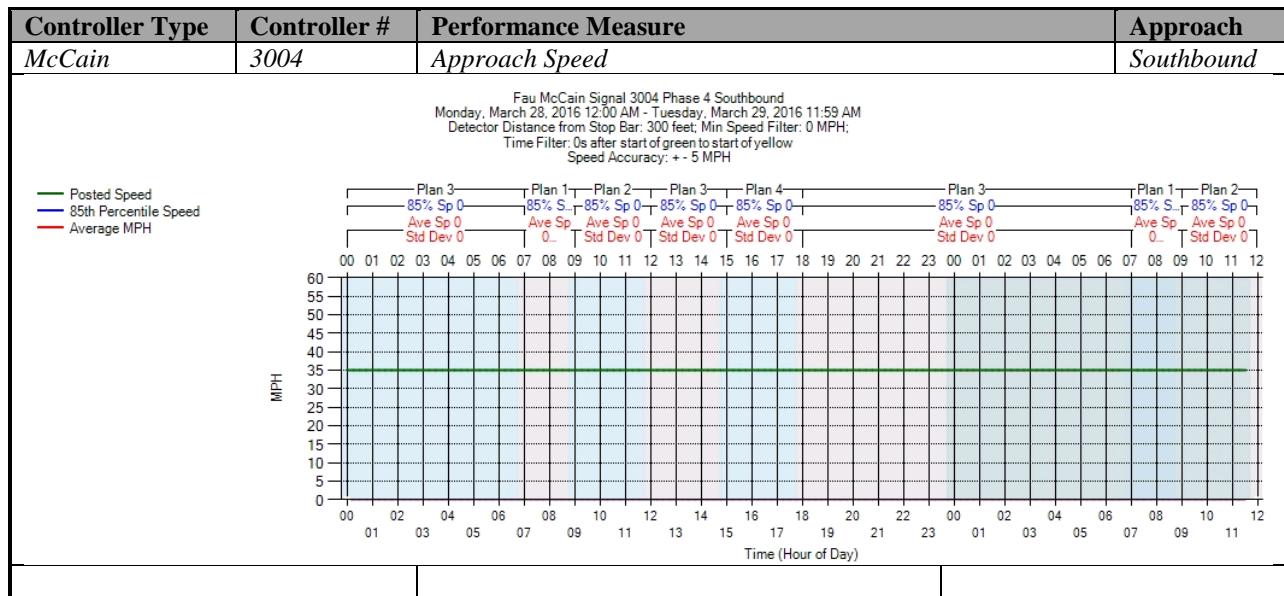


Figure A-127. McCain – Approach Speed – SB

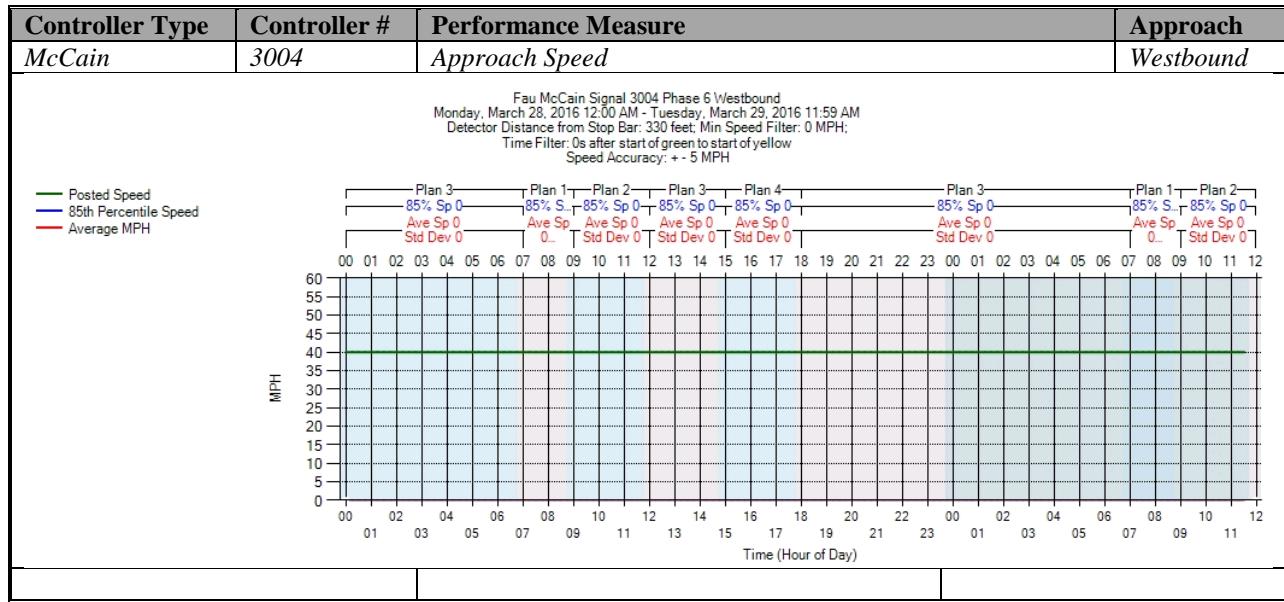


Figure A-128. McCain – Approach Speed – WB

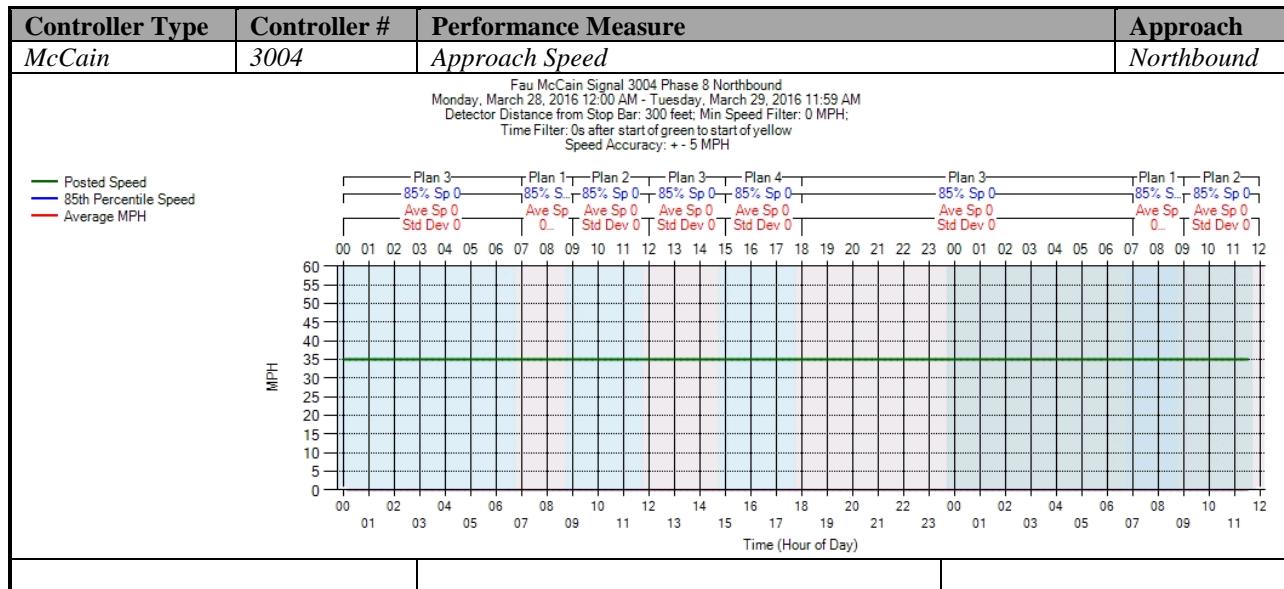


Figure A-129. McCain – Approach Speed – NB

j) Split Monitor – McCain

(C:\Installs\Deeptistuff\SPMWebFiles\SPMWebFiles\SPMSourceFiles\v3.2Deepti\Signal Timing Diagrams)

