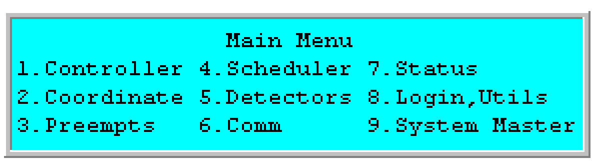
Operations Manual

For

2070/ATC Closed Loop Systems

Version 65.x – 2070 FMS Master
Version 76.x – 2070/ATC FMS Master



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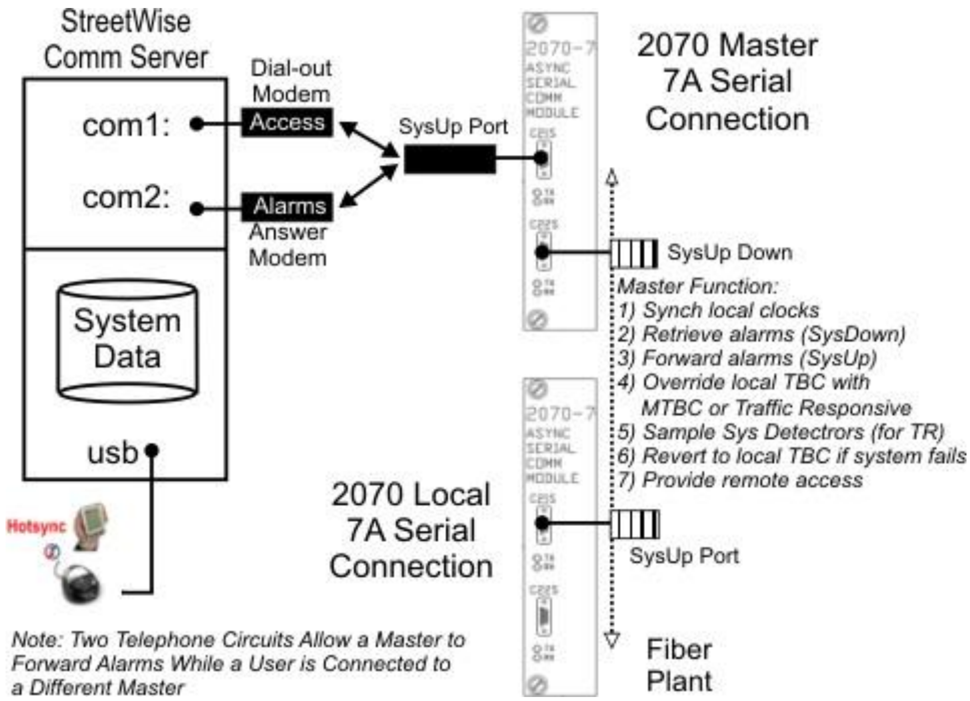
1 Introduction to Field Management Stations

Distributed traffic control systems share data communication and supervisory control between a central ATMS, *Field Management Stations* (FMS) and one or more secondary controllers supervised by each FMS. This architecture was formerly called closed loop operation utilizing field masters with dedicated point-to-point data communication paths to define the signal system network. Cubic | Trafficware, Inc. is participating in the development of NTCIP 1210 Field Management Stations (FMS). This emerging ITS standard not only defines control objects and protocols for closed loop systems, but will provide the backbone communication for a number of ITS architectures that share a common TCP/IP data network.

Cubic | Trafficware, has produced closed loop masters for NEMA TS1 and TS2 platforms since the late 1980's and a current manual is available for the Model 981 TS2 master. However, a separate manual will be maintained to document the development of NTCIP 1210 on the 2070/ATC platform until NTCIP 1210 is ported to the TS2 FMS.

1.1 The Cubic | Trafficware Closed Loop System

A Cubic | Trafficware closed loop system interconnects a TS2 981, 2070 or ATC master with up to 32 secondary controllers. Communication is provided using an asynchronous (serial) data communications platform or an Ethernet platform. Asynchronous devices interface *System-Up* or *System-Down* or the internal FSK modem port as shown below and provide data rates from 600 to 57.6K baud. In addition, the 2070 supports TCP/IP data communications as per NTCIP 1210 allowing devices to communicate over an Ethernet based network.



1.2 Closed Loop Master / Sub-master System

The master software runs as a "central master" from the or as a "field master" resident in a local controller which serves as a secondary and a master controller. A separate hardware device is not required to host a field master. The master database is assigned a unique ID address within the ATMS which is unique from all other secondary Station ID addresses.

The ATMS maintains a database for the field master using the Master ID to upload/download changes to the local master. This database defines the master sub-system and various levels of control, including traffic responsive operation.

The *Master Parameter* (MM->9->1) configures the master to one of the following operating modes:

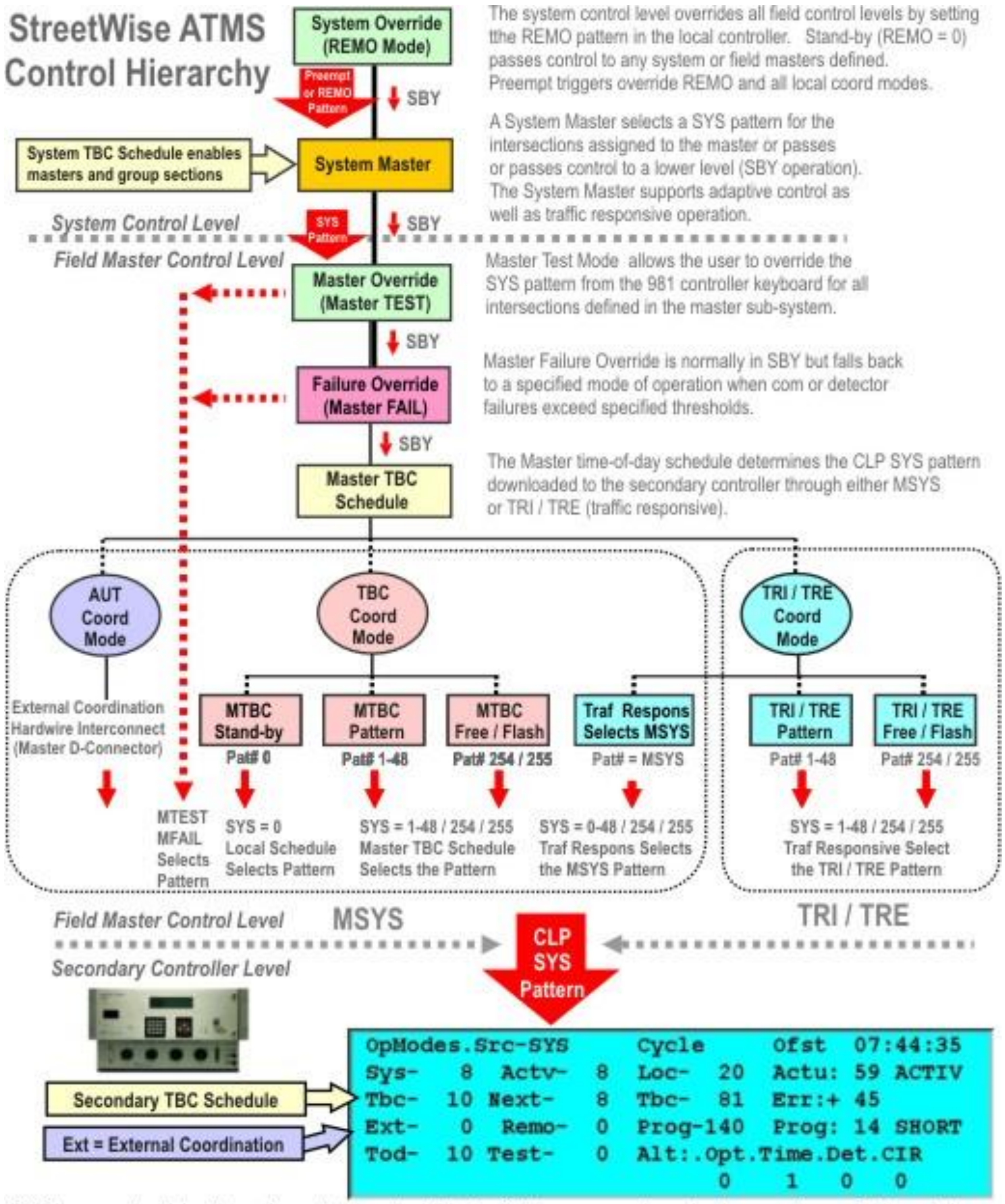
- LOCAL – The *Local* master forfeits all control over the secondary controllers in it's subsystem (communication hub only)
- MASTER – The *Master* provides supervisory control over the secondary controllers in defined in it's subsystem

