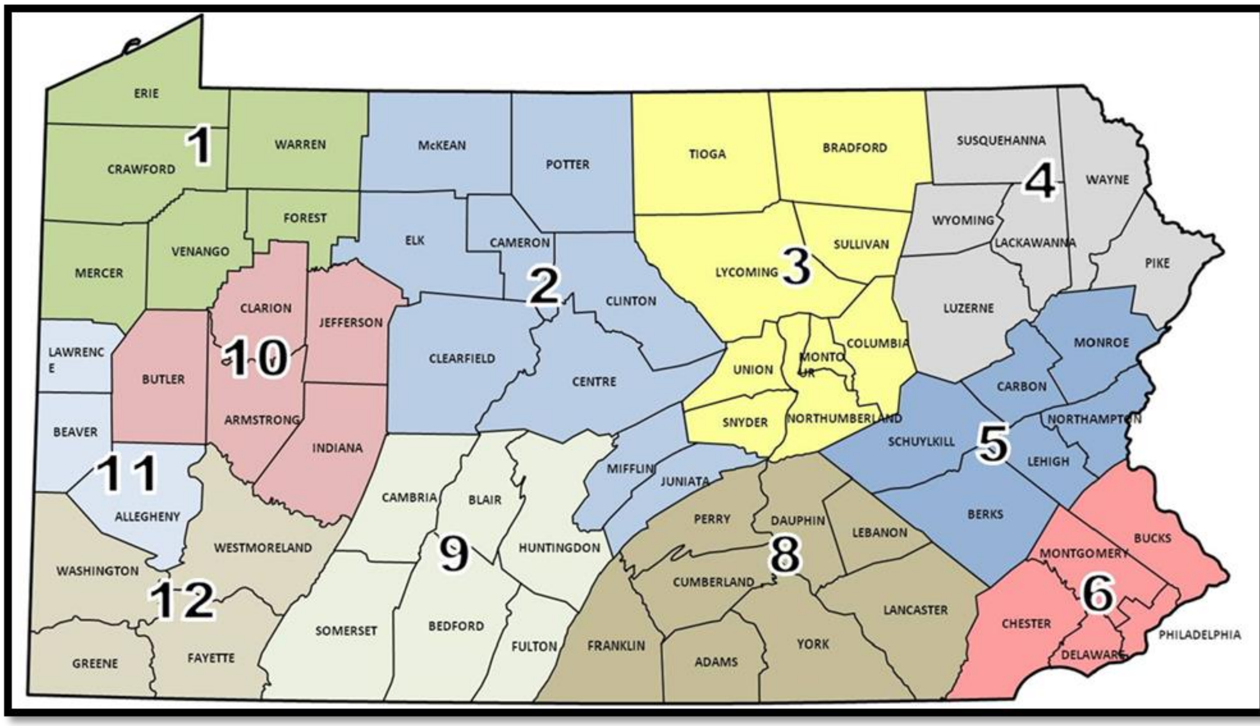
CHAPTER 1. INTRODUCTION

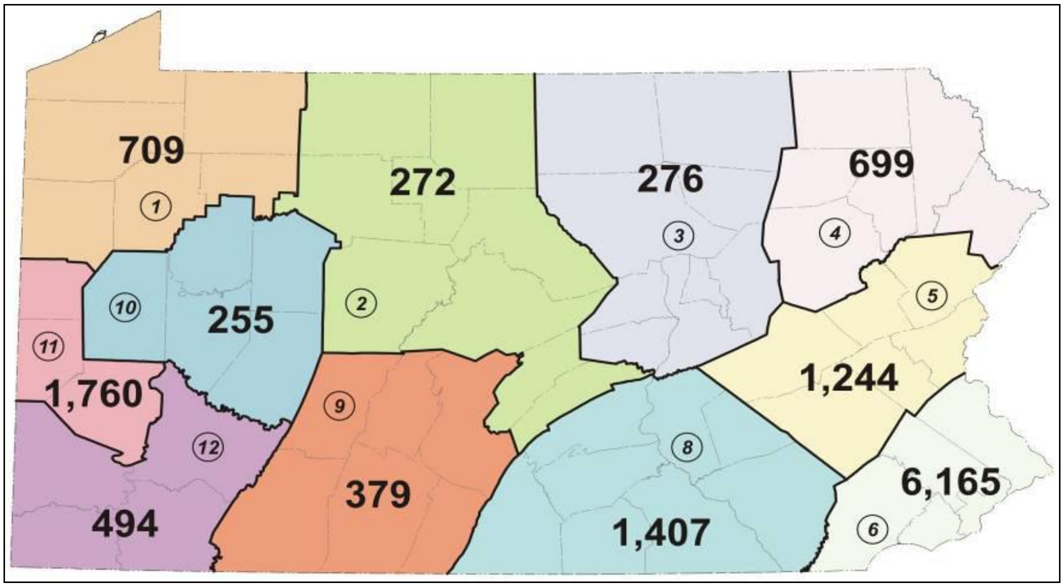
1.A District Contacts

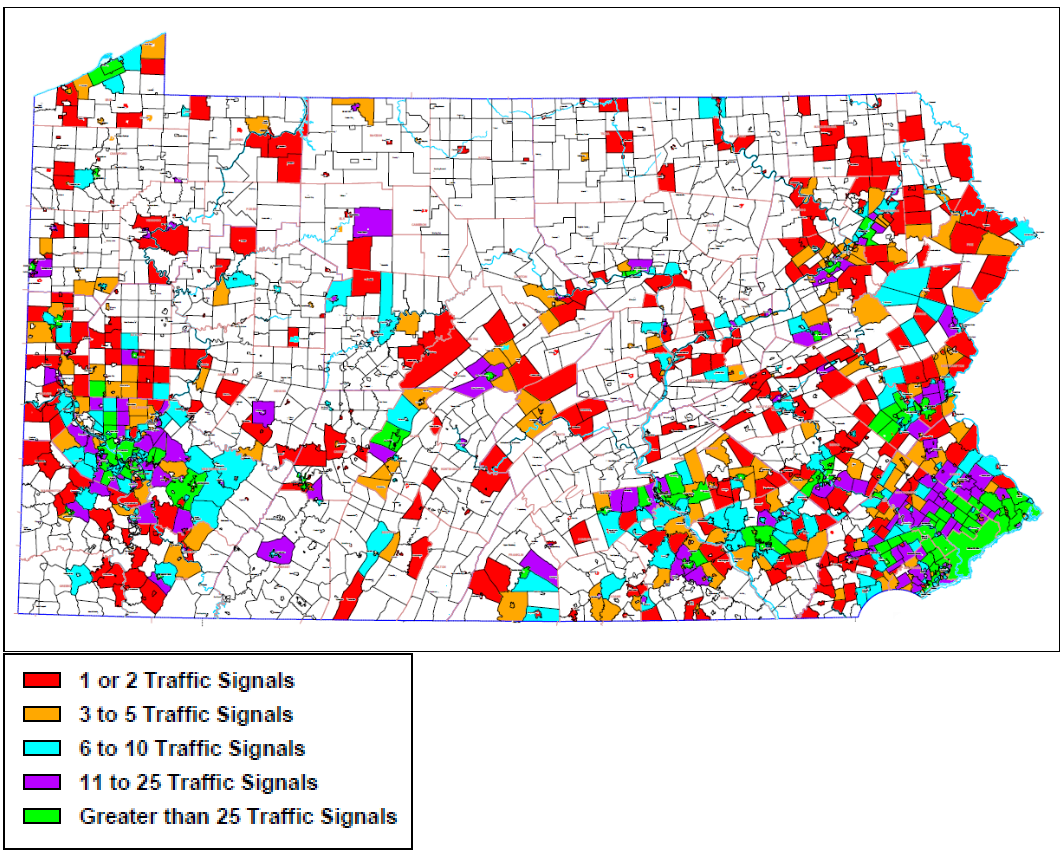


District	Current Contact Name	Email	Contact Number
1	Susan Roach	sroach@pa.gov	(814) 678-7177
2	Dennis Prestash	dprestash@pa.gov	(814) 765-0402
3	Lara Lapinski	llapinski@pa.gov	(570) 368-4250
4	Thomas Pichiarella	tpichiarel@pa.gov	(570) 963-3187
5	Christopher Surovy	csurovy@pa.gov	(610) 871-4478
6	Ashwin Patel	ashpatel@pa.gov	(610) 205-6567
8	Eric Kinard	ekinard@pa.gov	(717) 787-9237
9	Tony Tanzi	ttanzi@pa.gov	(814) 678-7177
10	Melissa McFeaters	mmcfeaters@pa.gov	(724) 357-2844
11	Ed Miller	edmille@pa.gov	(412) 429-4970
12	Nancy Kolenc	nkolenc@pa.gov	(724) 439-7268
Central Office	Daniel Farley	dfarley@pa.gov	(717) 783-0333

1.B Traffic Signals by District

The images shown below illustrates the number of traffic signals within the given district. This is discussed in more detail in Chapter 2 on Traffic Signal Maintenance.