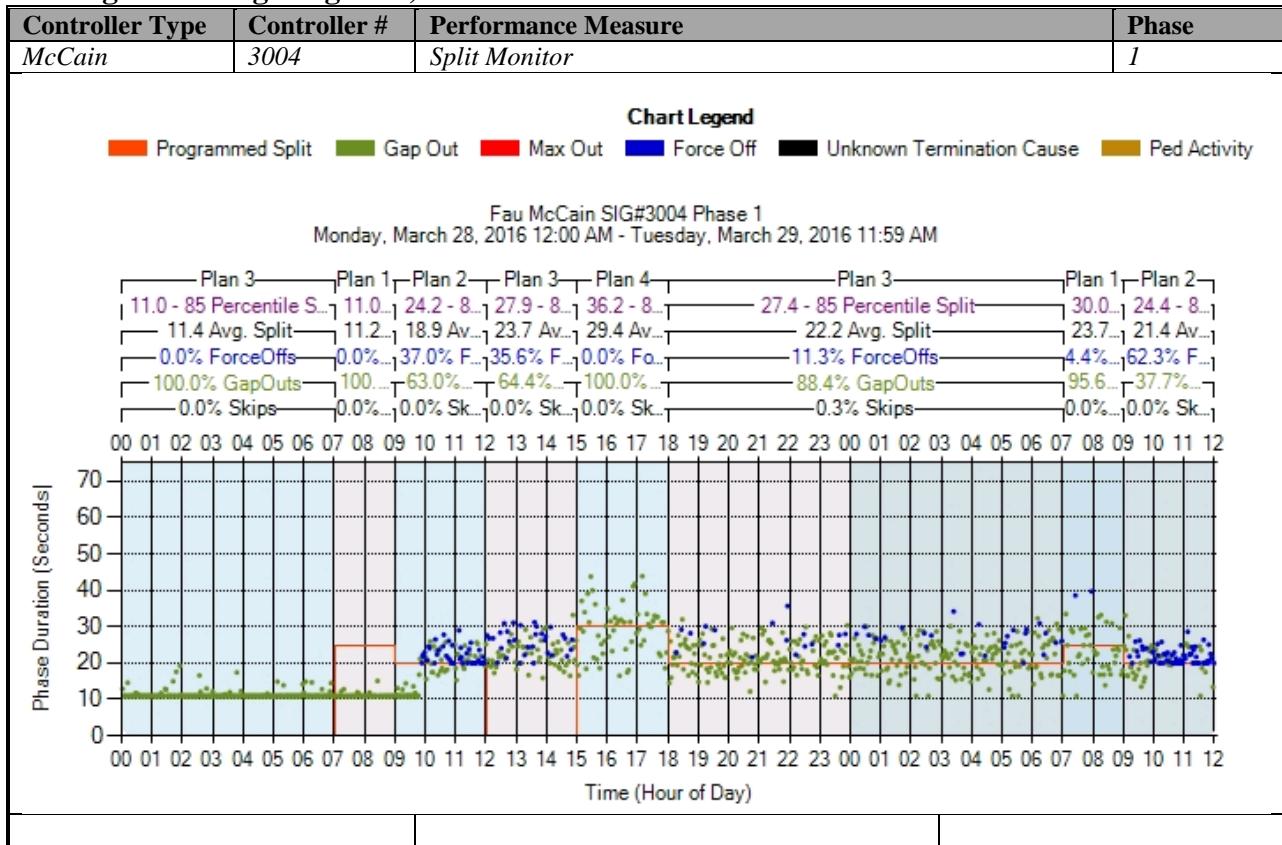


Figure A-130. McCain – Split Monitor – Phase 1

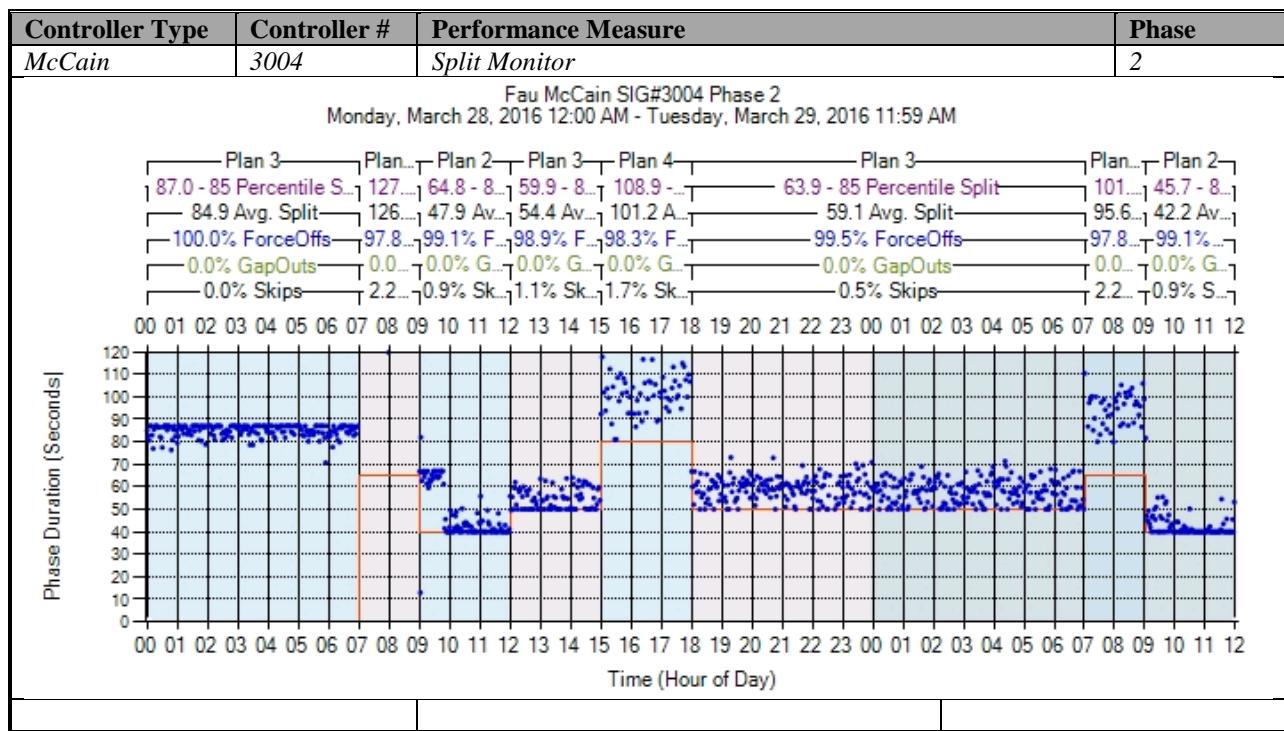


Figure A-131. McCain – Split Monitor – Phase 2

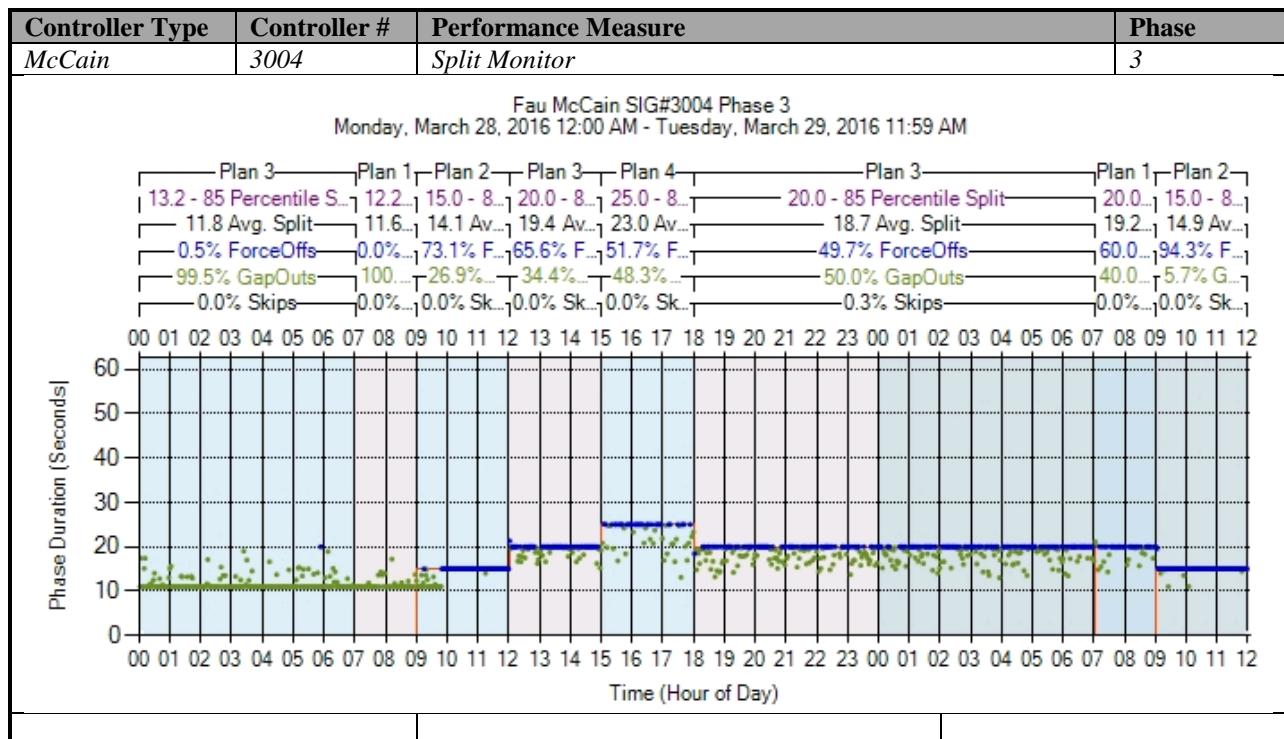


Figure A-132. McCain – Split Monitor – Phase 3

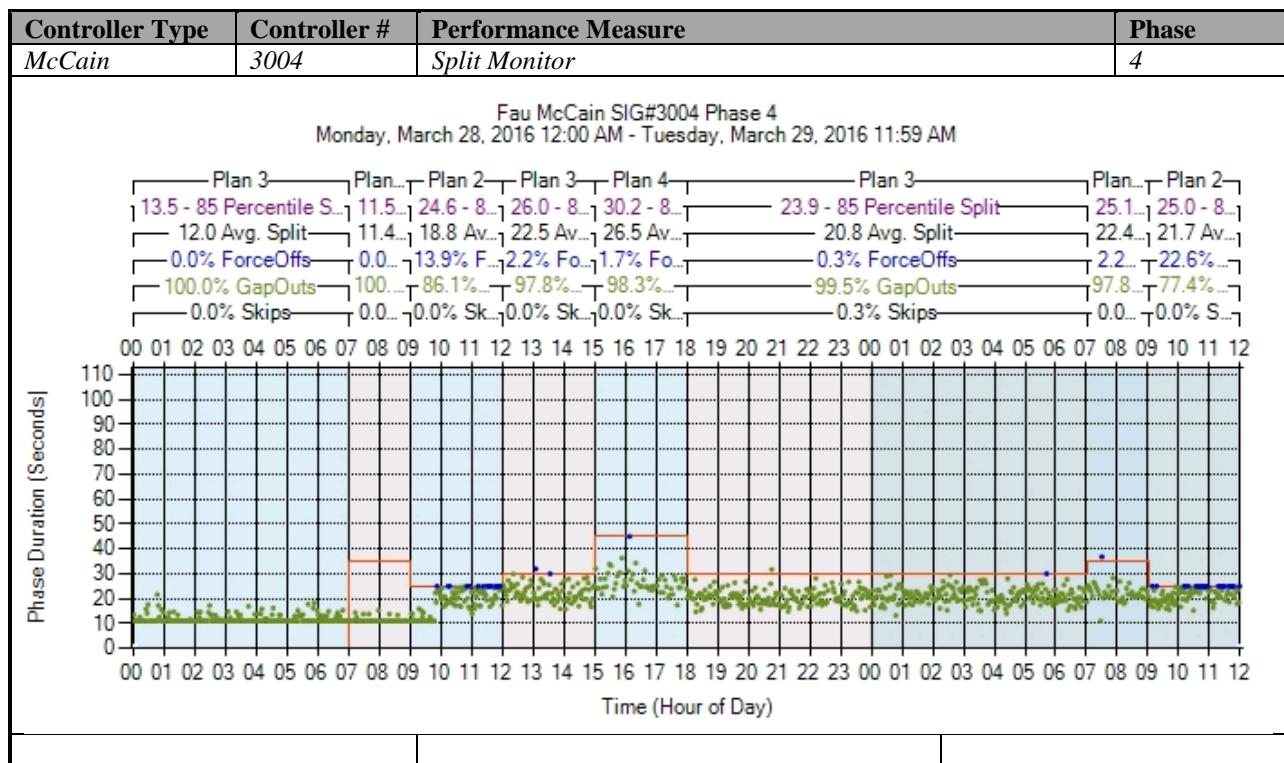


Figure A-133. McCain – Split Monitor – Phase 4

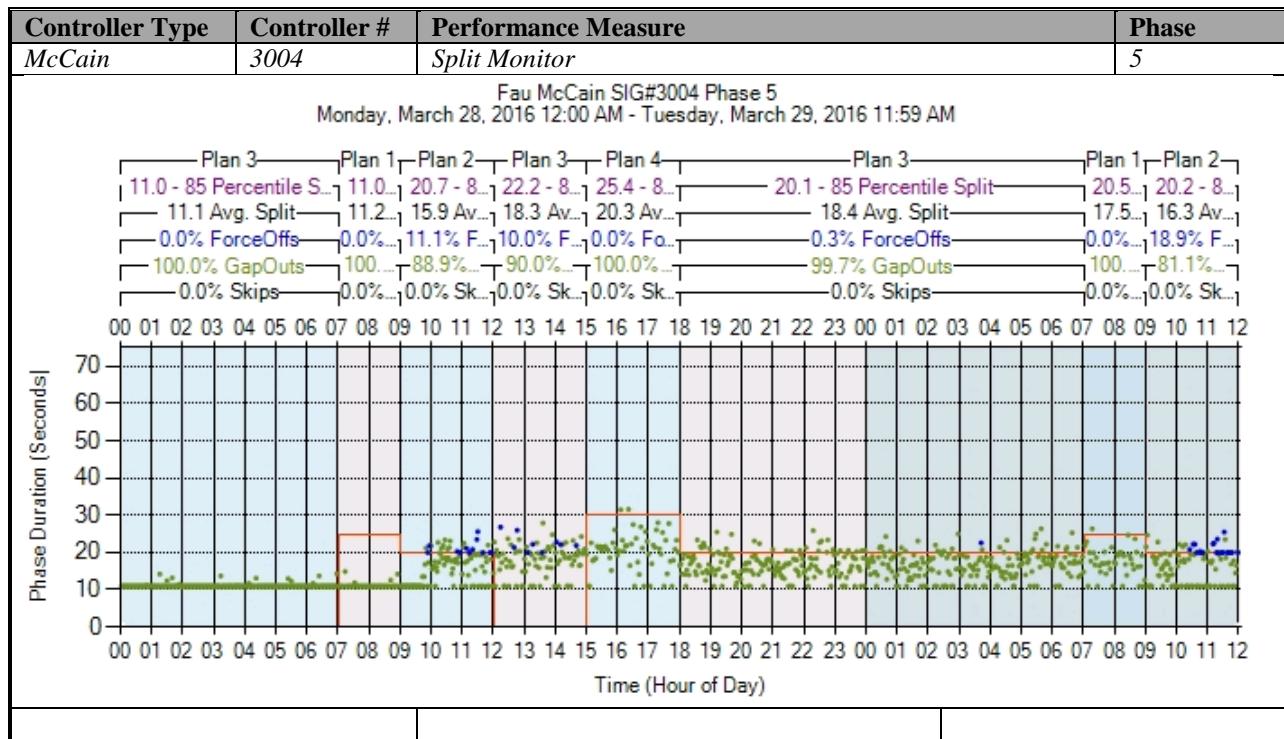


Figure A-134. McCain – Split Monitor – Phase 5

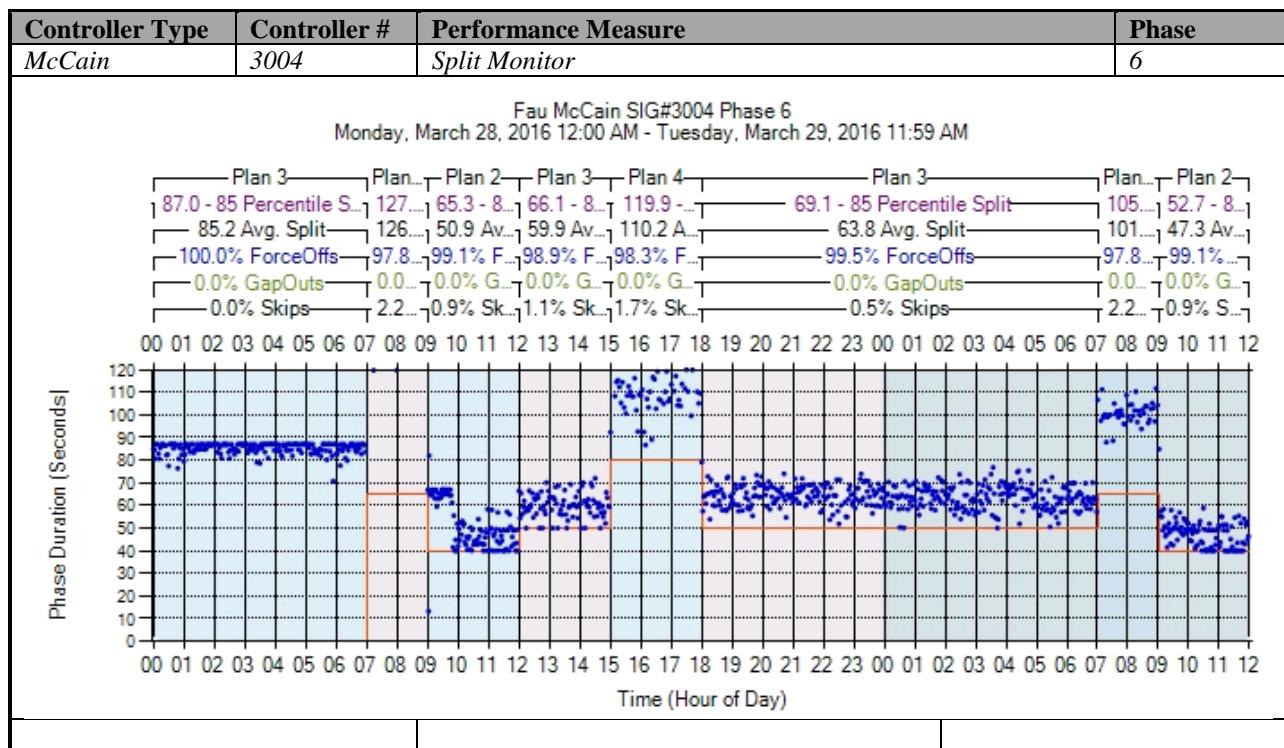


Figure A-135. McCain – Split Monitor – Phase 6

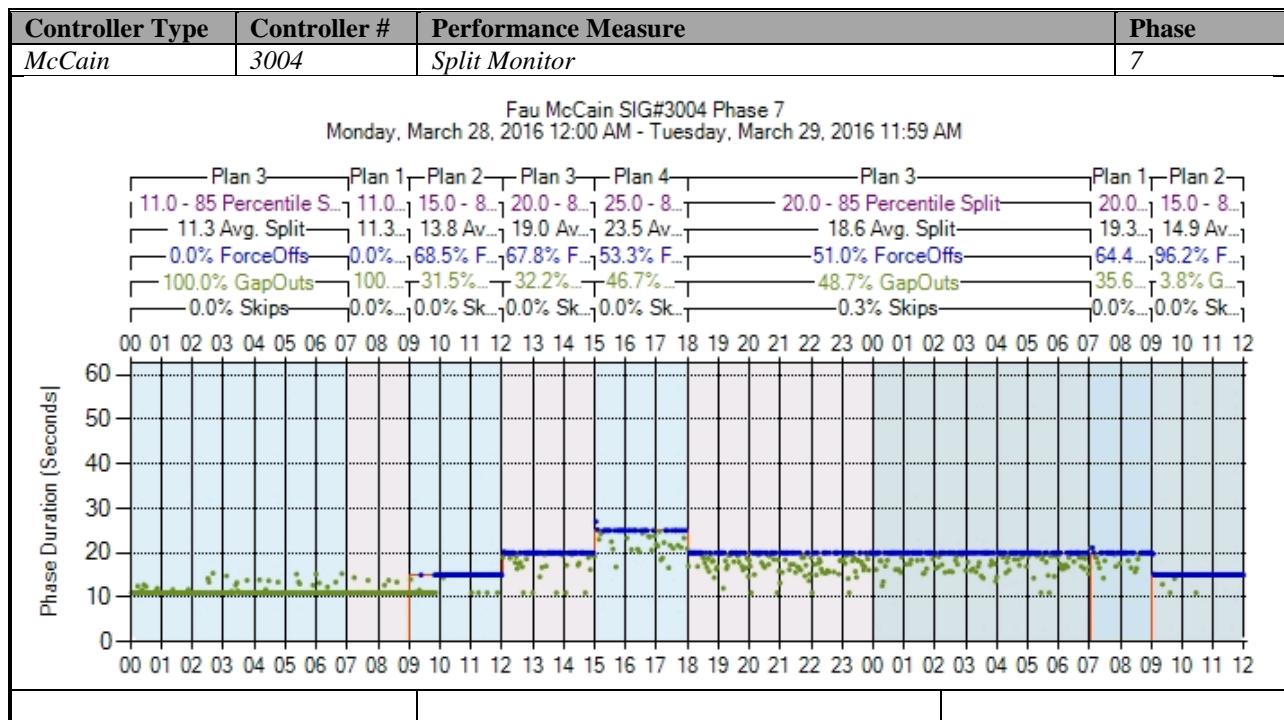


Figure A-136. McCain – Split Monitor – Phase 7

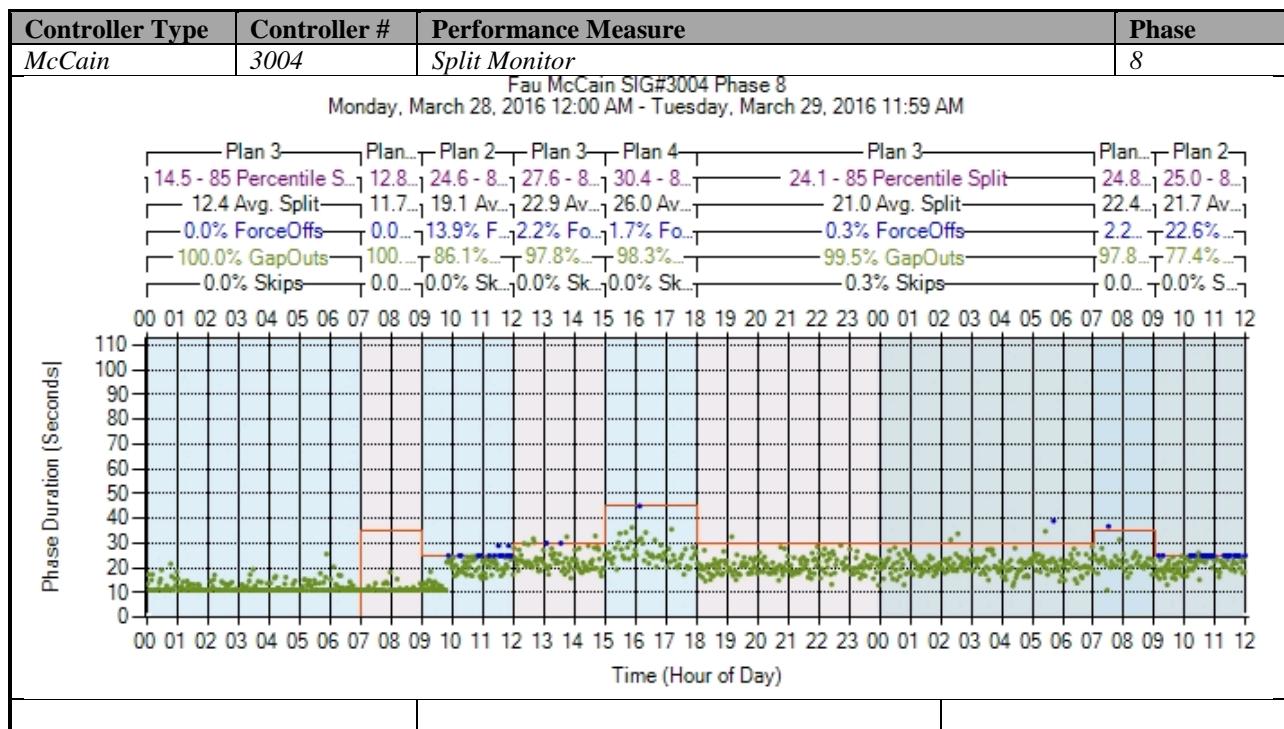


Figure A-137. McCain – Split Monitor – Phase 8

k) Turning Movement Counts

No graphs – Need to add new detectors after the stop bar. To be accomplished later.

I) Yellow and Red Actuations

No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.