Only one *Master* may be assigned to a the ATMS asynchronous communication channel; however, multiple masters may exist on the same Ethernet network. Each *Master* may communicate with a maximum of 32 secondary controllers assigned to its *Subsystem.*

1.3 Control Hierarchy in a Closed Loop System

The following *Control Hierarchy* describes the overall operation of ATMS ATMS and FMS devices within the system.

The NTCIP ***pattern*** is used to vary the operational of the local controller during free and coordinated operation. The active ***pattern*** in the controller may be set at the *System Control* Level, *FMS* Level or *Secondary Controller* Level. NTCIP defines a hierarchy that allows control levels to move to stand-by (SBY) by setting their control patterns to pattern# 0. The highest control level that is not in stand-by determines the active pattern in the secondary controller being supervised by that control level.



SYS is currently driving the active pattern on the MM->7->2 status screen above (under a system or field master). If the master goes to stand-by (SYS = 0), TBC will select pattern 10 as the active pattern. However, a REMO pattern from central will override both SYS and TBC but not local TEST mode. Preempt and preempt triggers have the highest priority over all coordination modes because preemption overrides all patterns.

ATMS Remote Control is the highest level of control in a Cubic | Trafficware ATMS, overriding all supervisory control from a FMS. *Remote* patterns may be downloaded manually by the operator with a timeout value that is used to set Remote to Pattern 0 after the timeout expires. *Remote control pattern* "0" effectively passes control from the *System Control* Level to the *FMS* control level.

Cubic | Trafficware has designed the *Field Management Station* software module so it can be launched as a "central master" from the ATMS time-of-day scheduler and run as a separate thread on the communications server. This configuration allows the FMS to be hosted by the central system without distributing the supervisory control of the master to a field location. The advantage of this method is that intersection assigned to the "central master" may reside on multiple communication paths since all communication *between* the master and the secondary controllers is maintained by ATMS.

The *Field Management Station* software module may also be distributed to a local 2070 controller. In this case the intersections managed by the FMS are interconnected through the *SysDown* (asynch) and Ethernet ports.

The highest level of control in a 2070 FMS is the *Master Test Configuration*. This control mode allows the user to manually override the *SYS* pattern generated by the FMS. Unless the *Master Test Configuration* is set to stand-by (SBY) operation (pattern 0), all lower control levels of control in the FMS are suspended.

The next level of control in a 2070 FMS is the *Failure Override Configuration*. This configuration is normally set to pattern 0 (stand-by) until a user specified threshold is exceeded that defines a failure condition. During a failure condition, the FMS provides a fallback response which is also user definable. The following are examples of error conditions detected by the 2070 FMS:

- **Communication Failure** – all secondary controllers typically revert back to local time-of-day operation
- **System Detector / Station Failures** – the number of failures controls whether the system reverts back to time-of-day
- **Stop Timing** – the user can revert the system to free if enough stop time errors are detected
- **External Input Failure** – only applies if external traffic responsive operation is in effect

During normal operation, *Master Test* and *Failure Override* are in stand-by and the level of control is passed to the *Master Time Base Schedule*. The MTBC and the Secondary Time Base Schedule (STBC) are separate schedules provided in the master and secondary database. Each schedule can be use to select patterns; however, MTBC has a higher priority than STBC because the master operates at a higher level than the secondary in the control hierarchy above. The MTBC determines which of the following modes of operation are in effect by time-of-day:

- External Coordination (AUT mode using external inputs)
- Master Time Base Coordination (MTBC)
- Traffic Responsive Operation (TRI)
- Isolated Operation (ISO – running Secondary Time Base Coordination , STBC)

Note that the MTBC schedule in the FMS is capable of selecting ISO which directs each secondary controller to select the active pattern from the local STBC, not the MTBC. At this point, the control level is passed completely to each local controller which is responsible for selecting the active pattern from the local time-of-day schedule.

NTCIP provides a *Fallback* mechanism that allows each secondary controller to recover from system failures and still remain coordinated within the subsystem by time-of-day. If the secondary controller does not receive a valid message from the FMS within a user specified *Fallback* time (in seconds), the secondary will revert back to the local time-of-day schedule. The FMS will then instruct all locations still in communication with the master to move to ISO after a user specified threshold of com failures is exceeded (*Failure Override Configuration*). As long as each local time-of-day pattern selects a common pattern and the system clocks within each controller remain in sync, coordination can be maintained during the communication failure until the *Failure Override Configuration* is over.

2 FMS Data Communications

```
              Main Menu
1.Controller 4.Scheduler 7.Status
2.Coordinate 5.Detectors 8.Login,Utils
3.Preempts   6.Comm      9.System Master
```

The keystroke sequence notation used in this manual follows the same convention as the Version 50/60/61/65 controller manual. The controller *Main Menu* is accessed from the MAIN DISP key (TS2) or the "star" key (2070).

```
          Signal System Master
1.Parameters  4.TR Tables   7.Status
2.Mstr Cnfgs  5.Scheduler   8.LocalSetup+
3.Detectors   6.LocalSetup  9.Alarms/Fail
```

The sequence **MM→9** provides access to the controller *Master Database*. A database fields accessed from this screen are stored as a separate database within ATMS. The master database is accessed with the unique address assigned to the *Master ID* (1-8192). The *Master ID* must also be unique from all secondary controller Station Ids.