1.C National Transportation System Report Card

The information in the Report Card are found at:

http://www.ite.org/reportcard/

- ✓ Municipal ownership in PA (one of 9 States)
- ✓ 14,000+ signals in PA (>5% of US total)
- ✓ 46% of PA's municipalities own a signal
  - 4% - More than 25 signals
  - 80% - 10 or less
  - 64% - 5 or less
  - 25% - 1
- ✓ $1 Billion asset
- ✓ National Score D+
- ✓ PA Score F

1.D Relationship of Maintenance and Operations

As shown in Section 1.B, there are thousands of traffic signals in the commonwealth. The timing and maintenance of these signals are the responsibility of the municipalities in which they are located. As a result, each municipality has an interest in traffic signal timing design, detection design, and traffic signal maintenance. This local control of signal operation and maintenance has resulted in differences in practice across the commonwealth. These differences may lead to operational inconsistencies and sub-optimal performance, which can increase delays and fuel consumption.

The course manual, slides and other materials focus on traffic signal maintenance and operations. These two functions (maintenance and operations) are closely interrelated. The operation of the traffic signal is only as good as the upkeep and maintenance of the signal. For instance, actuated control will allow a traffic signal to operate more efficiently. However, this actuated operation is only effective when the vehicle and pedestrian detection is maintained for proper performance. Therefore, this course will first discuss proper traffic signal maintenance and then traffic signal operations.

1.E Notes:

CHAPTER 2. TRAFFIC SIGNAL MAINTENANCE

2.A Chapter Presentation

Chapter 2 is dedicated to traffic signal maintenance. The chapter is laid out to follow the flow of Publication 191, "Guidelines for the Maintenance and Operation of Traffic Signals". The course will be presented in two formats based on the personnel category that will be reviewing the work. This will include the following

- ✓ Manager – Those involved in the planning, budgeting and management of maintenance activities.
- ✓ Signal Specialist – Those involved in performing maintenance activities.

The following table indicates the sections that are pertanant to the given personnel category.

● = indicates a section that is applicable to the personnel category

○ = indicates a section that is not applicable to the personnel category

⊙ = indicates a section that is not directly relevant to the personnel category, but should be reviewed

Section	Topic	Manager	Signal Specialist
2.1	Chapter References	●	⊙
2.2	Overview	●	⊙
2.3	Establishing a Traffic Signal Maintenance and Operation Program	●	○
2.4	Traffic Signal Maintenance Classifications	●	●
2.5	Documentation	●	●
2.6	Maintenance Activities	⊙	●
2.7	Traffic Signal Retiming and Equipment Upgrade Activities	⊙	●
2.8	Traffic Signal Maintenance Agreements	●	○
2.9	Municipal Service Purchase Contracts	●	○
2.10	Design Modifications	●	○
2.11	Maintenance Contracts/Agreements	●	○
2.12	Multi-Municipal Agreements	●	○

2.B Traffic Control Device Record Keeping (Asset Management)

The US Department of Transportation ***Asset Management Primer*** defines asset management as follows:

> "Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning."

PennDOT is in the process to develop a statewide Traffic Signal Asset Management System (TSAMS) to standardize, centralize, and automate how traffic signals are documented within Pennsylvania. The State Transportation Advisory Committee's (TAC's) report entitled Pennsylvania Traffic Signal Systems: a Review of Policies and Practices, dated January 27, 2005, indicated the long term benefits of a TSAMS solution to all traffic signal stakeholders. This study, along with TAC's report entitled Congestion Mitigation and Smart Transportation Study, dated May 2009 identified a TSAMS solution needs to be established to accurately manage the asset.

Additionally, in June 2011 the PennDOT concluded an automations assessment of asset planning processes in six asset categories – Bridge, Pavement, Transit, Intelligent Transportation Systems (ITS) Devices, Retaining Walls, and Traffic Signals. Termed Linking Planning and National Environmental Policy Act (NEPA) – or LPN for short- this initiative included a requirements elicitation component wherein LPN Business Analysts (BA) captured As-Is processes and documented gaps between current and desired asset planning end-state for the prescribed asset categories.