A.6 Intelight (2070-LDX) High Resolution Data Performance Metrics

a) Approach Delay – Intelight (C:\inetpub\wwwroot\SignalPerformanceMetrics)

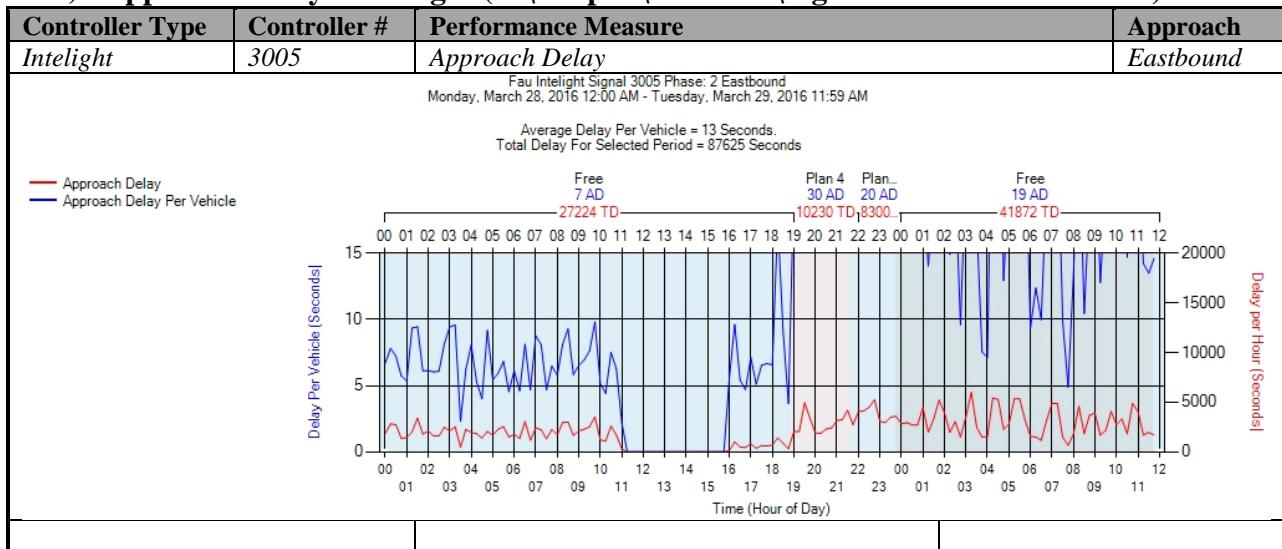


Figure A-138. Intelight – Approach Delay – EB

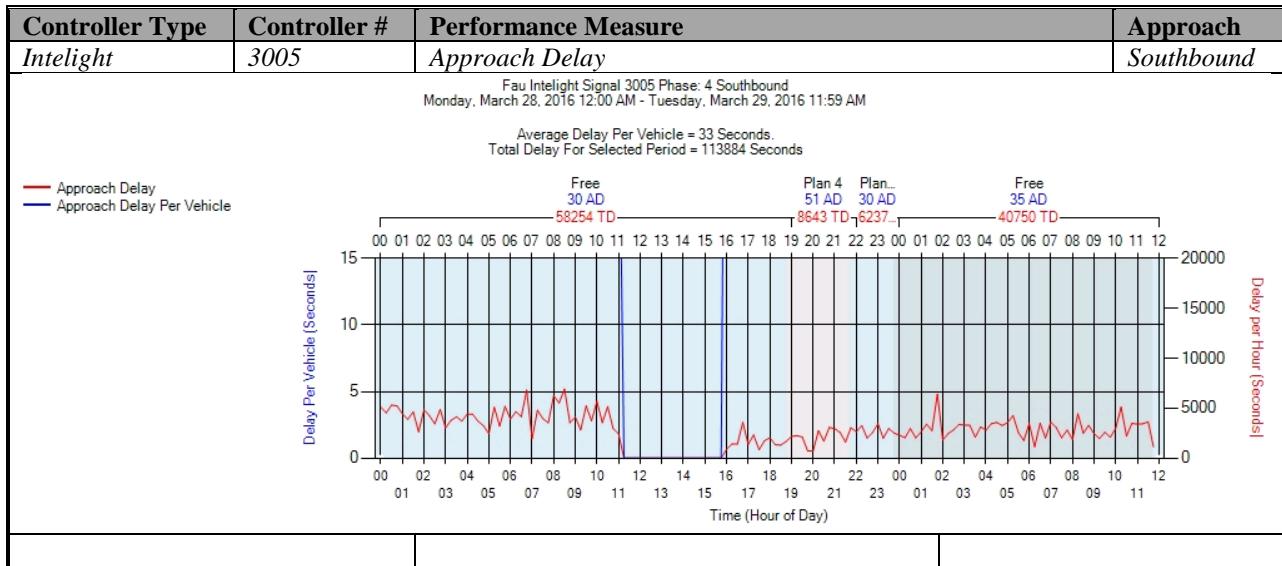


Figure A-139. Intelight – Approach Delay – SB

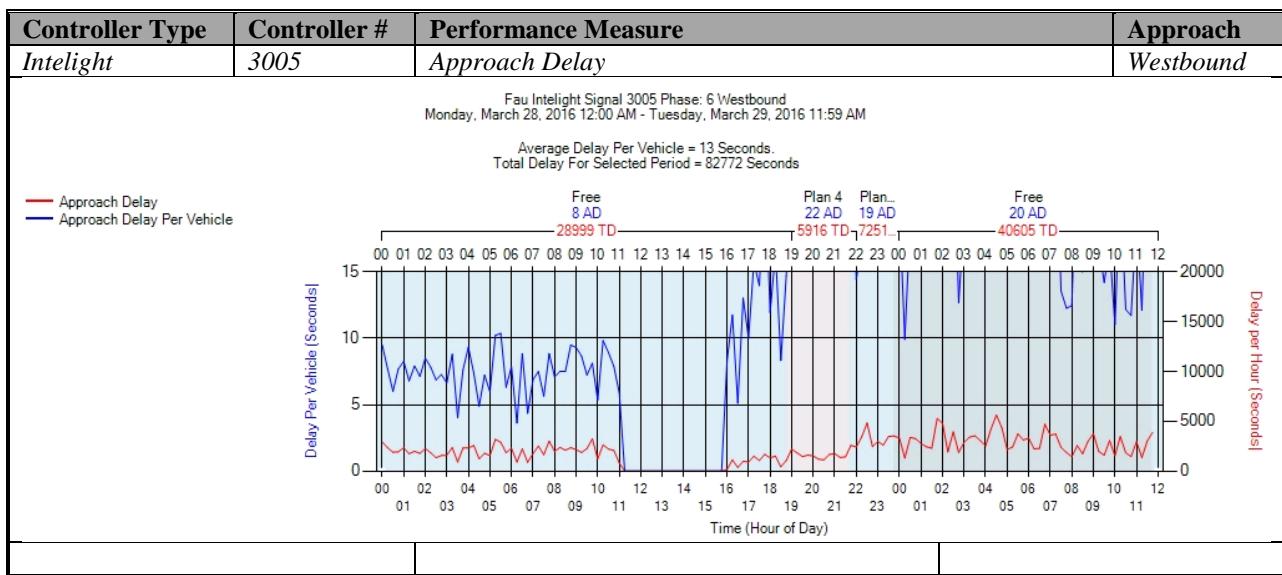


Figure A-140. Intelight – Approach Delay – WB

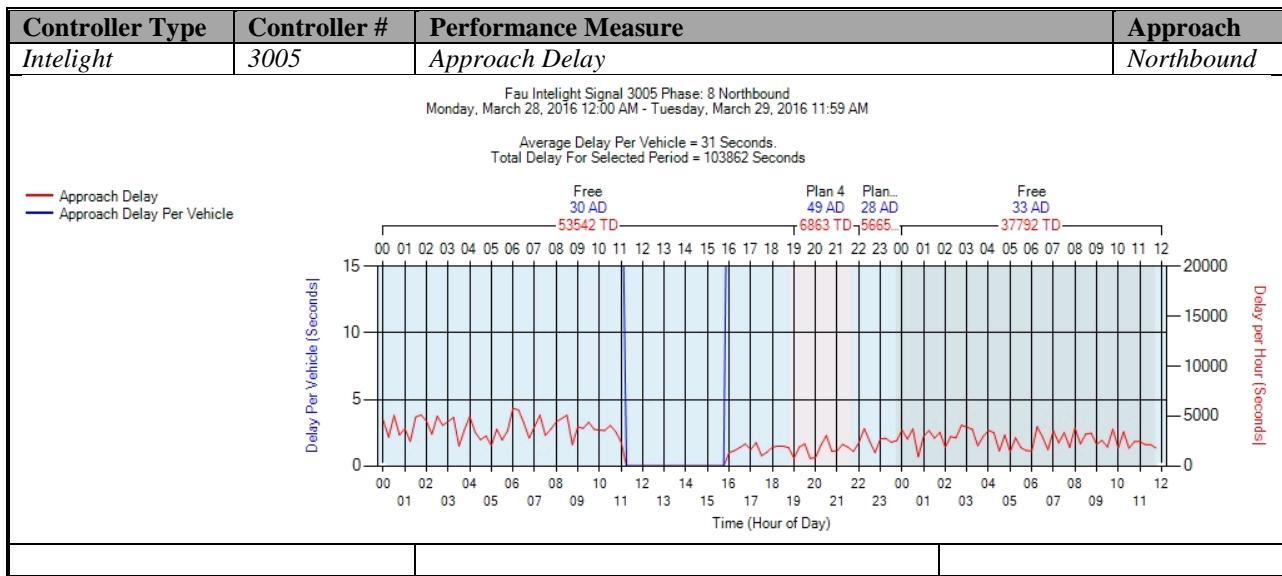


Figure A-141. Intelight – Approach Delay – NB

b) Approach Volume - Intelight (C:\inetpub\wwwroot\SignalPerformanceMetrics)

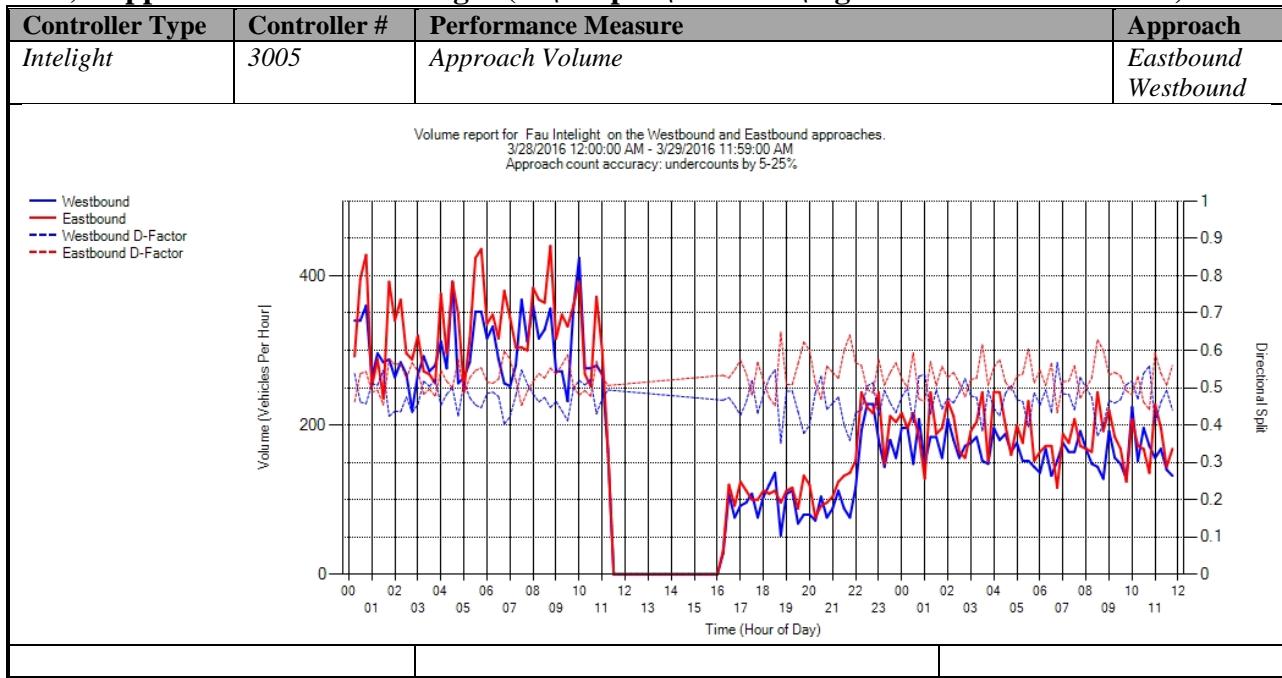


Figure A-142. Intelight – Approach Delay – WB & EB

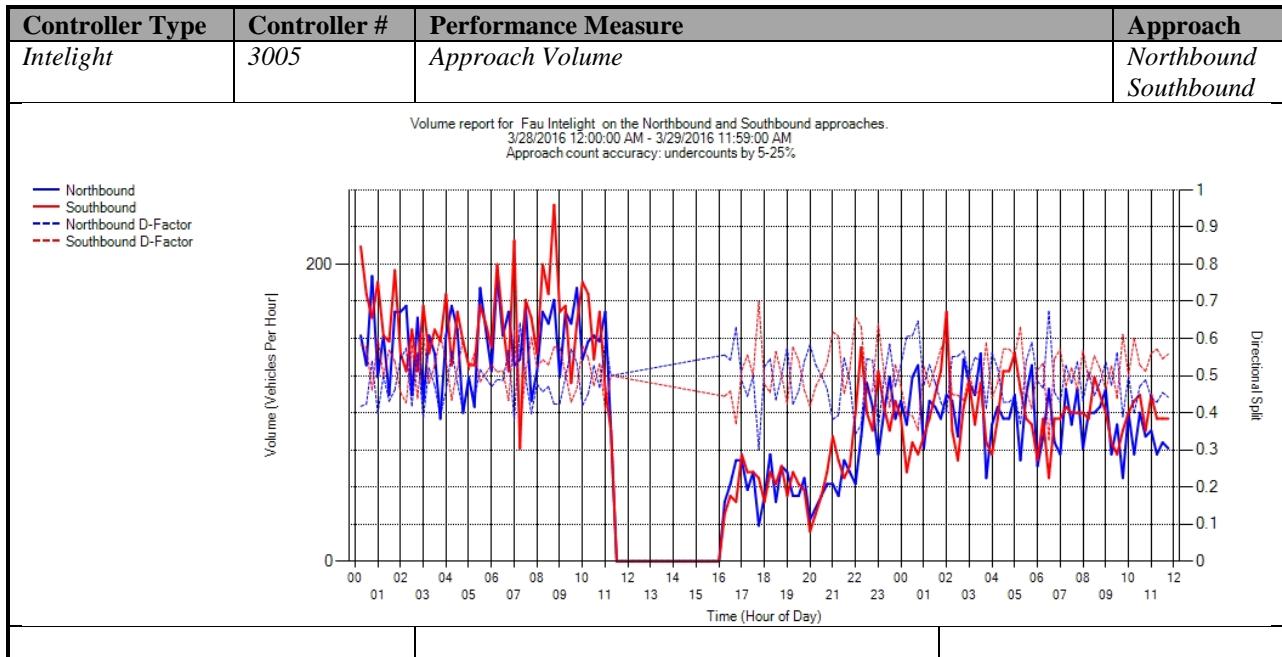


Figure A-143. Intelight – Approach Delay – NB & SB

Controller Type	Controller #	Performance Measure	Approach																																								
Approach Volume			Total																																								
		<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>6,778</td></tr> <tr> <td>Peak Hour</td><td>8:15 AM - 9:15 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>354</td></tr> <tr> <td>PHF</td><td>0.851</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Northbound Total Volume</td><td>3,289</td></tr> <tr> <td>Northbound Peak Hour</td><td>5:30 AM - 6:30 AM</td></tr> <tr> <td>Northbound Peak Hour Volume</td><td>165</td></tr> <tr> <td>Northbound PHF</td><td>0.859</td></tr> <tr> <td>Northbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Northbound Peak-Hour D-factor</td><td>1.02</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Southbound Total Volume</td><td>3,489</td></tr> <tr> <td>Southbound Peak Hour</td><td>8:15 AM - 9:15 AM</td></tr> <tr> <td>Southbound Peak Hour Volume</td><td>197</td></tr> <tr> <td>Southbound PHF</td><td>1</td></tr> <tr> <td>Southbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Southbound Peak-Hour D-factor</td><td>0.797</td></tr> </tbody> </table>	Metric	Value	Total Volume	6,778	Peak Hour	8:15 AM - 9:15 AM	Peak Hour Volume	354	PHF	0.851	Peak-Hour K-factor	NA			Northbound Total Volume	3,289	Northbound Peak Hour	5:30 AM - 6:30 AM	Northbound Peak Hour Volume	165	Northbound PHF	0.859	Northbound Peak-Hour K-factor	NA	Northbound Peak-Hour D-factor	1.02			Southbound Total Volume	3,489	Southbound Peak Hour	8:15 AM - 9:15 AM	Southbound Peak Hour Volume	197	Southbound PHF	1	Southbound Peak-Hour K-factor	NA	Southbound Peak-Hour D-factor	0.797	
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		<table border="1"> <thead> <tr> <th>Metric</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Total Volume</td><td>13,187</td></tr> <tr> <td>Peak Hour</td><td>8:00 AM - 9:00 AM</td></tr> <tr> <td>Peak Hour Volume</td><td>729</td></tr> <tr> <td>PHF</td><td>0.916</td></tr> <tr> <td>Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Westbound Total Volume</td><td>6,215</td></tr> <tr> <td>Westbound Peak Hour</td><td>8:00 AM - 9:00 AM</td></tr> <tr> <td>Westbound Peak Hour Volume</td><td>340</td></tr> <tr> <td>Westbound PHF</td><td>0.944</td></tr> <tr> <td>Westbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Westbound Peak-Hour D-factor</td><td>1.14</td></tr> <tr> <td> </td><td> </td></tr> <tr> <td>Eastbound Total Volume</td><td>6,972</td></tr> <tr> <td>Eastbound Peak Hour</td><td>8:00 AM - 9:00 AM</td></tr> <tr> <td>Eastbound Peak Hour Volume</td><td>389</td></tr> <tr> <td>Eastbound PHF</td><td>1</td></tr> <tr> <td>Eastbound Peak-Hour K-factor</td><td>NA</td></tr> <tr> <td>Eastbound Peak-Hour D-factor</td><td>0.874</td></tr> </tbody> </table>	Metric	Value	Total Volume	13,187	Peak Hour	8:00 AM - 9:00 AM	Peak Hour Volume	729	PHF	0.916	Peak-Hour K-factor	NA			Westbound Total Volume	6,215	Westbound Peak Hour	8:00 AM - 9:00 AM	Westbound Peak Hour Volume	340	Westbound PHF	0.944	Westbound Peak-Hour K-factor	NA	Westbound Peak-Hour D-factor	1.14			Eastbound Total Volume	6,972	Eastbound Peak Hour	8:00 AM - 9:00 AM	Eastbound Peak Hour Volume	389	Eastbound PHF	1	Eastbound Peak-Hour K-factor	NA	Eastbound Peak-Hour D-factor	0.874	
Metric	Value																																										
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Figure A-144. Intelight – Approach Volume – WB