Communication between an FMS and each secondary controller supervised by the FMS uses a "poll-response" scheme. All communication is initiated by the FMS over the *SysDown* port or Ethernet interface. In an asynchronous communication system, the poll message from the master is "heard" by all secondary controllers in the sub-system. However, the response message sent back to the master is generated by the secondary which matches the *Station ID* in the poll message. Similarly, in an Ethernet based network, each secondary is addressed by it's unique TCP/IP address on that network. This chapter discusses the programming in the master database that is used to configure asynchronous or IP based communications in the master subsystem.

NOTE: The ATMS central software requires that the topology of the communications platform be consistent, i.e. if the central communicates asynchronously to a master then the master must communicate asynchronously to all locals under it. If a central communicates via Ethernet (IP addressing) to a master then the master must communicate via Ethernet to all locals under it.

2.1 Assigning Secondary ID's to the Subsystem (MM->9->8)

```
       Signal System Local Setup+
Nbr Addr  Port
 1     0   0
 2     0   0
 3     0   0
 4     0   0
 5     0   0
 6     0   0
```

Each FMS polls a maximum of 32 secondary controllers assigned to the master through MM->9->8, *Local Setup+* as shown to the right.

Addr

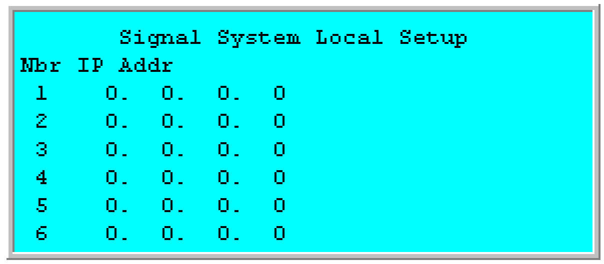
The *Station ID* for each secondary supervised by the master must be assigned to the subsystem through this parameter. Any *Address* other than zero will instruct the master to begin polling that *Station ID* as follows:

1) If the IP addresses of all secondary controllers are zero (see MM→9→6 below), then asynchronous communication will be used to communicate with the secondary
2) If the IP address of the secondary controller is not zero (see MM→9→6 below), then Ethernet will used.

Port

If the IP address of the secondary controller is not zero (see MM→9→6 below), then the corresponding Port Number that is programmed in the Local controller's IP setup screen (MM→6→5) must also be programmed at this location.

2.2 Ethernet TCP/IP Address Assignment (MM->9->6)



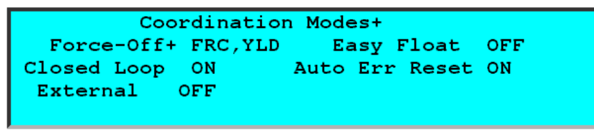
The MM→9→6 menu configures the TCP/IP address for each secondary assigned to the FMS. If the IP address of the secondary assigned to the subsystem under MM->9->6 is 0.0.0.0, this instructs the FMS to communicate with the secondary over an asynchronous data port (such as the SP1 or SP2 serial data ports on the 2070).

Again note that the ATMS central software requires that the topology of the communications platform be consistent, i.e. if the central communicates asynchronously to a master then the master must communicate asynchronously to all locals under it. If a central communicates via Ethernet (IP addressing) to a master then the master must communicate via Ethernet to all locals under it.

The user will program both the MM→9→6 data screen and the MM→9→8 screen if they are communicating via IP addressing. If they are communicating asynchronously, the user should only program the MM→9→8 screen.

Chapter 10 Data Communications in the controller manual explains how to configure the 2070 hardware ports SP1 and SP2 and bind these ports to *SysUp* and *SysDown* (section 10.10). This documentation is not duplicated here because this programming is part of the secondary database, not the master database.

2.3 Secondary Closed Loop Parameter (MM->2->1)



The *Closed Loop* parameter under MM->2->1 must be turned ON before the secondary controller can be supervised by the master. Setting *Closed Loop* ON allows the secondary to receive the SYS pattern downloaded from the master.

Setting *Closed Loop* OFF allows the master to update the secondary controller's real-time clock and to poll alarms and events without overriding the secondary time-base control schedule (STBC). Set this parameter OFF if you only want the master to update clocks and retrieve status from the controllers assigned to the subsystem.

IF Closed Loop is OFF, the secondary will still respond to manual *Remote* patterns from the ATMS. However, any SYS pattern received by an FMS will be ignored and the secondary will derive the active pattern from it's local schedule (STBC).

3 Master Parameters

```
Closed Loop Parameters
        Stn Type:   LOCAL
Min Chg Tim(min):      0  Sample Accum  0
Loc Smpl Tm(min):      0  Spare:        0
Tx Err Time(min):      0  Spare:        0
```

3.1 Master Parameters (MM->9->1)

The following master parameters affect the overall operation of the master much like unit parameters affect the secondary controller. Master Parameters are accessed from MM->9->1.

Station Type (Stn Type)

The *Stn Type* can be toggled through LOCAL or MASTER.

The MASTER type identifies the 2070 master as the supervisor of the secondary controllers assigned to the master subsystem. This initiates master polling of all secondary controllers (station ID's) defined in the master subsystem. The master polls the secondary controllers for alarms, detector data and status and buffers alarm and event data until polled by the ATMS.

The LOCAL type prevents the master from taking control of the secondary controllers assigned to its subsystem. However, the master will continue to update the secondary controller real-time clocks.

Minimum Change Time (Min Chg Tim)

Min Chg Tim (0 to 255 minutes) limits on how quickly the master can change coordination patterns under traffic responsive operation. *Minimum Change Time* balances the quick response desired from a traffic responsive system with the negative transition effect during a patterns change. Setting *Min Chg Tim* shorter than *Local Sample Time* has no effect because the traffic responsive calculations are always recalculated at the end of the *Local Sample Time.*

Local Sample Time (Loc Smple Tm)

Local Sample Time (0 to 255 minutes) sets the poll rate for all system detectors polled by the master. *Local Sample Time* in the master must be set equal to the *Vol/Occ Period* setting in the secondary controllers (MM->5->8->1). Sample times of 10 to 15 minutes are commonly used for traffic responsive operation.

Local intersection detectors are polled by the master to calculate volume / occupancy measures for traffic responsive operation. If you run traffic responsive, make sure that the *Vol/Occ Period* under menu MM->5->8->1 is set to the same value as the *Local Sample Time* discussed in section 3.1.

Transmit Error Time (Tx Err Tim)

Transmission Error Time (0 to 255 minutes) is used to set the sampling period for accumulating failures in the system. The failure modes are discussed in Chapter 9 under the *Failure Cfg* table.