Currently, PennDOT Engineering District representatives collect Traffic Signal data locally in homegrown Microsoft® Access® or Excel® applications, or as hard-copies. Districts collect data using the standard form TE699 – Traffic Signal Descriptions, but there are no current policies on what data elements to collect, retain, or update, resulting in dissimilar and outdated data. Current methodologies are deficient in many areas, including:

- ✓ Data collection, access, detail, accuracy, completeness and uniformity
- ✓ Performance measurement and determination of priorities
- ✓ Maintenance tracking and performance monitoring
- ✓ Reporting
- ✓ Centralized storage

As a result, PennDOT is moving toward a centralized data source that is accessible to all levels of user groups including Central Office, Engineering Districts, Federal Highway Administration, Municipalities, Planning Partners, Consultants, Contractors, Suppliers, and the public.

2.C Warranties and User Manuals

Warranty documentation and product user manuals should be readily available. These will be useful for signal technicians when troubleshooting items.

2.D Troubleshooting

2.D.1 Study the Intersection

Troubleshooting a traffic controller assembly malfunction requires a logical and efficient approach. Since any malfunction can have a variety of causes, it is important to proceed methodically. Don't be tempted to start randomly changing devices or checking for loose connections.

It is not possible to begin troubleshooting without a clear idea of the intersection configuration and phase assignments. Study the intersection before proceeding further.

2.D.2 Study the Traffic Controller Assembly

Take a few moments to study the traffic controller assembly. Make note of all the installed devices. See if advanced warning and/or pre-emption are used.

Depending on the intersection configuration, it may be necessary to familiarize yourself with the intersection and cabinet electrical drawings and timing sheets.

2.D.3 Define the Problem

Take time to examine the controller unit and conflict monitor displays and/or message logs. These displays will indicate the state of the traffic controller assembly at the time the fault occurred.

Check the input modifier cards and load switch indicators to confirm the status indicated by the controller unit and conflict monitor.

These observations will help to identify the areas of the traffic controller assembly where the fault may have occurred.

2.D.4 Locate the Fault

When the general location has been identified, use your knowledge of the standard device assignments and/or the electrical drawings to perform a check of the faulty circuit.

Once again, it is important to remain focused and to proceed in a logical, step-by-step manner.

Be sure to perform a thorough operational check of the traffic controller assembly after making any repairs If the problem still exists after you have finished making repairs, carefully recheck your steps before proceeding further.

2.D.5 Documentation

One of the most important troubleshooting steps is documentation. Be sure to fill out a log of your activities. This information will be important to the next person who works on the traffic controller assembly.

Keep a central database of all corrective maintenance activities. This assists other personnel in their troubleshooting efforts and helps to identify and eliminate chronic problems.

2.E Notes:

CHAPTER 3. DATA COLLECTION

3.A Notes:

CHAPTER 4. LOCAL INTERSECTION CONCEPTS

4.A Notes:

CHAPTER 5. LOCAL INTERSECTION TIMING

5.A Notes:

CHAPTER 6. COORDINATION CONCEPTS

6.A Notes:

CHAPTER 7. PREEMPTION AND PRIORITY CONTROL

7.A Notes:

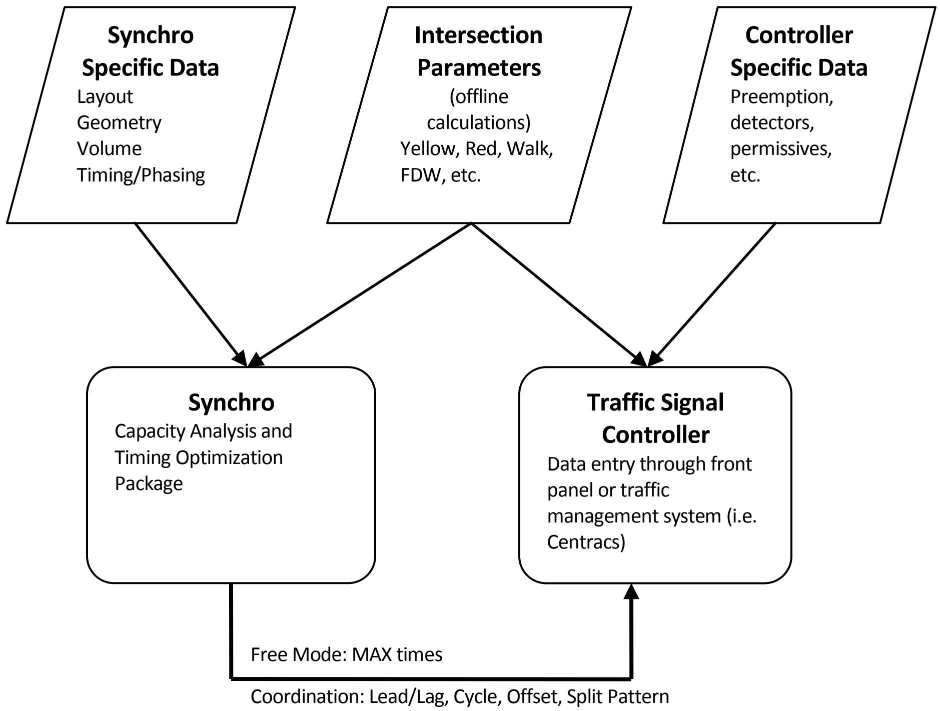
CHAPTER 8. TRAFFIC MODEL CALIBRATION

8.A Notes:

CHAPTER 9. TIMING PLAN IMPLEMENTATION AND EVALUATION

9.A Relationship Between Intersection Data, Synchro, and Controller

The graphic that follows illustrates the integration of data needs between Synchro and the controller. Some data is specific to Synchro, some data specific to the controller, and a body of parameters/data that will be used by both Synchro and the controller.



9.B Typical Synchro Output for a Single Intersection

The image illustrated below is the Synchro "Phases: Timings" report. This report includes a wide variety of data, some which is not needed for your controller. In addition, some of the data values are calculated "off-line" and are inputs into Synchro and the controller (see the previous graphic). A brief explanation of each of these data items is described in the table following this figure.

Sample Synchro Phases: Timings Report

See definition below for each line item from the Synchro print-out

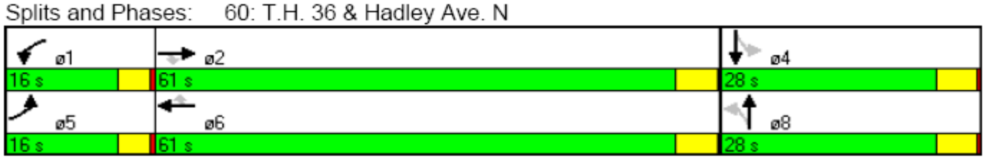
Timing Report, Sorted By Phase
60: T.H. 36 & Hadley Ave. N 5/10/2004

#								
1	Phase Number	1	2	4	5	6	8	
2	Movement	WBL	EBT	SBTL	EBL	WBT	NBTL	
3	Lead/Lag	Lead	Lag		Lead	Lag		Synchro Output, Input to Controller
4	Lead-Lag Optimize	Yes	Yes		Yes	Yes		
5	Recall Mode	None	None	None	None	None	None	
6	Maximum Split (s)	16	61	28	16	61	28	Synchro Output, Input to Controller (sec)
7	Maximum Split (%)	15.2%	58.1%	26.7%	15.2%	58.1%	26.7%	Synchro Output, Input to Controller (%)
8	Minimum Split (s)	15	30	21	15	30	21	
9	Yellow Time (s)	3.5	4.5	4.5	3.5	4.5	4.5	
10	All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	
11	Minimum Initial (s)	5	5	5	5	5	5	
12	Vehicle Extension (s)	3	5	3	3	5	3	
13	Minimum Gap (s)	3	3	3	3	3	3	
14	Time Before Reduce (s)	0	30	0	0	30	0	
15	Time To Reduce (s)	0	20	0	0	20	0	
16	Walk Time (s)		5	5		5	5	
17	Flash Dont Walk (s)		11	11		11	11	
18	Dual Entry	No	Yes	Yes	No	Yes	Yes	
19	Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	
20	Start Time (s)	0	16	77	0	16	77	
21	End Time (s)	16	77	0	16	77	0	
22	Yield/Force Off (s)	12	72	100	12	72	100	
23	Yield/Force Off 170(s)	12	61	89	12	61	89	
24	Local Start Time (s)	89	0	61	89	0	61	Synchro Output, Input to Controller (170)
25	Local Yield (s)	101	56	84	101	56	84	
26	Local Yield 170(s)	101	45	73	101	45	73	

#	Intersection Summary		
27	Cycle Length	105	Synchro Output, Input to Controller
28	Control Type	Actuated-Uncoordinated	
29	Natural Cycle	75	