c) Arrivals On Red - Intelight (C:\inetpub\wwwroot\SignalPerformanceMetrics)

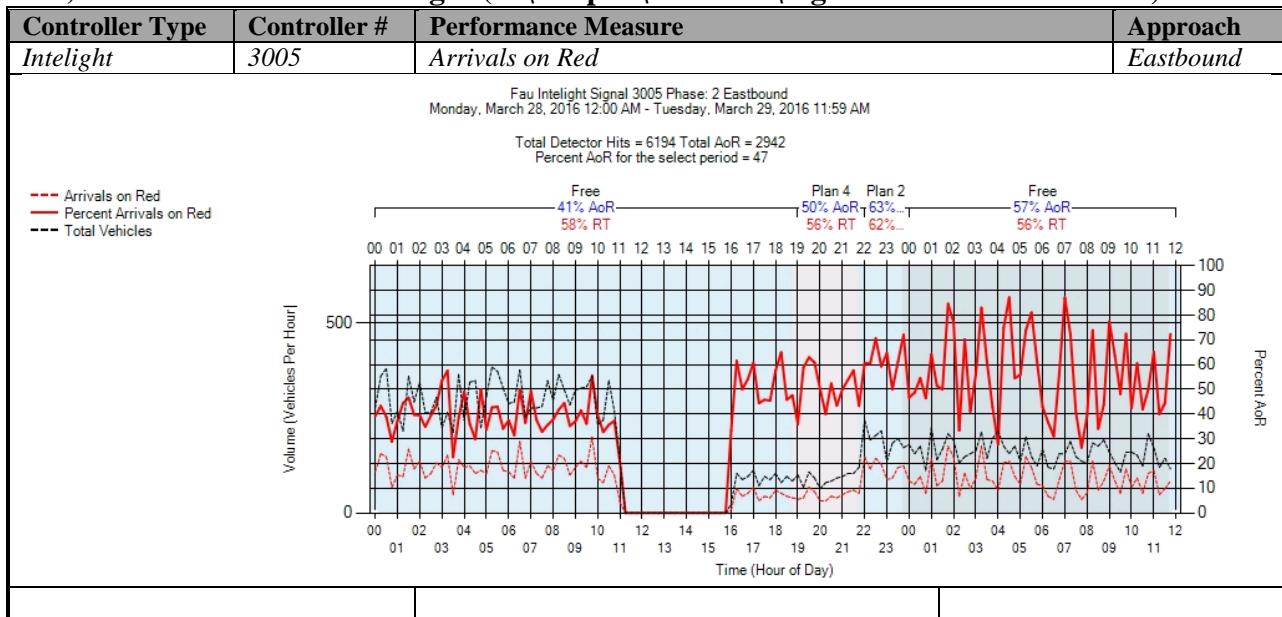


Figure A-145. Intelight – Arrivals on Red – EB

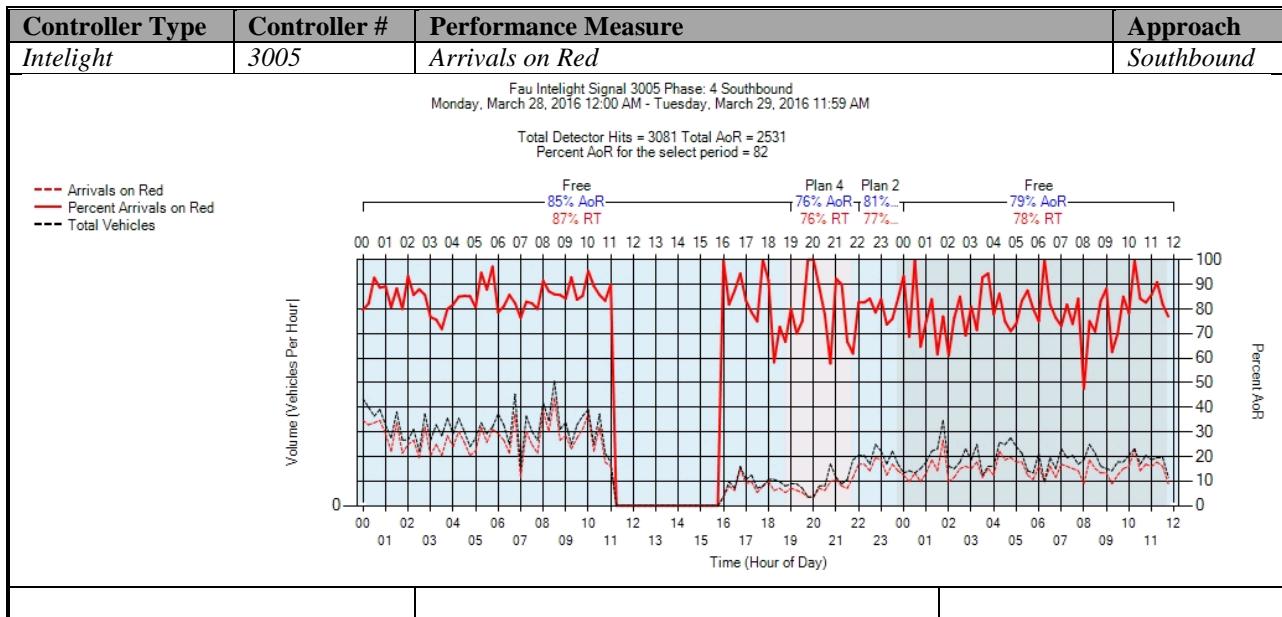


Figure A-146. Intelight – Arrivals on Red – SB

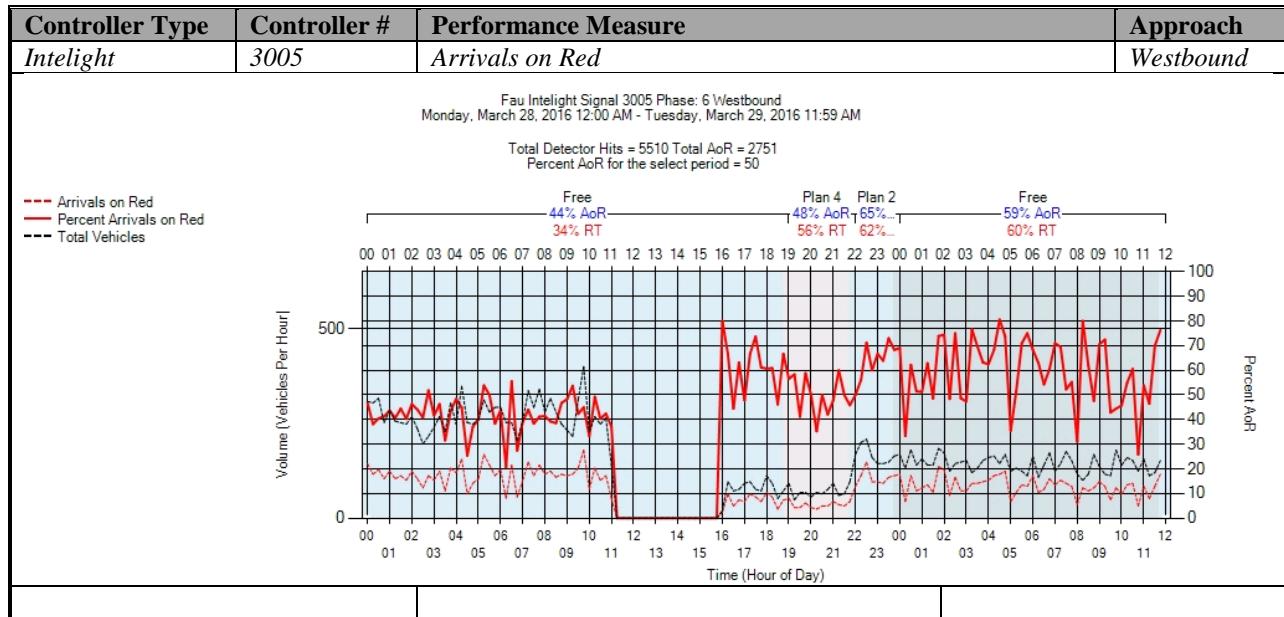


Figure A-147. Intelight – Arrivals on Red – WB

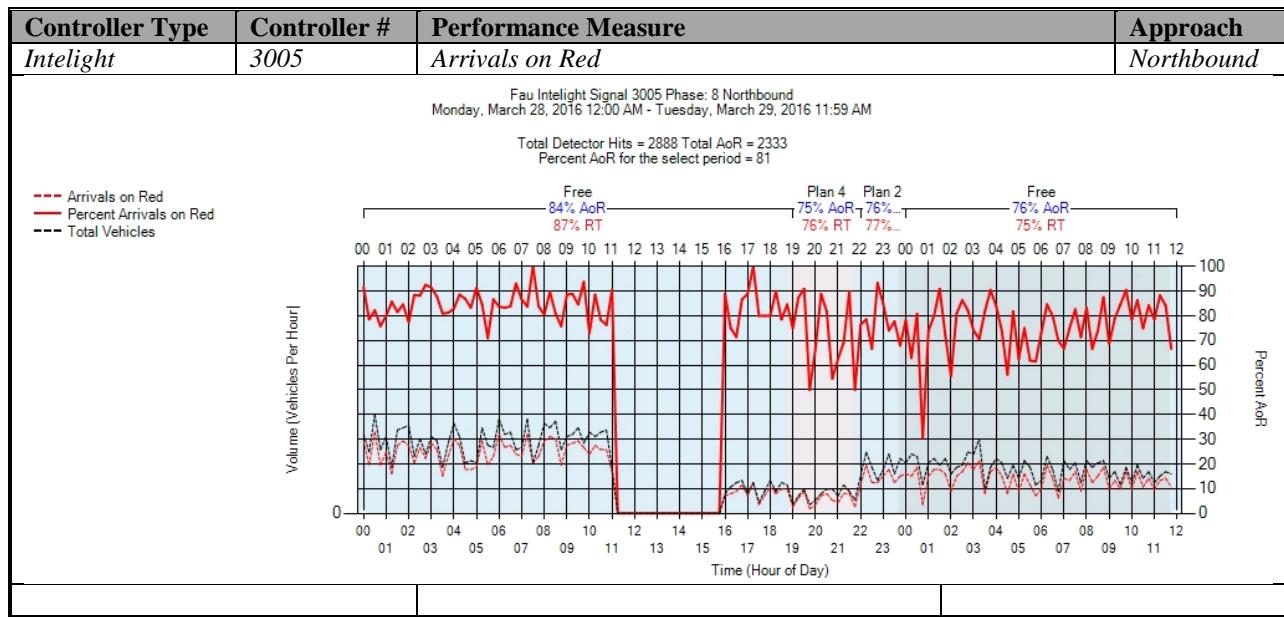


Figure A-148. Intelight – Arrivals on Red – NB

d) Purdue Coordination Diagram - Intelight (C:\inetpub\wwwroot\SPMImages)