Sample Accum

The *Sample Accumulator* allows you to merge V+O samples forwarded to central. The V+O traffic responsive calculations are always based on the *Local Sample Time* described above; however, it may be desirable to merge sample data in the event report gathered by the ATMS. For example, a traffic responsive system with a 5 minute detector *sample time* with the *sample accumulator* set to 3 can accumulate a 15-minute V+O sample uploaded from the ATMS at 15-minute intervals.

4 Master Time Base Scheduler

```
      Master Time Based Scheduler
1.Set Date/Time 4.Day Plan    7.CrossOfst
2.Easy Schedule 5.Action Tbl 8.MTB Config
3.Adv Schedule  6.Commands    9.Status
```

The *Master Time Base Scheduler* (MTBC) is the heart of the FMS because this scheduler selects control mode that supervises all secondary controllers assigned to the sub-system. These MTBC control modes include FMS time-of-day pattern selection and traffic responsive operation.

Every secondary controller in the subsystem responds to the SYS pattern generated by the FMS if the *Closed Loop* option of the secondary is set ON. Secondary controllers may be monitored (but not controlled) by the master if the *Closed Loop* option is OFF If *Closed Loop* is OFF, the secondary controller will revert to it's local schedule (STBC) and ignore all messages from the FMS.

The *Master Time Based Scheduler (MTBC)* is accessed under menu MM->9->5.

4.1 Master Scheduler (MM->9->4)

```
Set Date & Time
            Date      Day   Time   Secs
 Current  08-29-04   SUN   09:58    58
  Set To  00-00-00         00:00    00
```

The master date and time can be set under the MTBC menu (MM->9->5->1) or the STBC menu (MM->4->1). These menus access the system date and time which are not stored in either the master or secondary databases.

4.1.1 Master Easy Scheduler (MM->9->4->2)

```
 # Day  Mo:From-Thru DOM:From-Thru Plan
 1 OFF      00-00         00-00      1
 2 OFF      00-00         00-00      1
 3 OFF      00-00         00-00      1
 4 OFF      00-00         00-00      1
```

The *Master Time Base Scheduler* is programmed under MM->9->5 like the *Secondary Time Base Scheduler* is programmed under MM->4. "Easy Schedule" and "Advanced Schedule" provide an annual calendar to select a day plan for each day of the year as specified in NTCIP. *Day Plans* are programmed to select *Actions* by time-of-day.

Actions are extended in the *Master Time Base Scheduler* to do more than select a pattern by time-of-day. MTBC actions control whether MTBC, STBC or traffic responsive selects the pattern or whether the subsystem runs in flash or free operation.

The MTBC "Easy Schedule" (MM->9->5->2) is a shortcut method provided in the Version 50/60 software to program the annual calendar specified by NTCIP to select a "Day Plan" by day-of-week and month/day of year.

4.1.2 Master Advanced Scheduler (MM->9->4->3)

The entries in the *"Advanced Schedule"* below (MM->9->5->3) were programmed under "*Easy Schedule"* as shown in the previous menu screen. "*Easy Schedule"* allows the user to specify day-of-week, month and day ranges to simplify coding an "X" under each of the separate entries in the *"Advanced Schedule"*.

```
       Day        Month          more~
 #   SMTWTFS    JFMAMJJASOND
 1   .XXXXX.    XXXXXXXXXXXX
 2   .......    ............
 3   .......    ............
 4   .......    ............
```

```
□     Date    1         2         3  Day
 # 1234567890123456789012345678901 Plan
 1 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   1
 2 ...............................   1
 3 ...............................   1
 4 ...............................   1
```

4.1.3 Master Day Plans (MM->9->5->4)

```
Plan- 1      Evt Time Actn  Evt Time Actn
Link: 0        1 00:00   1    2 06:00   2
               3 09:00   3    4 16:00   4
               5 19:00   5    6 00:00   0
               7 00:00   0    8 00:00   0
```

The purpose of the NTCIP based time-of-day schedule is to select a "Day Plan" (far right entry in the above menu) for each day of the year using the master and secondary schedules (MTBC and STBC).

The MTBC schedule provides 24 "Day Plans" under MM->9->5->4 in addition to the 24 "Day Plans" provided in the secondary scheduler under MM->4->4. Each "Day Plan" table provides up to 16 event entries to select an 'Action" by time-of-day.

The master and secondary schedules are completely independent. Therefore, even if MTBC and STBC call the same *Day Plan* through their separate schedules, these *Day Plans* are not related. The MTBC Day Plan is programmed under MM->9->5->4 and the STBC Day Plan is programmed under MM->4->4.

"Actions" are used differently in the master scheduler (MTBC) and secondary scheduler (STBC). The difference between MTBC based *"Actions"* and STBC based *"Actions"* is the key to understanding closed loop operation. *"Actions"* are fully defined in the next section.

4.2 Master Action Table vs. Secondary Action Table

The MTBC and STBC schedules both select *Actions* by time-of-day. However, master control *Actions* and secondary control *Actions* are quite different. STBC *Actions* are used to select coordination patterns and special function bits by time-of-day. MTBC *Actions* are used to select coord modes for the closed loop system. Compare the *Action Table* for the secondary controller with the master schedule below.

Secondary Action Table

MM->4->5
STBC

Note: STBC patterns are based on NTCIP objects and are referenced by pattern number.

Actn	Patrn	Aux-123	Spec-12345678	Pre.1.2
1	255	...	....	0 0
2	0	...	....	0 0
3	0	...	....	0 0
4	0	...	....	0 0
5	254	...	....	0 0

Master Action Table

MM->9->5->5
MTBC

Note: MTBC and STBC refer to the same NTCIP based pattern #'s

Actn	Coord..	Patrn..	Ofst	Comnd..	#
1	TBC	3	1	TBC	7
2	TRI	0	0	TRI	4
3	FRE	0	0	FRE	0
4	ISO	0	0	ISO	0
5	AUT	0	0	AUT	0
..					
100	FL	0	0	FL	0

!!! Please note that Comnd Mode and Command # are independent parameters

Preview of Coord Modes

The *Master Action Table* defines the *Coord Modes* varied by time-of-day through the master time base scheduler. The following modes are used to alter secondary controllers with *Closed Loop* parameter set ON.

- Selecting pattern 1-48 places all controllers in the subsystem to that pattern from the master
- Selecting pattern 254 places all controllers in the subsystem to FREE from the master
- Selecting pattern 255 places all controllers in the subsystem to FLASH from the master
- Selecting TRI runs Traffic Responsive from the internal TR calculations in the master
- Selecting TBC mode allows you to set the pattern from the MTBC rather than the local STBC schedules

  Offset (Ofst) and Command # is not used in the 2070 MTBC (provides backward compatibility with TS1 closed loop systems in the TS2 981 Master)

These coord modes of operation will be fully discussed in the next chapter.