Offset Not shown - Synchro Output

30 Splits and Phases: 60: T.H. 36 & Hadley Ave. N



Line No.	Description
1.	Phase Number is the number assigned to the movement. In Synchro, use the same number that you would use within the controller.
2.	Movement is simply the movement direction assigned to the Phase Number. In Synchro, NB is always up. In the controller, this information can be assigned in the Phases in Use.
3.	Lead/Lag is an input and output feature of Synchro. This setting can be changed to test your current lead/lag left turn treatments. During an optimization, this can be tested for optimal conditions and will serve as an input into the controller. The Lead/Lag phases may change over the course of the day, week or year. The method to change from lead to lag (and visa versa) will be discussed in the sections that follow.
4.	Lead-Lag Optimize is a user defined feature used during the optimization process of Synchro. If it is desired to look at leading and lagging lefts during optimization, this can be set to Yes, Fixed if fixed as the set value. Take caution not to use lead/lag lefts with protected/permissive signals.
5.	Recall Mode defines the type of recall used in the Synchro analysis. This is a setting that is determined by the user, and not by Synchro.
6.	Maximum Split (s) is the split value in seconds. In Synchro, this will be the optimal split after an optimization. If the controller is set to Actuated-Coordinated, this will be the split used for the appropriate Pattern data.
7.	Maximum Split (%)is the same value as above, but shown in percent. In the controller, the user defines whether to enter data in splits or percent.
8.	Minimum Split is a value that is ONLY used in your Synchro analysis. This value is not set in the controller. During the optimization process in Synchro, the Maximum Split will not be allowed to go below this value.
9.	Yellow Time is an input value into Synchro. This value is calculated off-line prior to analysis in Synchro or input into the controller.
10.	Red Time is an input value into Synchro. This value is calculated off-line prior to analysis in Synchro or input into the controller.
11.	In Synchro, the Minimum Initial is the minimum green that the phase will show. The controller may use a different feature, such as minimum green, extensible green, etc.
12.	The Vehicle Extension value in Synchro is calculated off-line. This may be referred to as the passage time, gap time or vehicle extension.
13.	Minimum Gap is an off-line value that is an input into Synchro. This is a value for volume density gap reduction.
14.	The Time Before Reduce is used for volume density gap reduction. It is determined off-line and is an input into Synchro and the controller.
15.	Time to Reduce is used for volume density gap reduction. It is determined off-line and is an input into Synchro and the controller.
16.	Walk Time is an input value into Synchro. This value is calculated off-line prior to analysis in Synchro or input into the controller.

Line No.	Description
17.	**Flash Don't Walk Time is an input value into Synchro. This value is calculated off-line prior to analysis in Synchro or input into the controller.**
18.	**Dual Entry is an input value into Synchro and the controller. If set, this phase appears when a phase is showing in another ring and no calls or recalls are present within this ring and barrier.**
19.	**Inhibit Max in Synchro is an input used within Synchro for Actuated-Coordinated systems. When Yes, a non coordinated phase can show more than its maximum time when it starts early. The Maximum value used in Synchro is the Maximum Split.**
20.	**Start Time is a Synchro output term used to define the beginning of green referenced to the local clock. It is not an input in the controller.**
21.	**End Time is a Synchro output term used to define the end of green referenced to the local clock. It is not an input in the controller.**
22.	**Yield/Force Off Is the phase yield or force-off time, referenced to the system clock, beginning of yellow. It is not an input in the controller.**
23.	**Yield/Force Off 170 Is the phase yield or force-off time, referenced to the system clock, beginning of flashing don't walk. It is not an input in the controller and used for 170 style controllers.**
24.	**Local Start Time is the same values as above except referenced to the local offset point. It is not an input in the controller.**
25.	**Local Yield is the same values as above except referenced to the local offset point. It is not an input in the controller.**
26.	**Local Yield 170 is the same values as above except referenced to the local offset point. It is not an input in the controller.**
27.	**The Cycle Length in Synchro will be the optimal cycle after an optimization. If the controller is set to Actuated-Coordinated, this will be the split used for the appropriate Pattern data.**
28.	**Controller Type is the type of controller being analyzed by Synchro. This is not an input into the controller, but is determined by other settings within the controller.**
29.	**Natural Cycle is an output value simply used by Synchro and is not a controller input.**
30.	**Splits and Phases diagram graphically illustrates the phases, movements and split times.**
31.	**Offset (not shown) is used for Coordinated systems. The offset, reference point, reference phases and actual offset are displayed. The offset is given in seconds and percent. In the controller, this is set in the pattern data**

It is worth noting again that Synchro analysis evaluates a specific period of time with a specific set of parameters (i.e. the previous Synchro timing report lists a single MAX split time). MAX 2 and MAX3 times can be developed using Synchro or other software tool.