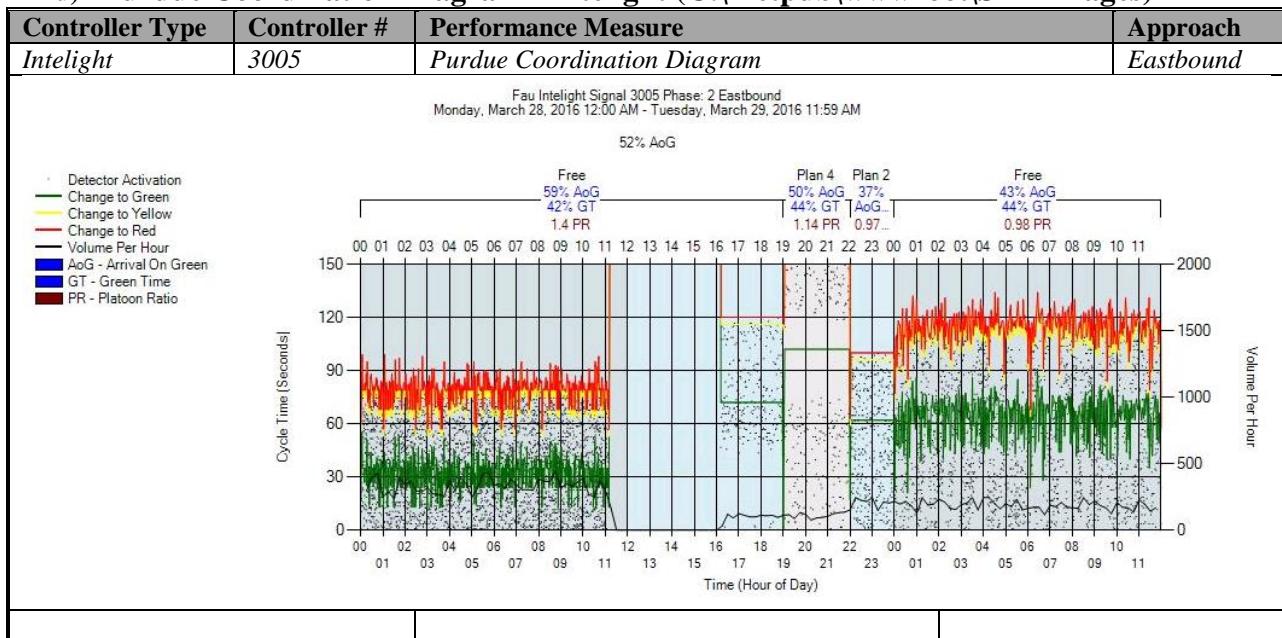


Figure A-149. Intelight – Purdue Coordination Diagram – EB

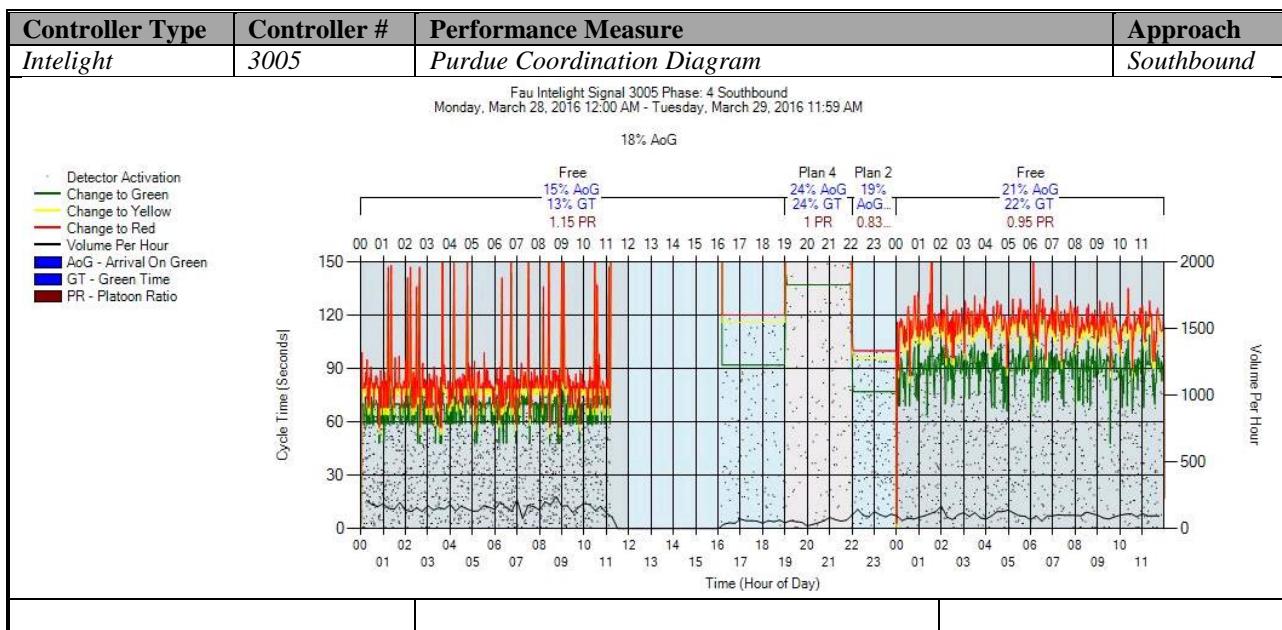


Figure A-150. Intelight – Purdue Coordination Diagram – SB

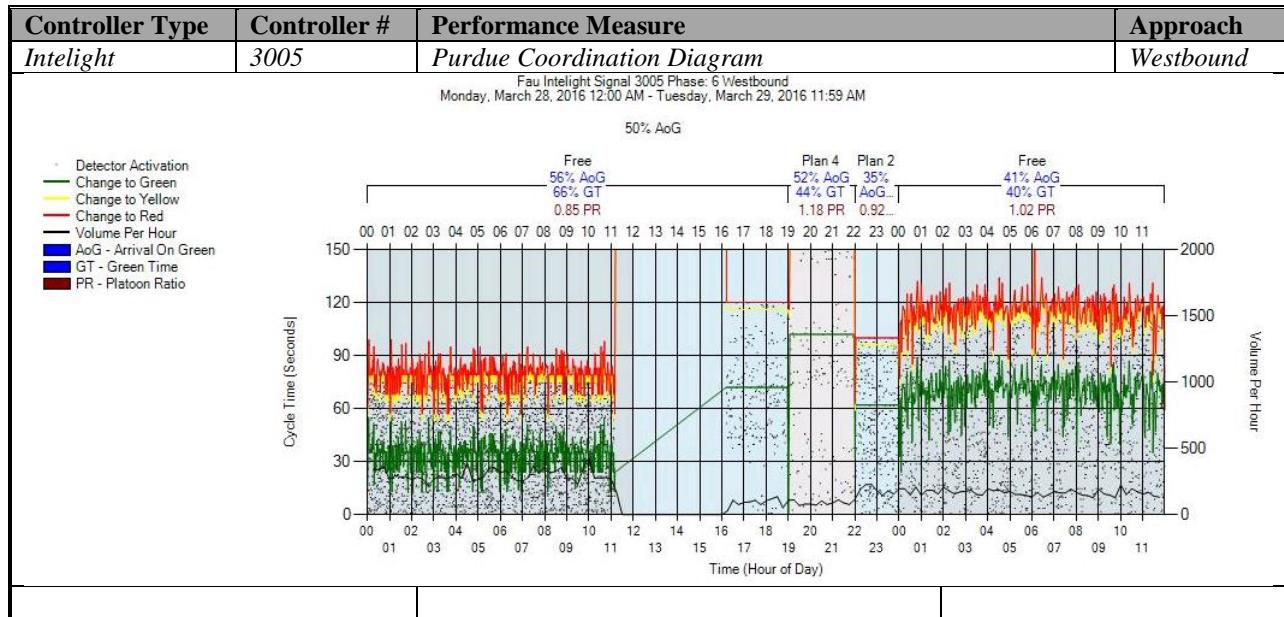


Figure A-151. Intelight – Purdue Coordination Diagram – WB

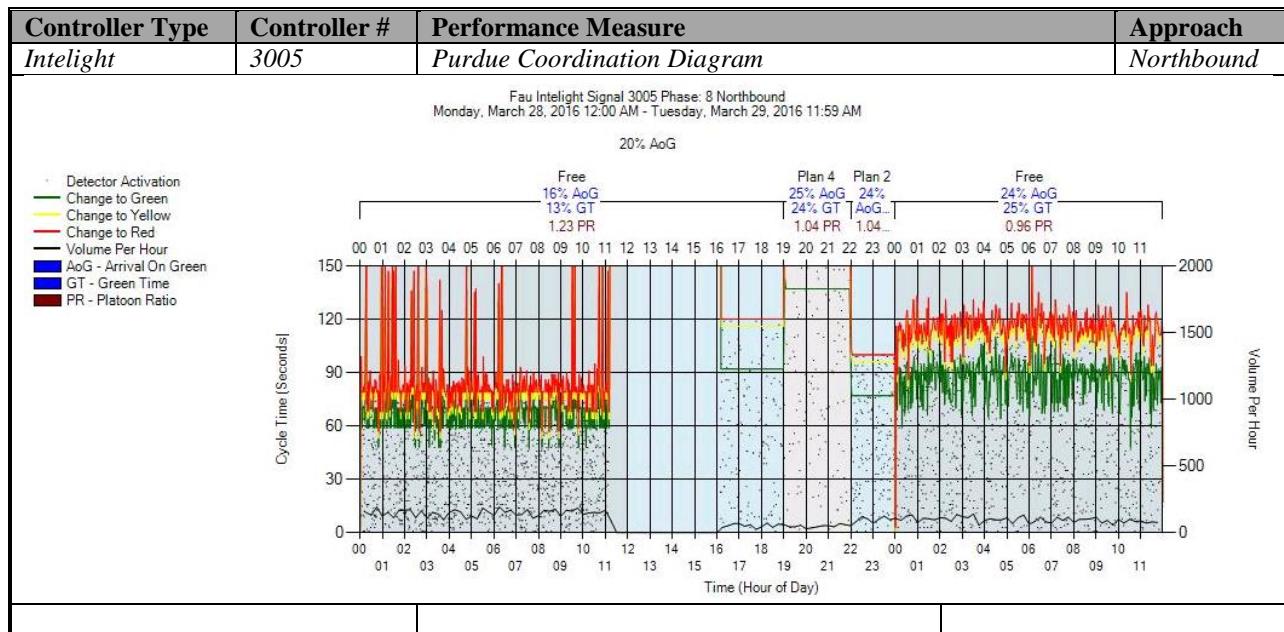


Figure A-152. Intelight – Purdue Coordination Diagram – NB

e) Purdue Split Failure

No graphs – Needs to be configured in the SPM Tool. To be accomplished later.

f) Pedestrian Delay

No graphs – Needs to be configured in the controller. To be accomplished later.

g) Preemption Details

No graphs – Needs to be configured in the controller. To be accomplished later.

h) Purdue Phase Termination

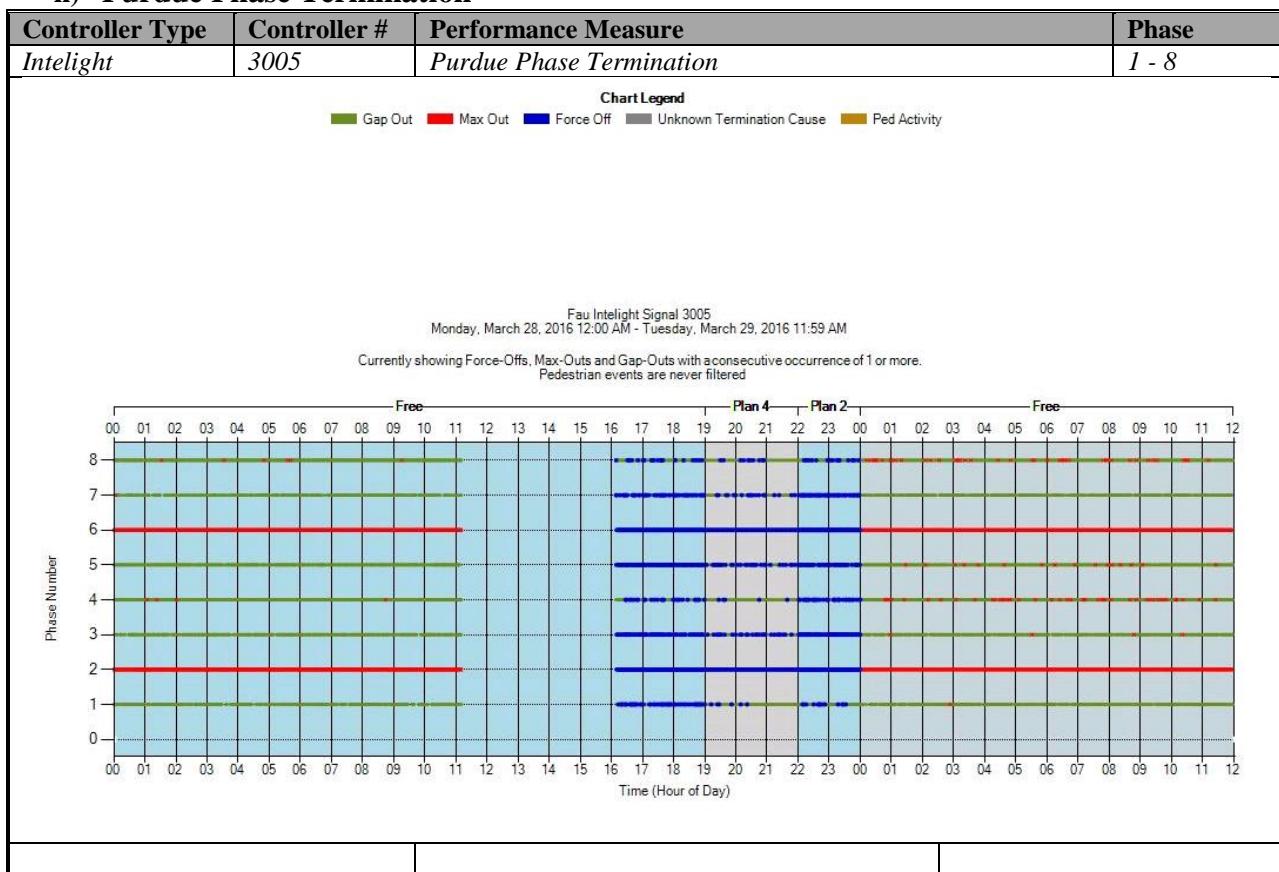


Figure A-153. Inteliight – Purdue Phase Termination

i) Speed (Check in C:\inetpub\wwwroot\SignalPerformanceMetrics\misc)

The graphs exist, but without data from the controller because speed detectors need to be configured in the controller. To be accomplished later.