5 Coord Modes

Understanding the master configurations is the key to understanding closed loop master operation.

The active **coord mode** is set by the highest level of control (configuration) depicted in section 1.3:

- *Master Test Configuration* (operator override)
- *Master Fail Configuration* (system failure override)
- *MTBC Configuration* (master time-base schedule)

Flash and *Free Operation* are implemented as patterns rather than modes. NEMA defines Flash as *Pattern* 255 and Free as *Pattern* 254. *Patterns* may be called from the *Master Test Configuration, Master Fail Configuration* or from the *MTBC Configuration.*

TRI is traffic responsive (TR) operation *internal* to the master. Traffic responsive may also be implemented from a central master in The ATMS *external* to the field master. Traffic responsive operation is discussed fully in chapter 7.

It is also possible for a central master running within The ATMS to override the SYS pattern of secondary controllers assigned to a field master (FMS). This allows The ATMS to supervise master groups and provide "marriage and divorce" of master groups from the central control level.

AUT	Selects pattern/offset from each controller's external inputs (see MM->2->2). If the hardwire interconnect is not working, then revert back to TBC mode.
TBC	Selects pattern/offset from the master's time-of-day schedule (see MM->9->5->5) TBC is used in the *Master Time Base Configuration* to select the mode from the *MTBC Schedule.* TBC can revert each controller to their own internal STBC schedule (pattern 0) or select from any of the 48 patterns programmed into each controller. NTCIP pattern# 254 is used to select free operation and pattern# 255 calls for flash operation.
TRI	Selects pattern/offset from the Traffic Responsive Internal program (see MM->9->4->INTRNL).
ISO	Instructs the local controllers to select their coord pattern # from their secondary time-base schedule (STBC). The ISO mode is only available in the *Master Test Configuration* and the *Master Fail Configuration*. The *Master Time Base Configuration* implements ISO using the TBC mode with pattern# 0 to revert all controllers in the closed loop system to STBC

6 System Detectors

System volume and occupancy data is used in the traffic responsive calculations to select timing patterns from a table lookup procedure to select cycle, split and offset (COS) values for TRI operation. Local intersection detectors may be assigned as system detectors in the closed loop master. Any of the 64 detectors in a secondary controller may be assigned as one of the 48 system detectors in the master. The *Local Sample Time* in the master and the *Vol/Occ Period* in the secondary should be the same.

6.1 System Detector Assignment (MM->9->3)

```
System Det#   1             ..Vol..Occ.
      ..Pri..Sec Full Rate/%    0    0
Stn ID:    0    0   Fail #1 >    0    0
Det #:     0    0           <    0    0
 Det Group: IN      Fail #2 >    0    0
Smooth Val:  0              <    0    0
                    Fail #3 >    0    0
               +            <    0    0
```

Each system detector is assigned one primary detector and an optional secondary (or backup) detector that is only used if the primary detector has failed. A *Copy Detector* function is provided under MM->9->6 to simplify coding system detectors. System detectors are assigned to the closed loop master using MM->9->3->DET#.

Station ID and Detector

Detectors are referenced by station ID and number (1-16). A station ID of 0 indicates that the detector is not active and will not be considered in the traffic responsive flow calculations. A primary detector must be assigned if a secondary is assigned, but a secondary detector is not required. Note that primary and secondary detectors may be assigned from different local controllers.

Detector Group

System detectors can be assigned as an IN bound, OUT bound or CROSS street detector. This association is used in the traffic responsive calculation to select cycle, split and offset pattern values.

Smooth Val

The *Smooth Value* (0 – 100) controls how each volume and occupancy sample is averaged with the previous sample. An entry of 0 disables smoothing and each new detector sample replaces the previous detector sample. An entry of 100 does not average the current sample until the next sample is taken. Section 7.1.1 discusses detector smoothing.

Full Rate / %

Separate *Full Rate/%* values (0 – 100) are provided to scale volume and occupancy values as discussed in section 7.1.1. Note that a value of 0 can be used to disable either volume or occupancy for the system detector.

The *Full Rate/%* volume parameter can be approximated by the maximum number of counts per minute expected for the system detector. The saturation flow rate of one travel lane is generally accepted as 1800 – 2000 vehicles/hour for one lane. This corresponds to a *Full Rate/%* value of 30 – 33 vehicles/minute at full saturation. Note that the ratio of green/cycle length (g/C) over the detector further limits this full rate % value.

Full Rate volume is a function of the roadway and the variables that govern it such as speed, vehicle types, etc. It is the number of cars per minute per lane (ie. system detector) when the roadway is saturated. For example if the user programs 20 under full rate volume (ie. 20 cars per minute), the user is expecting that the lane is saturated at 1200 cars per hour.

The *Full Rate/%* occupancy parameter scales the occupancy value and is measured in percent. If occupancy on green + yellow is used, the maximum *Full Rate/%* is the split percentage for the phase associated with the detector. Values of 30 – 50% are typically used to scale occupancy to a percentage value that indicates the current level of congestion for the system detector.

Failure

Failure “>” defines a threshold of volume and occupancy above which the detector is considered to be failed.

Failure “<” defines a threshold of volume and occupancy below which the detector is considered to be failed.

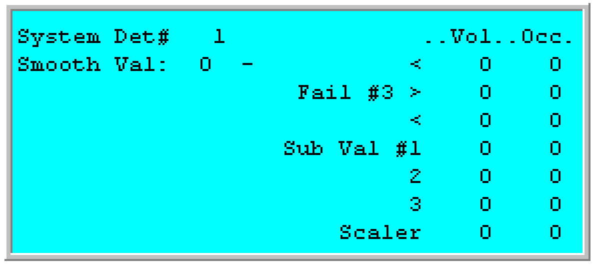
Smoothed volume and occupancy values are used to test these failure ranges. Three sets of threshold failure ranges are provided for each system detector. MTBC actions can be used to select these failure ranges by time-of-day.

If you do not want to apply substitution to failed detectors, then default “Failure > 100” and “Failure < 0”.

Substitution Values (Sub. Val)

Three sets of *Substitution Values* are provided for each system detector. MTBC actions can be used to select the *Substitution Values* by time-of-day. These volume and occupancy values are substituted in the traffic responsive calculations should both primary and secondary system detectors fail. If these values are zero when a detector fails, the detector will be removed from service.

Scaler



Scaler values are provided to weight volume and occupancy for each detector. *Scaler* values in the range of 0 – 9 can be used to weight the relative importance of volume and occupancy for each detector and also can weight one detector's V+O higher than another detector V+O.

Scalar values can be set to "0" if you want either volume or occupancy to be used in the V+O calculation.