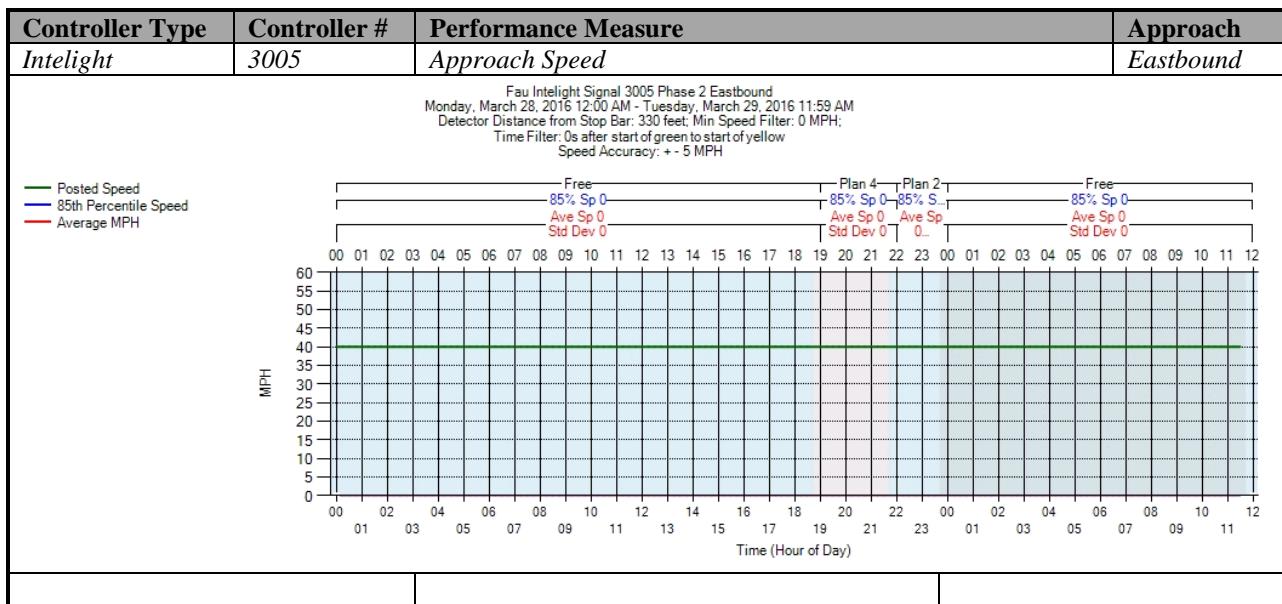


Figure A-154. Intelight – Approach Speed – EB

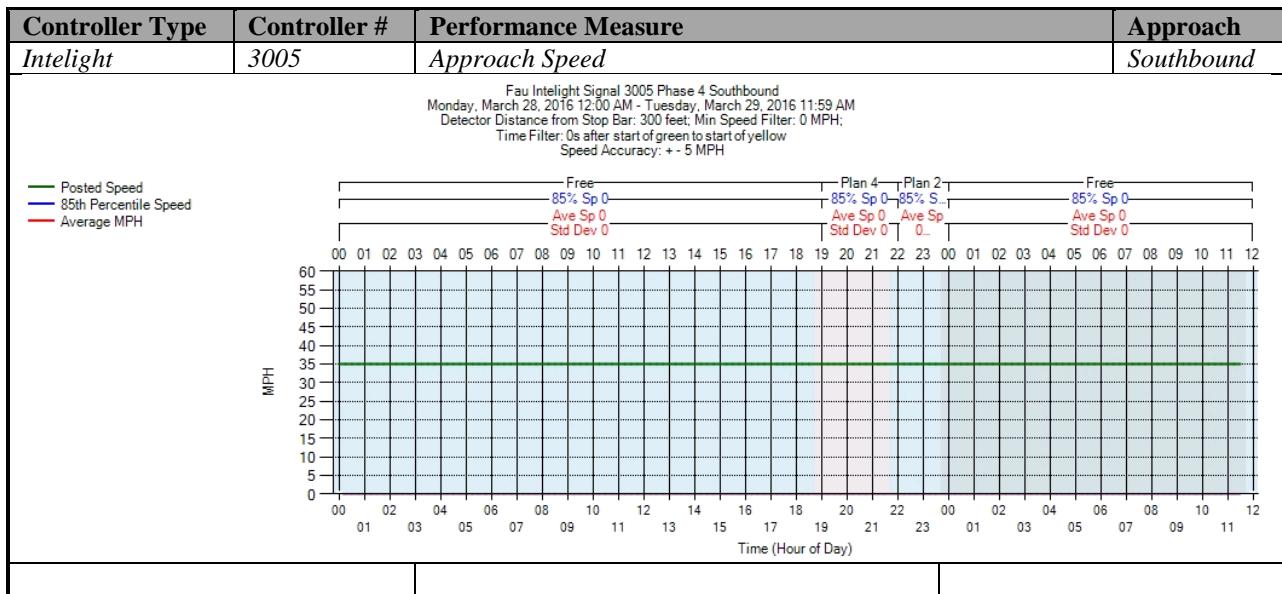


Figure A-155. Intelight – Approach Speed – SB

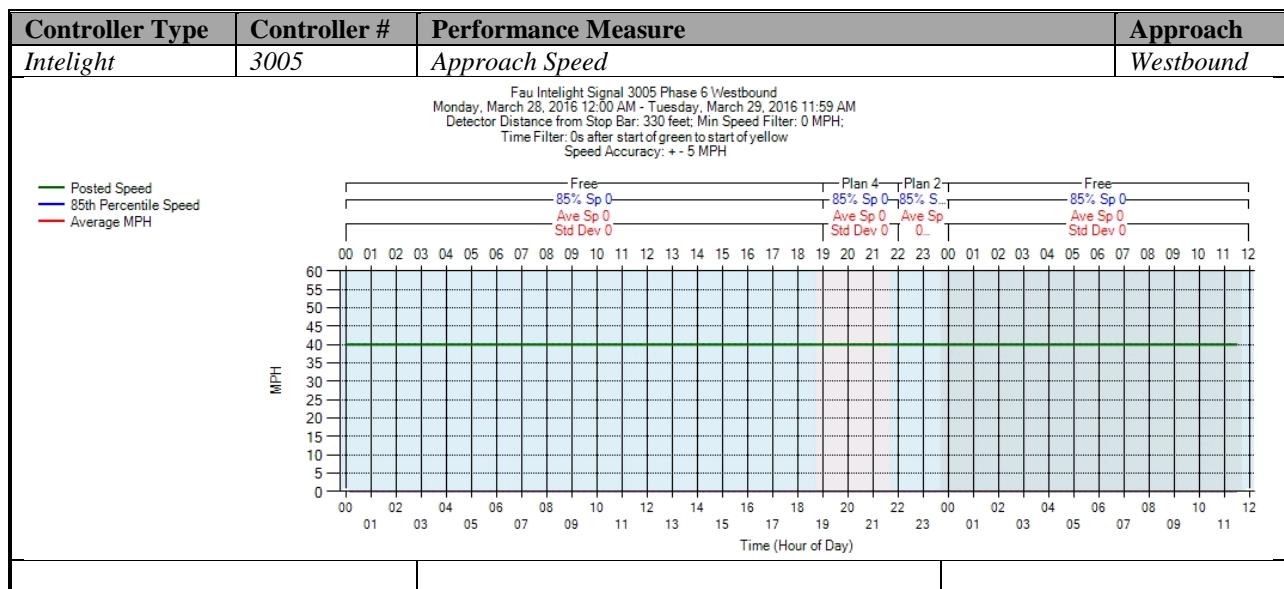


Figure A-156. Intelight – Approach Speed – WB

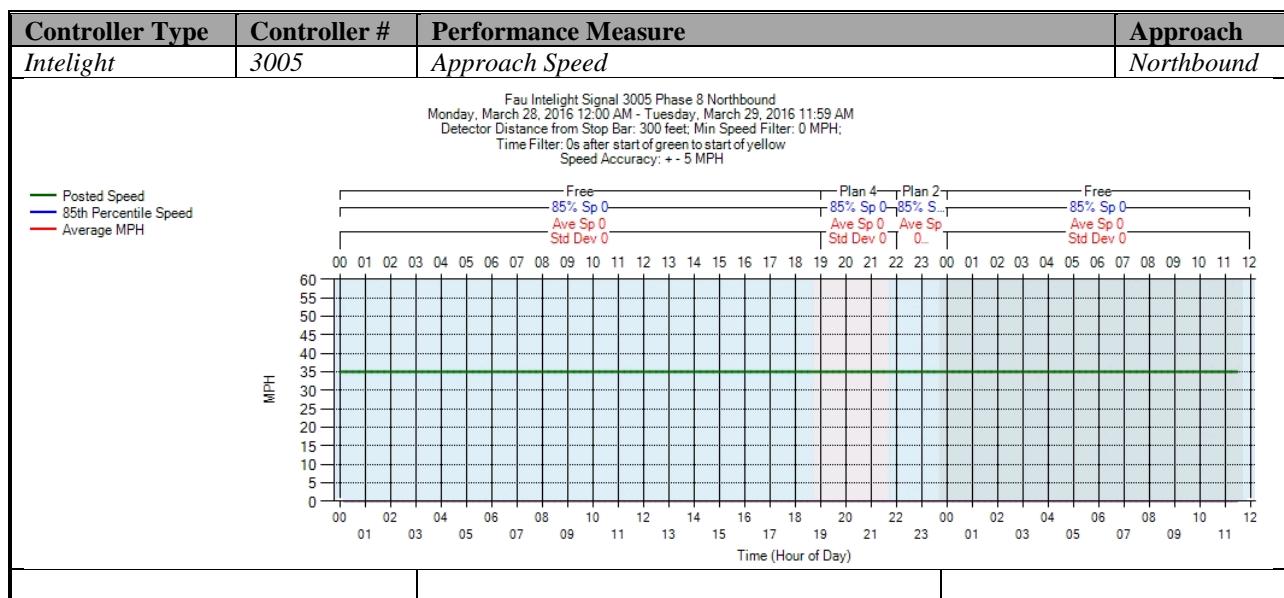


Figure A-157. Intelight – Approach Speed – NB

j) Split Monitor – Intelight

(C:\Installs\Deeptistuff\SPMWebFiles\SPMWebFiles\SPMSourceFiles\v3.2Deepti\Signal Timing Diagrams)