6.2 Relationship Between Volume and Occupancy

When setting up the system master, it is often useful to relate percent occupancy to percent scaled volume. This relationship can be found through the following equations:

$$\frac{\%\text{Occupancy} * 240 \text{ (veh / mile)}}{100} = \text{Density (veh / mile)}$$

$$\frac{\text{Volume (veh /min)}}{\text{Speed (veh / min)}} = \text{Density (veh / mile)}$$

For the occupancy relationship above, 240 Vehicles/Mile is derived assuming an average vehicle length of 22 feet. Thus, 5280 feet / 22 (feet/veh) yields approximately 240 vehicles per mile at a saturated or 100% occupancy value.

Occupancy may be related to volume through the following formula:

$$\frac{100 * \text{ Volume (veh/mile)}}{240 \text{ (veh/mile)} * \text{Speed (Miles/min)}} = \%\text{ Occupancy}$$

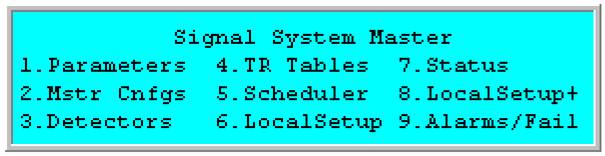
Typically, for a given speed, full-scale volume is correlated to full-scale occupancy if both are to be used to control traffic. At a speed of 30 miles per hour:

Volume (Veh/Min)	%Occupancy
2	1.66
5	4.16
10	8.33
15	12.5
30	25

7 Traffic Responsive Operation

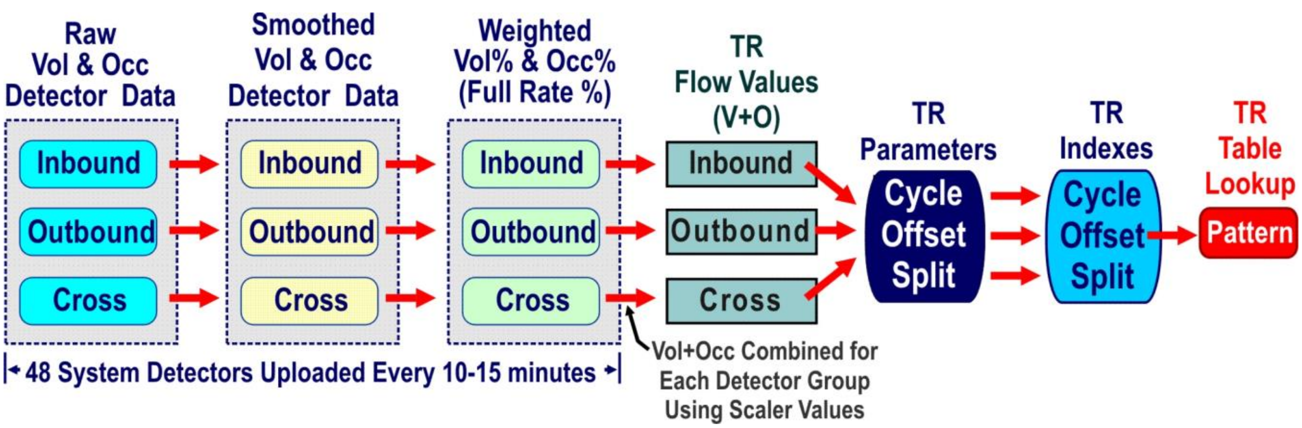
Traffic responsive control systems originated in the 1970's with the federal UTCS project in Washington, D.C. This project set the standard for traffic responsive operation for the last 30 years. UTCS defined system detectors as inbound, outbound or cross street detectors. Volume and occupancy were combined using weighting factors to compute separate V+O values for the inbound, outbound and cross street approaches within the network. UTCS used these computed V+O values to select a traffic responsive pattern using a table lookup procedure.

Closed loop systems appeared in the 1980's. Many of the centralized features of UTCS were distributed to on-street masters and local controllers. Most closed loop systems today continue to implement traffic responsive operation from the local "on-street" level instead of from a centralized computer; however, the calculations are basically the same dating back to UTCS. On-street masters poll the system detector data from the secondary controllers and perform the calculations to select a traffic responsive pattern at the local level. The central computer is primarily used to provide supervisory control of the system, monitor status and maintain system databases.



7.1 TR Calculations Using Volume + Occupancy

Each master controller collects volume and occupancy data from up to 48 system detectors in the master subsystem. Raw volume and occupancy data is first smoothed to "average" the data with the previous sample. Then the smoothed data is weighted using the *Full Rate%* values supplied by the user to calculate Vol% and Occ% for each detector. Vol% and Occ% are then weighted using *Scalers* to compute *TR Flow Values* for the *Inbound, Outbound* and *Cross* directions. The *TR Flow Values* are used to calculated *Cycle, Offset and Split Parameters* which are in turn used to lookup a *Cycle, Offset and Split Index*. Lastly, the indexes are used to select a pattern from the TR pattern tables. These TR calculations are defined in this section and are summarized as follows:



7.1.1 Smoothed Vol% and Occ%

Traffic volume and occupancy measures vary greatly from one sample to the next, especially if the sample period is less than 10–15 minutes. Typically, 10 or 15-minute samples are "smoothed" or "averaged" with the last "smoothed" sample. The *Smooth Value* is assigned for each detector as discussed in section 6.1. The formula used to "smooth" each volume and occupancy sample is given below. Note that if the *Smooth Value* is "0", then the current sample is not averaged with the previous volume or occupancy sample and no smoothing takes place.

$$SmoothedValue = \frac{(NewValue * (100 - SmoothVal) + OldValue * SmoothVal)}{100}$$

Vol %

Volume % compares the sampled volume (converted to a one minute flow rate) with the "Full Rate %" value discussed in section 6.1. Volume "Full Rate %" is a full-scale reading of flow rate expressed in vehicles / min. Since flow rate is also a function of green time (g/C) provided over the detector, Volume "Full Rate %" must be approximated.

Assume that volume "Full Rate %" is 18 veh/min for a smoothed 15-minute sample. The measured flow rate is 150 vehicles sampled over the 15-minute period. Note that volume must first be converted to a one-minute flow rate because "Full Rate %" is expressed in vehicles per minute.

Vol (rate per minute) = 150 veh / 15 minutes = 10 veh / min

Vol % = measured flow rate / full rate % = 10 / 18 = 56%

Occ %

Occupancy % is a measure of total vehicle presence over the detector during the sampling period. Full occupancy at 100% is equivalent to a constant call on the detector during the entire sampling period. NTCIP calls for occupancy to be expressed as an integer value in the range of 0-200 so that the resolution of occupancy can be measured within 0.5 %. However, occupancy is always 100% if occupancy if a detector call is constant over the entire sample period.

Version 50/60 controllers provide a "plus" detector feature called occupancy-on-green (MM->5->3) that allows occupancy to be measure only during the green or green + yellow clearance interval. This feature allows occupancy to be measured from detectors at or near the stop bar when traffic is flowing over the detector, but not during the red interval when standing queues are stopped over the detector. Occupancy-on-green+yellow is measured during a portion of the 10-15 minute detector sample equivalent to the split time.

Occupancy "Full Rate %" is a full-scale reading of occupancy expressed in %. Since occupancy is a function of the green time (g/C) over the detector and occupancy-on-green feature, occupancy "Full Rate %" must be approximated.

For example, if a detector samples occupancy during the green+yellow interval of the phase called by the detector, then the maximum occupancy is roughly equivalent to the split time of this phase. If occupancy "Full Rate %" for this detector is 60% and measured occupancy is 12%, then the Occ% value is calculated as follows:

Occ % = measured occupancy / full rate % = 12 / 60 = 20%

Real-time, smoothed Vol% and Occ% values for each system detector may be viewed under MM->9->7->5.

```
Smoothed   Nbr..Vol%..Occ%
Detector    1     0     0
Values      2     0     0
            3     0     0
            4     0     0
            5     0     0
            6     0     0
            7 +   0     0
```

7.1.2 TR Flow Values for the Inbound, Outbound and Cross Detector Groups

Each system detector is assigned to the *Inbound, Outbound or Cross* detector group and assigned an occupancy *Scaler* (*k*x) and a volume *Scaler* (*c*x). *TR Flow Values* are computed for each detector group using the formula below. Each *TR Flow Value* (*Inbound, Outbound and Cross*) is a weighted average of the Vol% and Occ% values for the detectors sampled for each detector group.

$$FlowValue = \frac{(k1*Occ_1 + k2*Occ_2 + ... + kx*Occx) + (c1*Vol_1 + c2*Vol2 + ...cx*Volx)}{k1 + k2 + ... + kx + c1 + c2 + ... + cx}$$

Note: *Scalers* express the relative weight of Vol% and Occ% for detector assigned to a group (inbound, outbound and cross). Increasing *Scalers* for each system detector by the same amount will not increase the *TR Flow Values* since all detectors are weighted the same. However, you may increase the relative weight of volume (or occupancy) for some detectors (and not others) by using different *Scaler* values.

Status display MM->9->7->6 above shows the current status of the TR calculations. Vol% and Occ% are combined to calculate a *TR Flow Value* for the *Inbound, Outbout and Cross* detector groups.

```
Computed    ....Flow.........Param..Index
TR Values     In    0    Cycle    0     1
             Out    0   Offset    0     1
           Cross    0    Split    0     1
```

In the next two sections, we will see how the measured *TR Flow Values* are used to calculate a *Cycle, Offset and Split Parameter* for each detector group. A table lookup procedure is then used to select the current *Cycle, Offset and Split Index* from these parameters.

7.1.3 Cycle, Offset and Split Parameters

The *Cycle, Offset and Split Parameters* are calculated from the *TR Flow Values* as follows. These parameters range from 0 to 100% and are used to perform a table lookup to select the *Cycle, Offset and Split Index*.

Cycle Index = Max. Inbound V+O <or> Max. Outbound V+O

Offset Index = ((Outbound – Inbound) / (Outbound + Inbound)) * 50 + 50

Split Index = ((Cross – Cycle Index) / (Cross + Cycle Index)) * 50 + 50

7.1.4 Cycle, Offset and Split Index

The TRI calculations perform a table lookup using the calculated Cy*cle, Offset and Split Parameters* to select a *Cycle, Offset and Split Index*. Separate threshold tables are used depending on whether the Cy*cle, Offset and Split Parameters* are increasing or decreasing to reduce the hysteresis or "bounce" in successive data samples.

The two threshold tables are programmed for each index under MM->9->4 (items 5., 6. and 7.). One table is used if the parameter is increasing compared with the last sample. The other table is used if the parameter is decreasing compare with the last sample. Here are example tables for the *Cycle Index* lookup (one if *Cycle Index* is increasing, the other if *Cycle Index* is decreasing). Similar threshold tables exist for selecting the *Offset and Split Index* from the *Offset and Split Parameters* and the same principles apply as illustrated here for *Cycle Index*.

CYCLE LENGTH THRESHOLDS

CYCLE LENGTH INCREASING	CYCLE LENGTH DECREASING
FREE to CYCLE 1 : 25	CYCLE1 to FREE : 17
CYCLE1 to CYCLE2 : 35	CYCLE2 to CYCLE1 : 28
CYCLE2 to CYCLE3 : 41	CYCLE3 to CYCLE2 : 36
CYCLE3 to CYCLE4 : 48	CYCLE4 to CYCLE3 : 40
CYCLE4 to CYCLE5 : 56	CYCLE5 to CYCLE4 : 49
CYCLE5 to CYCLE6 : 99	CYCLE6 to CYCLE5 : 99

For example, suppose the current *Cycle Index* is "4" and that the *Cycle Parameter* has <u>increased</u> during the last 15 minute sample period from 52% to 55%. A lookup from the <u>increasing</u> table, will retain the *Cycle Index* at "4" because 55% is less than the threshold of 56% necessary to change to *Cycle Index* "5".

Note that once the *Cycle Index* moves to "5", that the *Cycle Parameter* would have to drop to 49% (from the decreasing table) to move back to *Cycle Index* "4". Without separate threshold tables, the TR system would become unstable if the 15-minute *Cycle Parameter* began oscillating from 55 to 56 to 55 to 56. Using separate thresholds for increasing and decreasing trends reduces the hysterisis or "bounce" in the V+O data measured by the system.

7.2 TR Pattern Selection Using the Cycle, Offset and Split Index

The traffic responsive pattern is selected using a table lookup procedure once the *Cycle, Offset and Split Index* values have been calculated.

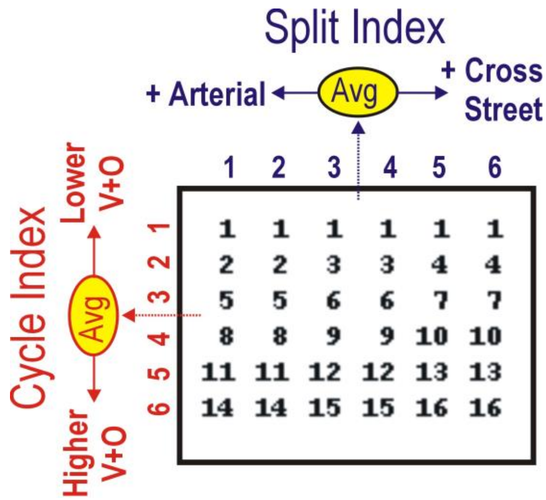
INT,OFT-1 Spl-Indx.	1	2	3	4	5	6
Cycle Indx-1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

Four separate offset tables (cycle/split matrices) are specified from menu MM->9->4->1. Any of the 48 patterns provided by Version 50/60 software may be assigned to these offset tables. The example below assigns 16 patterns to Offset Table 1. This table is used by the traffic responsive lookup procedure if the current *Offset Index* is "1":

Suppose the current *Cycle Index* is "4" and the *Split Index* is "2". Using the table lookup above, the TR timing plan selected by this lookup would be pattern# 8. If the *Master Time Base Scheduler* currently calls for TRI (Traffic Responsive Internal), then all secondary controllers in the subsystem with *Closed Loop* parameter ON will run pattern 8 defined in the secondary controller database. This traffic responsive (or SYS) pattern will remain in effect for the *Minimum Change Time* discussed in section 3.1. At the end of the *Minimum Change Time*, traffic responsive will be allowed to implement a new timing pattern based on updated *Cycle, Offset and Split Indexes* computed from the new volume and occupancy samples. This table lookup procedure is the essence of traffic responsive.