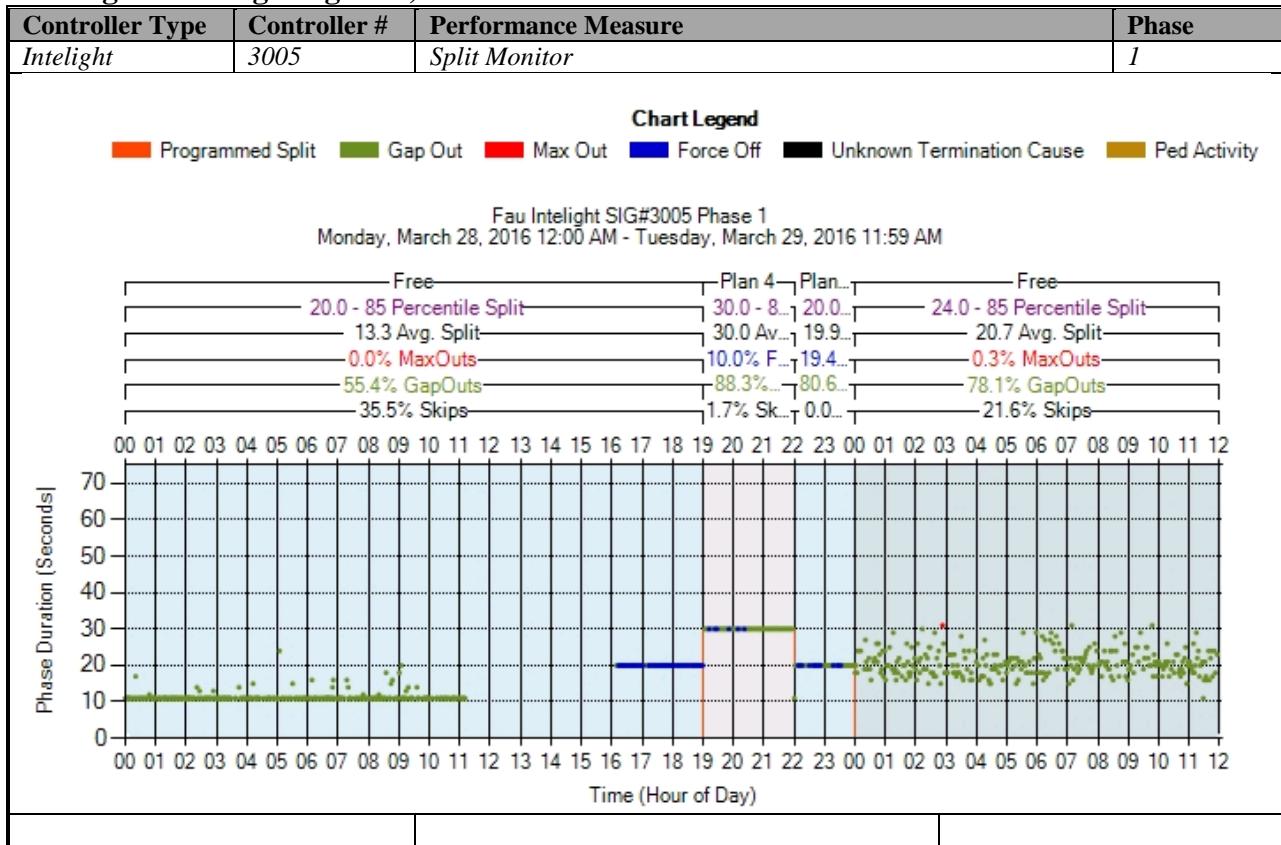


Figure A-158. Intelight – Split Monitor – Phase 1

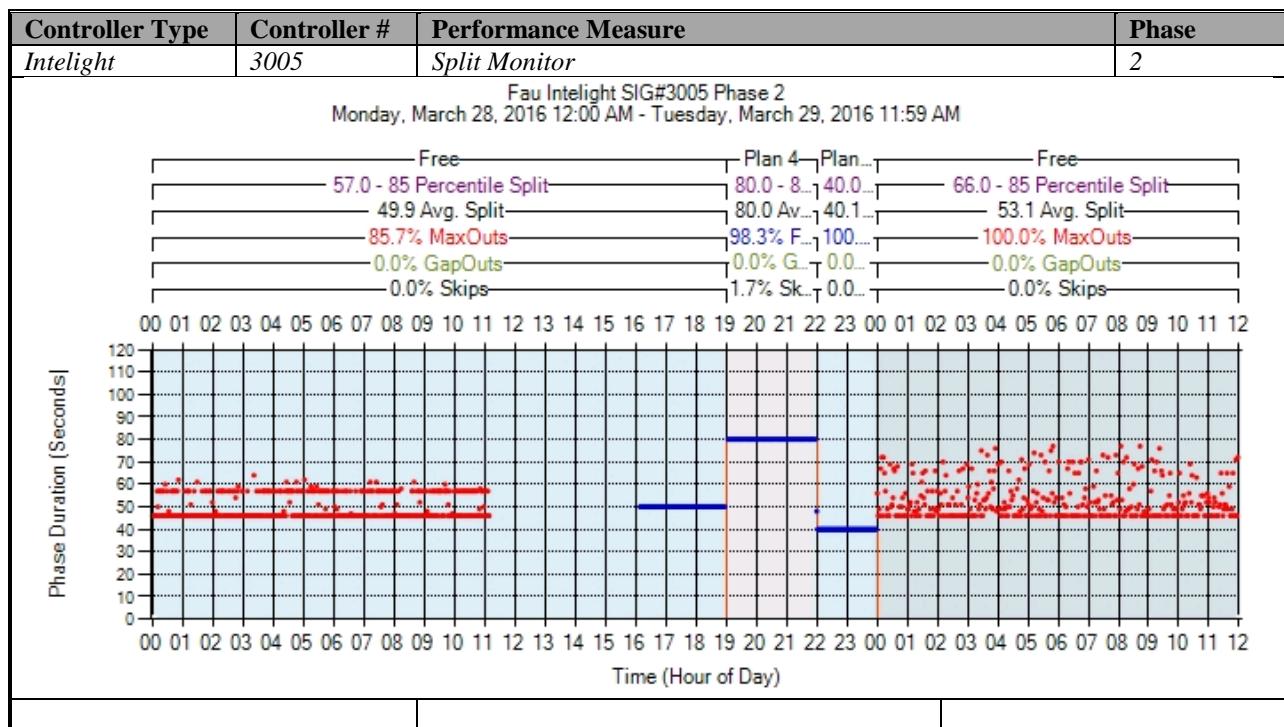


Figure A-159. Intelight – Split Monitor – Phase 2

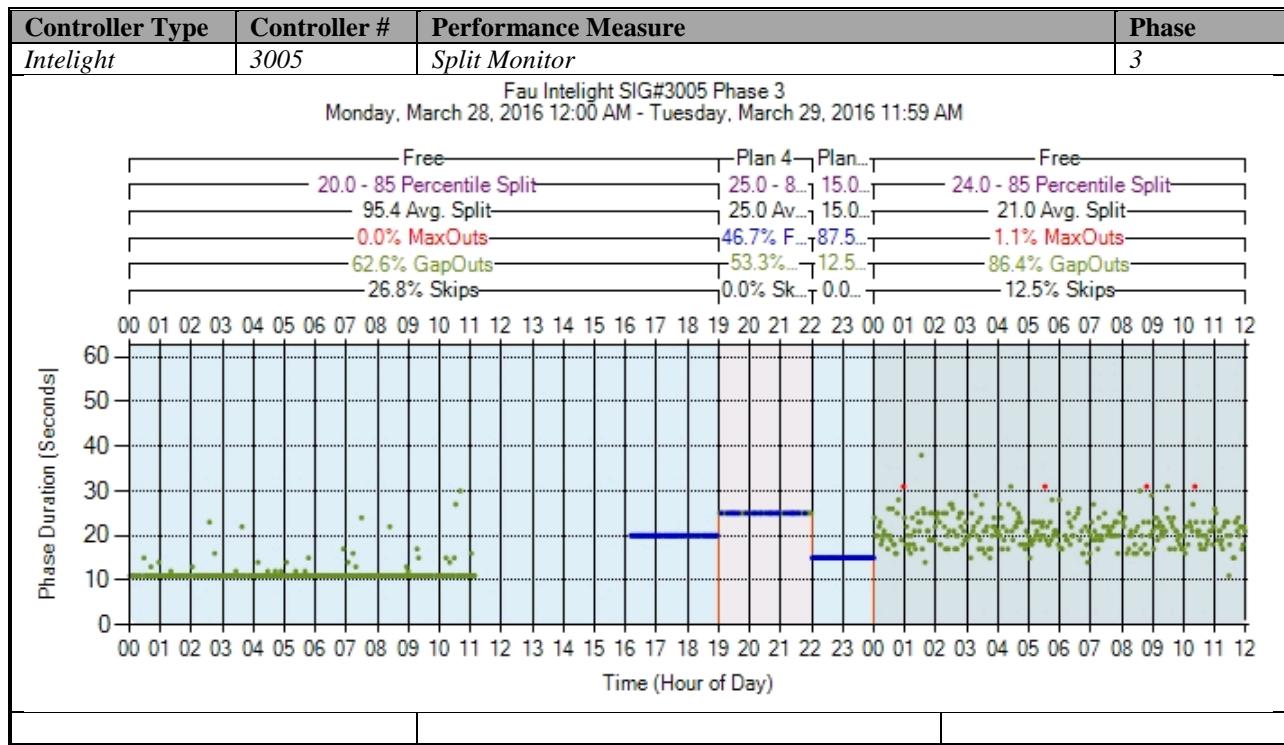


Figure A-160. Intelight – Split Monitor – Phase 3

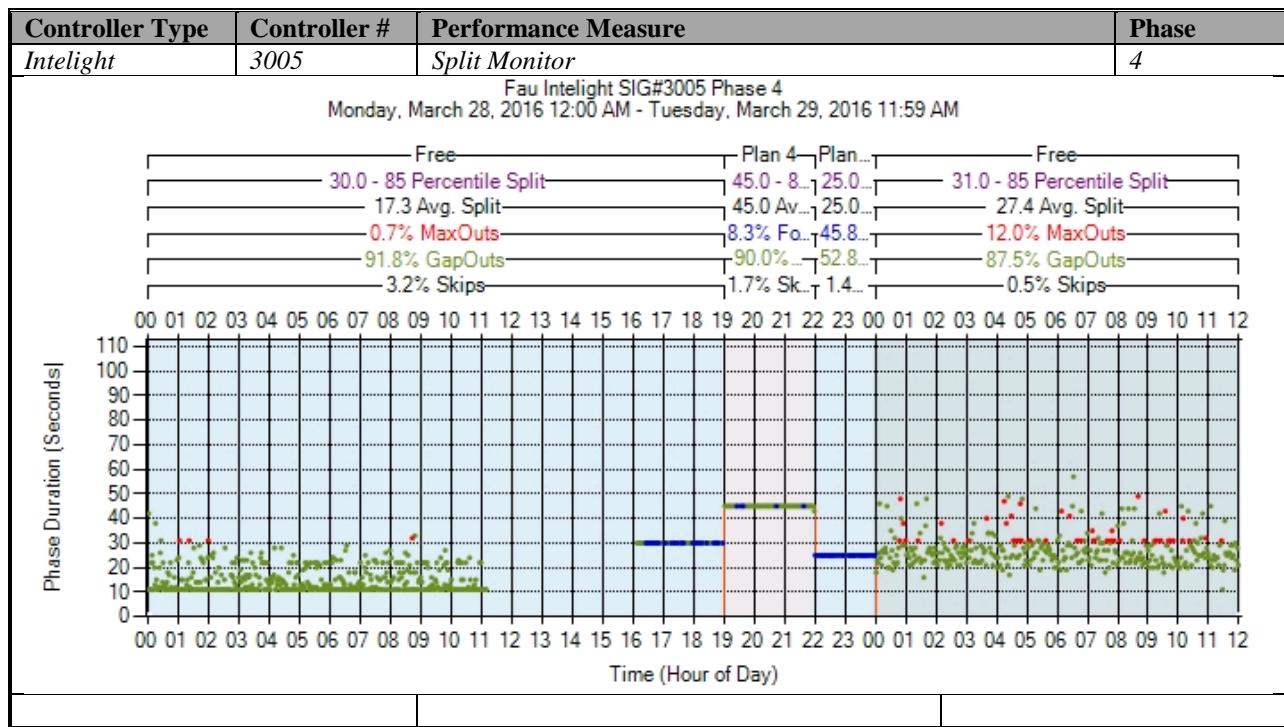


Figure A-161. Intelight – Split Monitor – Phase 4

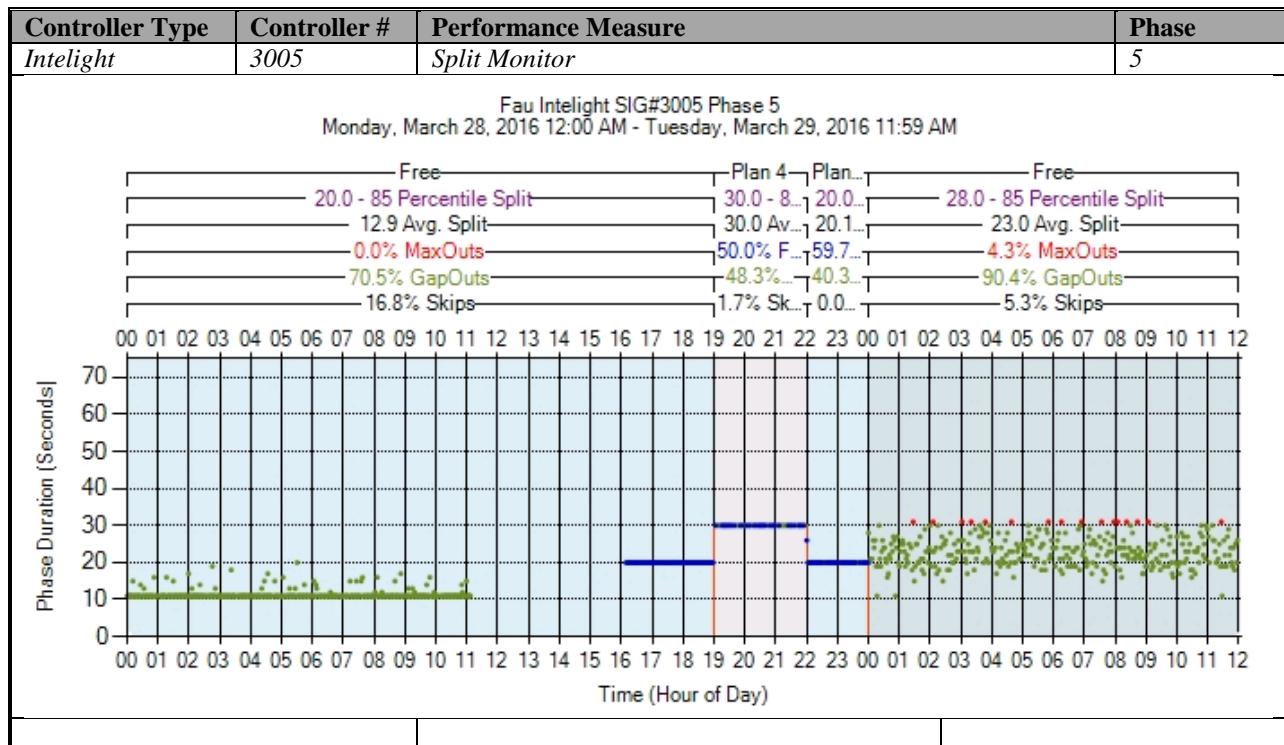


Figure A-162. Intelight – Split Monitor – Phase 5

Controller Type	Controller #	Performance Measure	Phase																								
Intelight	3005	<i>Split Monitor</i>	6																								
Fau Intelight SIG#3005 Phase 6 Monday, March 28, 2016 12:00 AM - Tuesday, March 29, 2016 11:59 AM																											
<p>The chart displays Phase Duration (Seconds) on the Y-axis (0 to 120) against Time (Hour of Day) on the X-axis (00 to 12). A red horizontal line at approximately 48 seconds represents the baseline. Blue horizontal bars indicate the duration of each phase. A light blue shaded area covers hours 00-18. A vertical orange line at hour 19 marks a transition. The duration for hours 19-23 increases to about 80 seconds, and for hours 00-04 it increases to about 50 seconds. Red dots represent individual data points.</p>																											
<table border="1"> <thead> <tr> <th>Free</th> <th>Plan 4</th> <th>Plan</th> <th>Free</th> </tr> </thead> <tbody> <tr> <td>50.0 - 85 Percentile Split</td> <td>80.0 - 8...</td> <td>40.0...</td> <td>49.0 - 85 Percentile Split</td> </tr> <tr> <td>47.8 Avg. Split</td> <td>80.0 Av...</td> <td>39.9...</td> <td>47.7 Avg. Split</td> </tr> <tr> <td>85.7% MaxOuts</td> <td>98.3% F...</td> <td>100...</td> <td>99.7% MaxOuts</td> </tr> <tr> <td>0.0% GapOuts</td> <td>0.0% G...</td> <td>0.0...</td> <td>0.0% GapOuts</td> </tr> <tr> <td>0.0% Skips</td> <td>1.7% Sk...</td> <td>0.0...</td> <td>0.3% Skips</td> </tr> </tbody> </table>				Free	Plan 4	Plan	Free	50.0 - 85 Percentile Split	80.0 - 8...	40.0...	49.0 - 85 Percentile Split	47.8 Avg. Split	80.0 Av...	39.9...	47.7 Avg. Split	85.7% MaxOuts	98.3% F...	100...	99.7% MaxOuts	0.0% GapOuts	0.0% G...	0.0...	0.0% GapOuts	0.0% Skips	1.7% Sk...	0.0...	0.3% Skips
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0.0% Skips	1.7% Sk...	0.0...	0.3% Skips																								

Figure A-163. Intelight – Split Monitor – Phase 6

Controller Type	Controller #	Performance Measure	Phase
Intelight	3005	<i>Split Monitor</i>	7

Fau Intelight SIG#3005 Phase 7
 Monday, March 28, 2016 12:00 AM - Tuesday, March 29, 2016 11:59 AM

Performance Metrics:

- Free: 20.0 - 85 Percentile Split, 107.6 Avg. Split, 0.2% MaxOuts, 54.7% GapOuts, 35.9% Skips
- Plan 4: 25.0 - 8.0, 25.0 Avg. Split, 31.7% F, 68.3%, 0.0% Skips
- Plan 10: 15.0, 15.0, 75.0, 25.0, 0.0
- Plan 11: 23.0 - 85 Percentile Split, 20.1 Avg. Split, 0.0% MaxOuts, 75.7% GapOuts, 24.3% Skips

Phase Duration (Seconds)

Time (Hour of Day)

Figure A-164. Intelight – Split Monitor – Phase 7

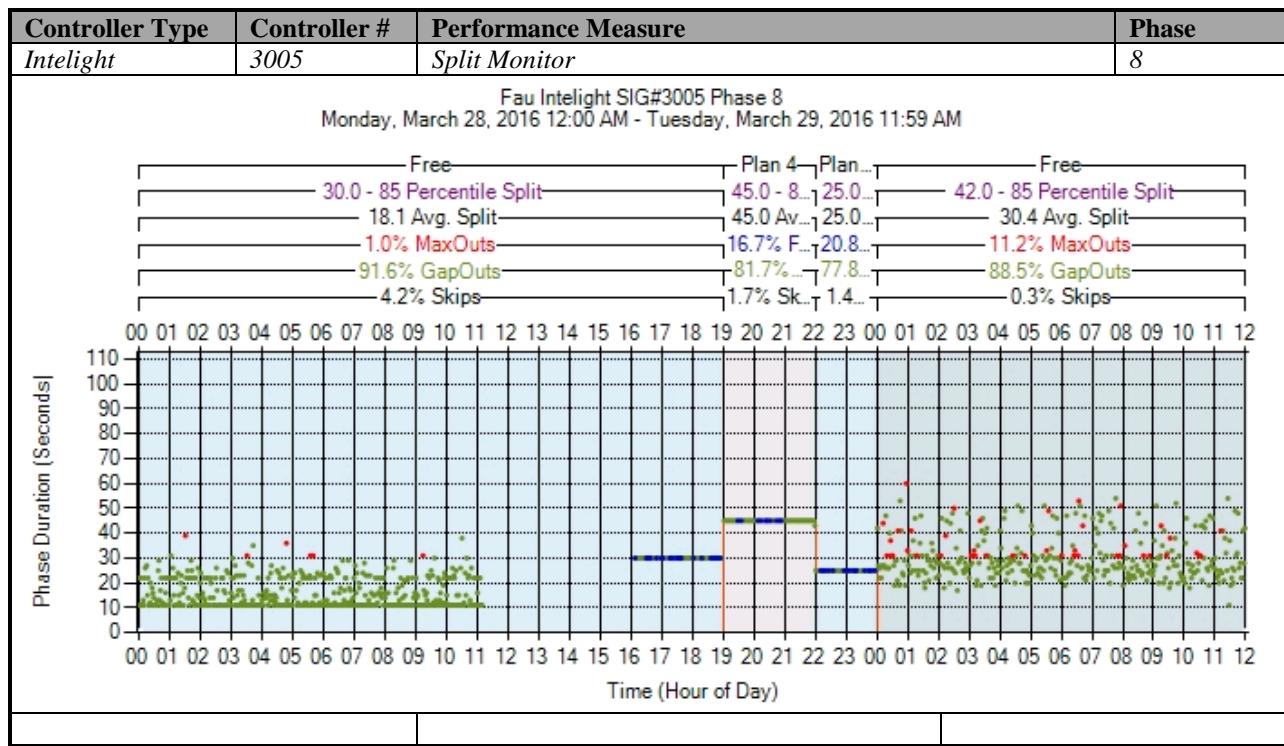


Figure A-165. Intelight – Split Monitor – Phase 8

k) Turning Movement Counts

No graphs – Need to add new detectors after the stop bar. To be accomplished later.

l) Yellow and Red Actuations

No graphs – Need to add new detectors in the intersection after the stop bar. To be accomplished later.

B Appendix: Multipoint Simultaneous Access of ASPMSS from Six Computers

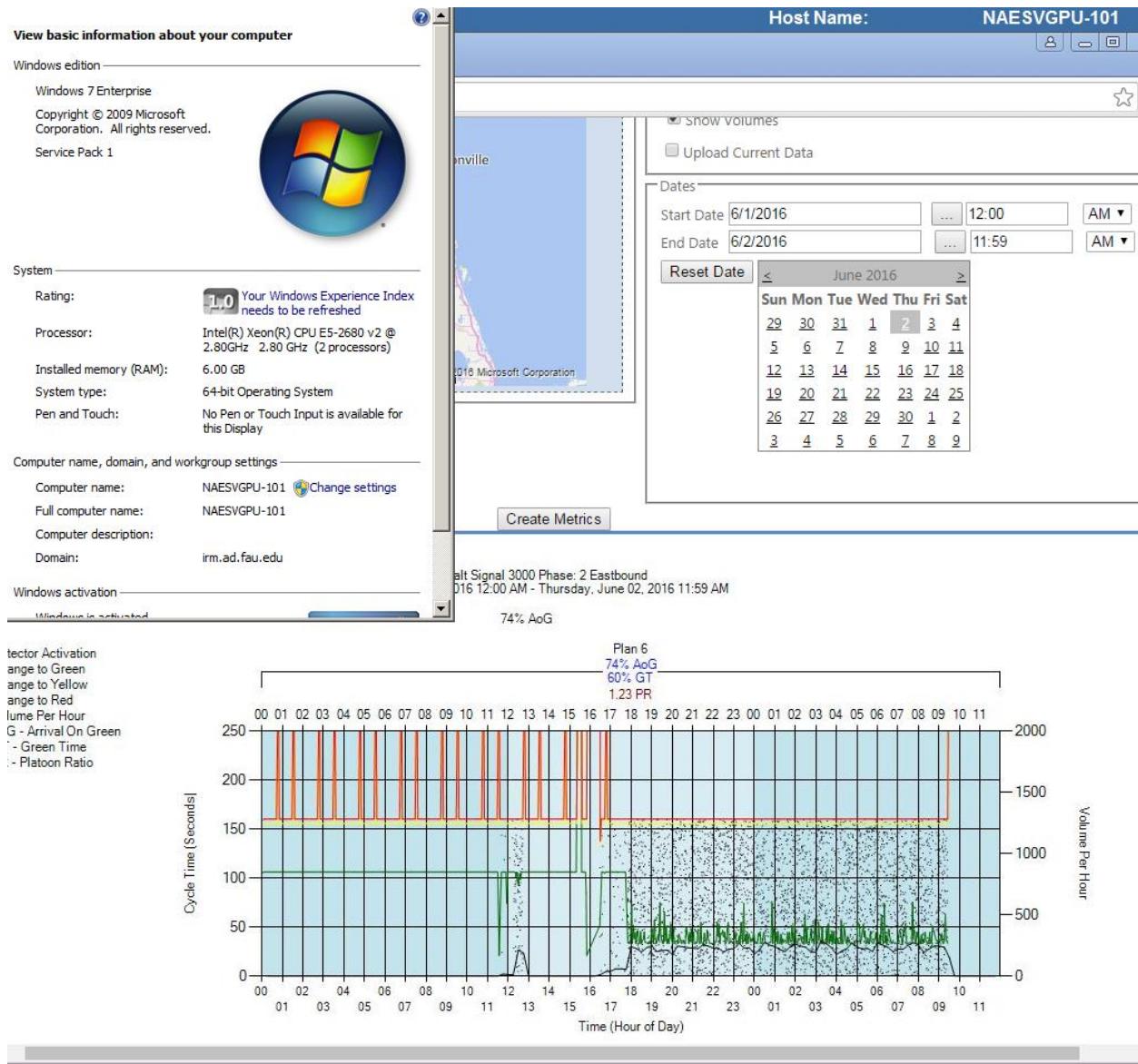


Figure B-1. Accessing FDOT SPM site from Station 1/Intersection 1 (ControllerID 3000)

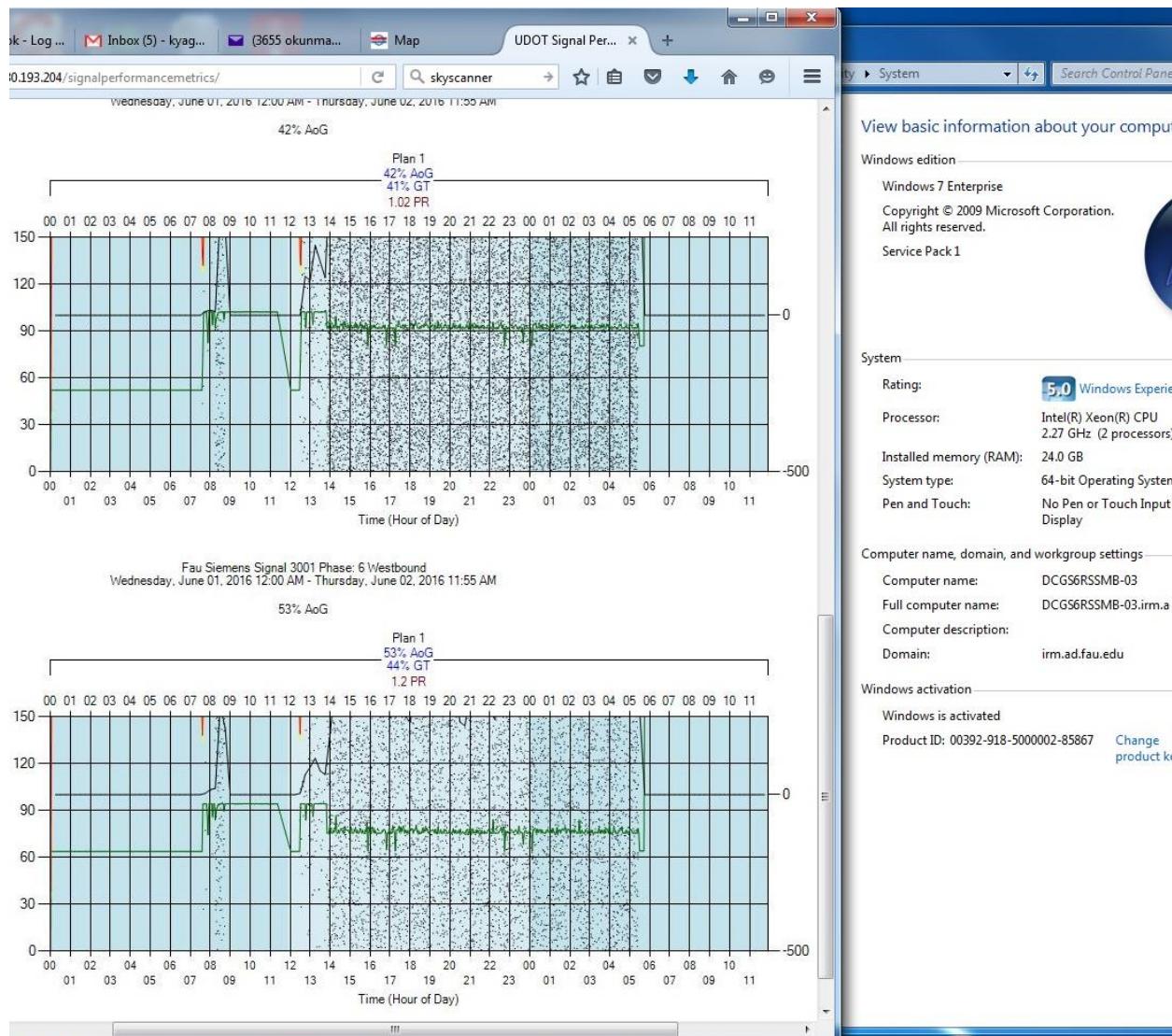


Figure B-2. Accessing FDOT SPM site from Station 2/Intersection 2 (ControllerID 3001)

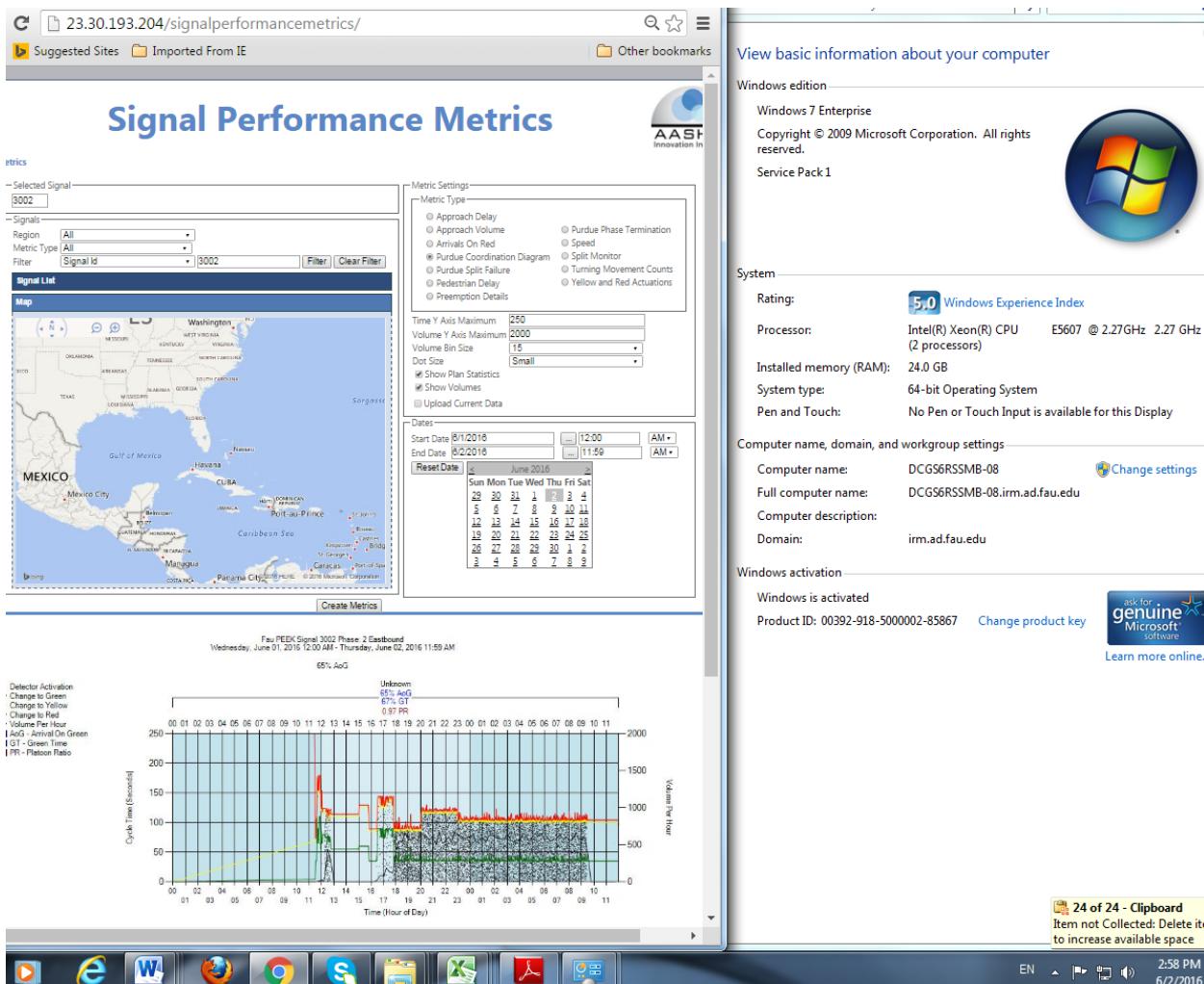


Figure B-3. Accessing FDOT SPM site from Station 3/Intersection 3 (ControllerID 3002)

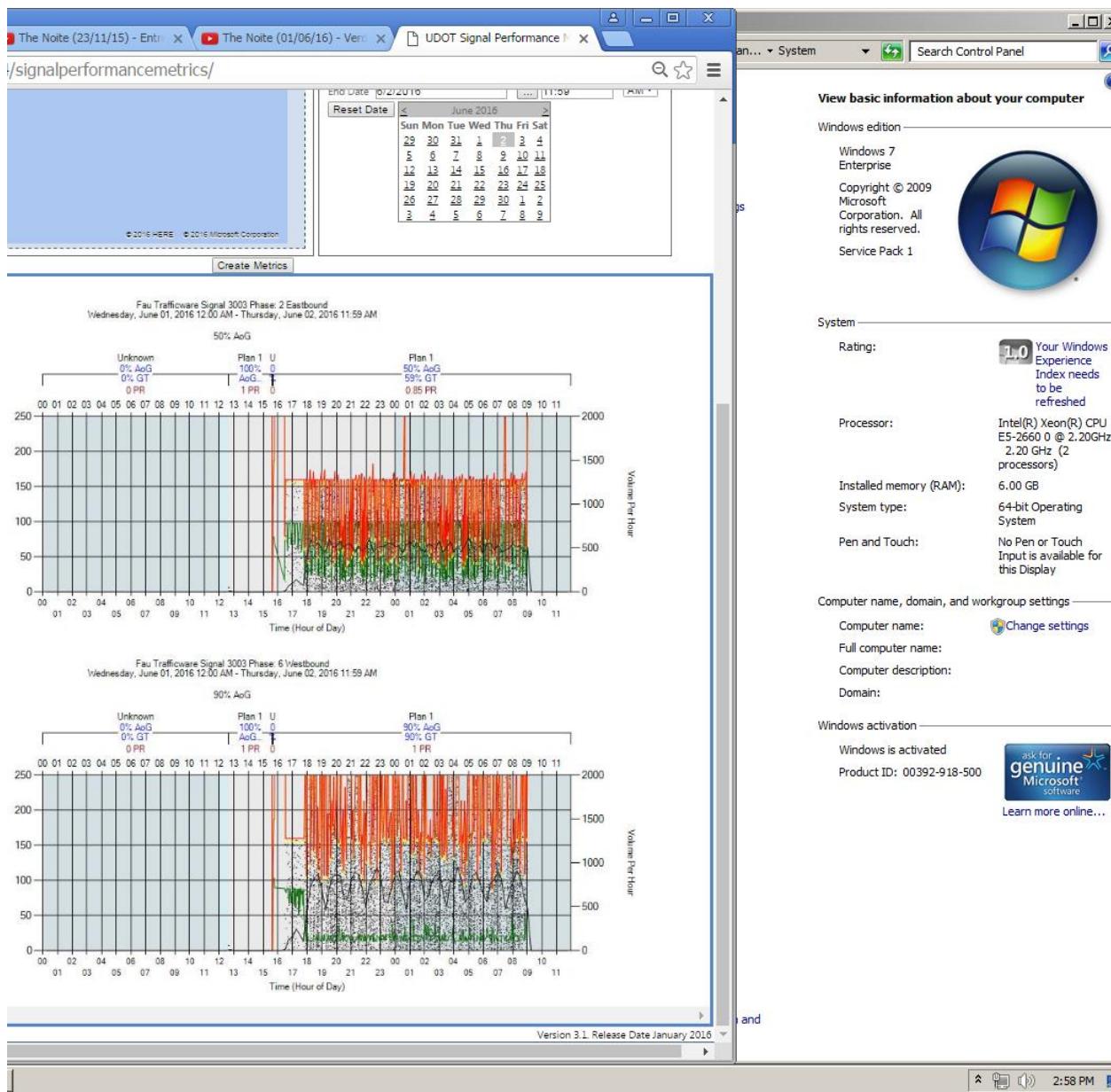


Figure B-4. Accessing FDOT SPM site from Station 4/Intersection 4 (ControllerID 3003)

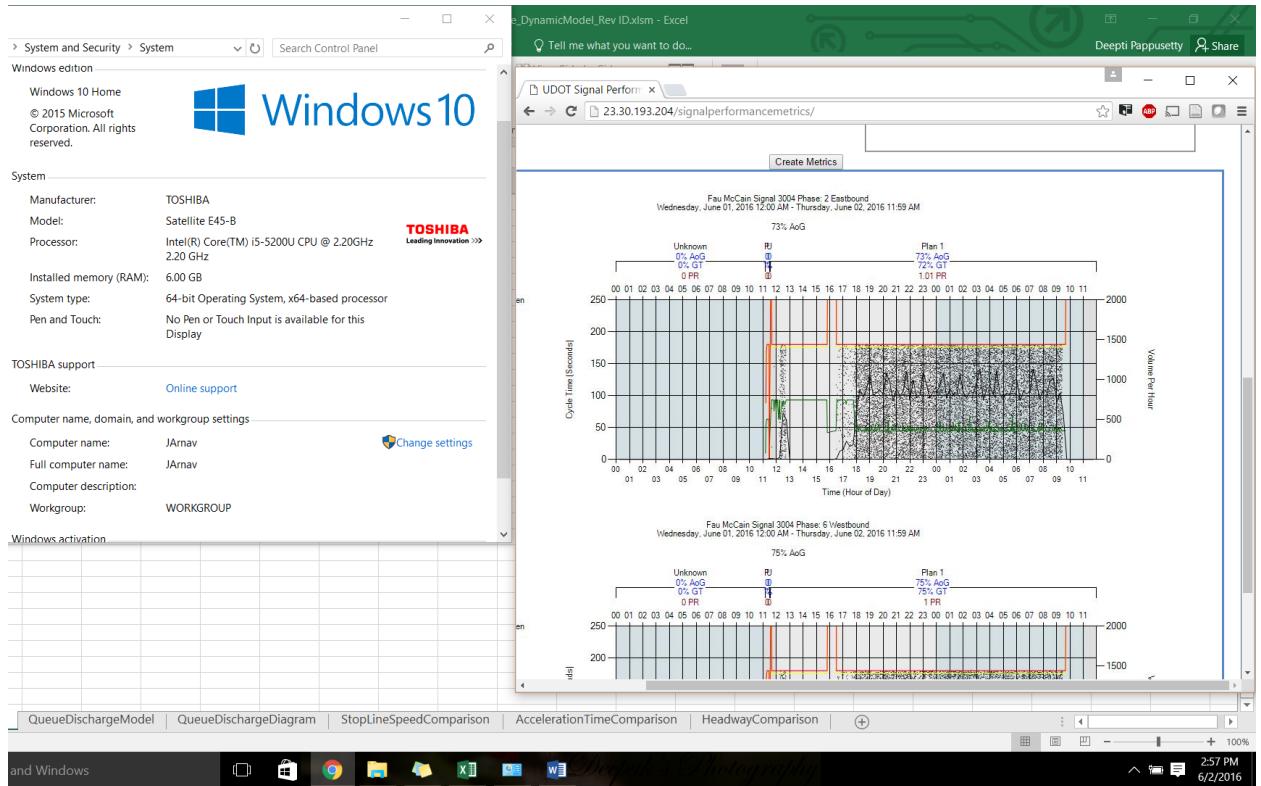


Figure B-5. Accessing FDOT SPM site from Station 5/Intersection 5 (ControllerID 3004)

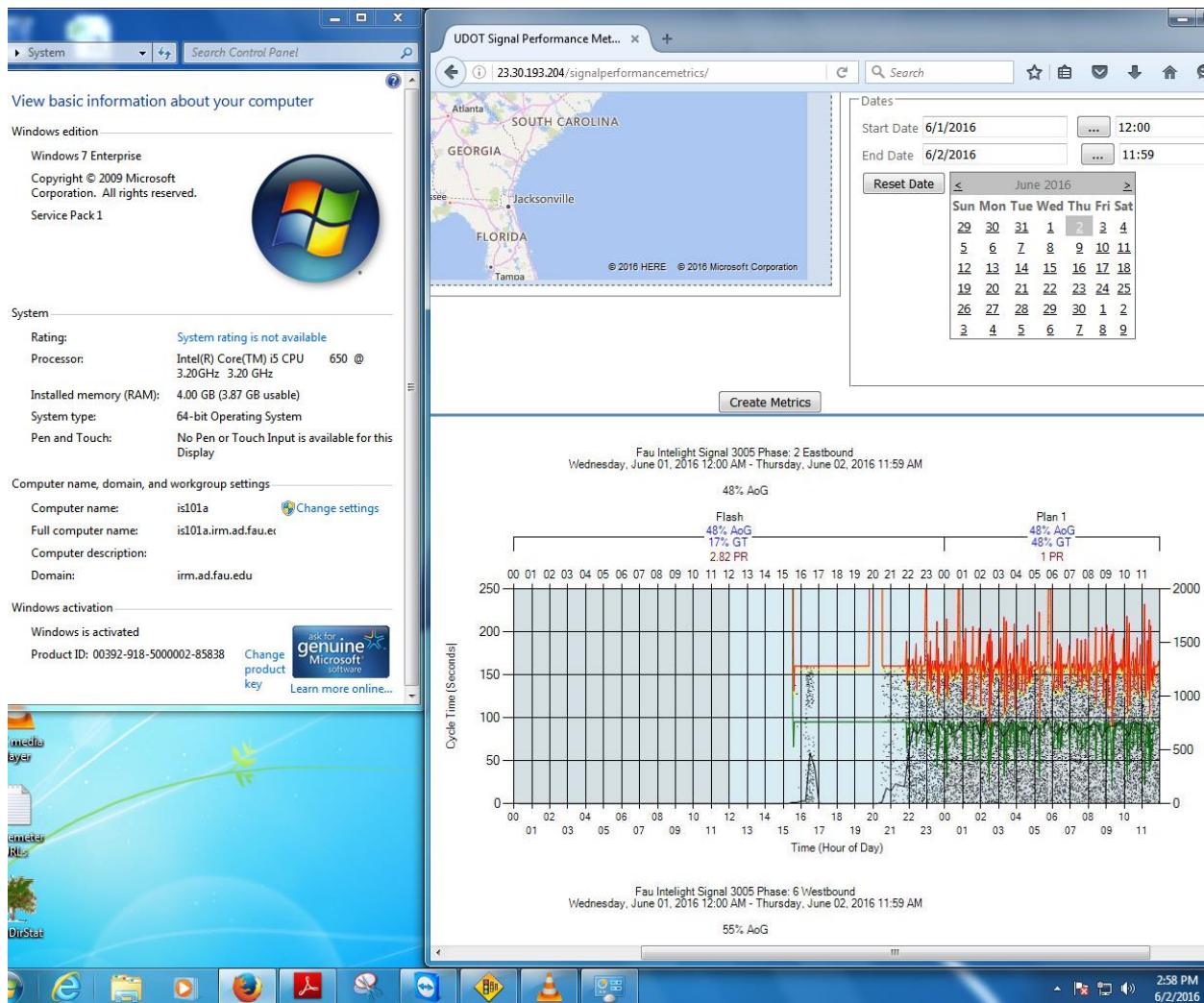


Figure B-6. Accessing FDOT SPM site from Station 6/Intersection 6 (ControllerID 3005)