Relationships Between Inbound, Outbound and Cross Street V+O Conditions

If you go back and study the equations in section 7.1.3 used to select the *Cycle, Offset and Split Indexes*, you will discover the following relationships between the indexes and V+O for each detector group.



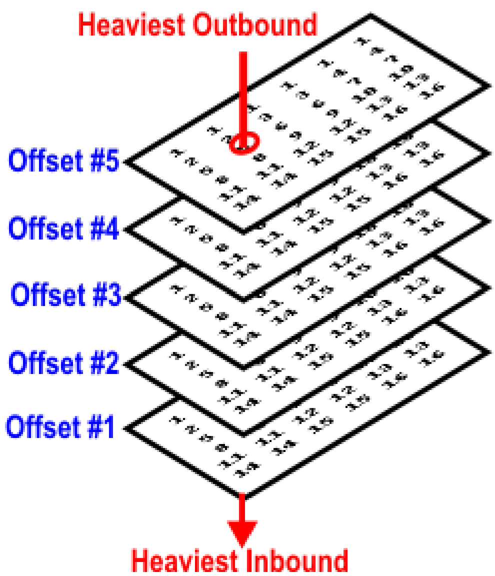
1) *Cycle Index* varies cycle length as a function of arterial V+O

Patterns within the same row typically share a common cycle length. For example Cycle 1 (row 1) might be assigned to free operation, Cycle 2 (row 2) at 80", Cycle 3 (row 3) at 90", etc. As V+O increases, the *Cycle Index* increases driving the cycle length higher for each row of patterns.

2) *Split Index* varies splits times based on *Arterial* vs. *Cross*

Because patterns within the same row share a common cycle length, the patterns in the same row can be varied to adjust the split times to favor either the arterial or cross street movements.

CIC (Critical Intersection Control) is an adaptive split feature that provides an alternate way to adjust split times at a common cycle length. CIC allows actuated phases to "grow" or "shrink" depending on whether phases max-out or gap-out during coordination. CIC provides a dynamic split adjustment for a single pattern assigned to each row in the cycle/split matrix.



3) *Offset Index* selects the pattern based on *Inbound* vs. *Outbound*

The *Offset Index* adds a third dimension to the traffic responsive pattern selection process. The four offset matrices can be visualized as four separate layers of the *Cycle / Split Index Tables* as shown to the left.

Offset Index is the relationship between the highest *Outbound* V+O compared with the highest *Inbound* V+O. Traffic responsive uses the *Offset Index* to select the *Cycle / Split Index Table* that favors an inbound or outbound demand in the network. The *Offset Index* is useful when the closed loop system exhibits a strong inbound preference at one time of the day and a strong outbound preference at another times.

You can specify *Offset Thresholds* under MM->9->4->7 to select the *Offset Index* like the discussion on *Cycle Index* in section 7.1.4.

Keep in mind that the Version 50/60 tables provide a maximum of 48 patterns with 24 unique split tables to define these matrices. However, there are 180 patterns that can be assigned to this matrix (5 offset tables * 6 cycles * 6 splits).

7.3 Example: Creating Indices using volumes

The following steps are done in order by the algorithm that creates the Cycle, Offset and Split indexes. The steps below represent how the volume index is chosen. Please note that the same steps are used to create the occupancy index.

7.3.1 Raw data

Raw data is gathered by counting actuations over your sample period. The reported value is counts per sampling period.

7.3.2 Normalized data

The raw data is normalized into a number that will vary between 0 and 100. It is a percentage of the full Flow Rate value, thus it is based on the Full Rate volume programming.

7.3.3 Smoothed value

The *Smooth* value (0 – 100) controls how each volume and occupancy sample is averaged with the previous sample The normalized data is smoothed using the detector smoothing factor. The first time the TR central master is turned on, only the raw data is used. Subsequent values are then calculated using the smoothing formula as discussed in section 5.1.1. Remember that a smoothing factor of "0" will always use the normalized data for each sampling period.

7.3.4 Threshold checks

Next detector failure thresholds are checked for each system detector. If a detector fails based on the thresholds programmed for each system detector, then the substitution value will be used for that detector, if programmed. The substitution value should be set up using flow percentages. Warning if your Full Rate values are set too low, your calculated normalized values will exceed the thresholds and substitution values will be used.

If the value from four successive system detector polls fails the *Failure Threshold*, the system detector will be permanently removed from the master poll and marked as undefined (UNDEF) if the substitution value is zero. If the substitution value is not zero, then the master will continue to poll the detector and substitute values for the smoothed sample until the *Failure Thresholds* are satisfied.

7.3.5 Scalars

Now the algorithm is ready to combine individual detector flow values to develop the overall flow values. The weight assigned to each detector is determined by its scalar. The first step is to rank each system detector's importance against the other system detectors in your corridor. Scalars are the mechanism to do this. The user should start by choosing the least used detector and setting its scalar to "1" and scale the other detectors form this base. Scalar values can range from 1-9. A scalar value of zero will eliminate the detector from this flow value calculation

7.3.6 Flow Parameters

Once scaled, flow parameters are calculated via the formula as shown in section 5.1.2.

7.3.7 Cycle, Offset, Split parameters

Next the cycle offset and split parameters are calculated using the formulas shown in section 5.1.3, once the Flow parameters are established. Their values will range from 1-100 percent.

7.3.8 Cycle Offset and Split indexes chosen via the Threshold tables

The user must program a threshold table to choose the Cycle offset and Split index. Each threshold table is set up to choose a index based on the Parameter percentages. Separate threshold tables are needed depending on whether the *Cycle, Offset* and *Split Parameters* are increasing or decreasing to reduce the hysteresis or "bounce" in successive data samples.

Two threshold values are specified for each table lookup. One threshold is used if the *Parameter* is increasing compared with the last sample. The other threshold is used if the *Parameter* is decreasing compared with the last sample.

7.4 Traffic Responsive Lookup Table Examples

These examples illustrate ways to configure traffic responsive for different conditions. Keep in mind if Pattern # 0 assigned to a lookup table is selected, the secondary controllers will revert to their local time-of-day schedules (STBC). Pattern 254 is reserved for free operation and Pattern 255 is automatic flash as specified by NTCIP.

7.4.1 No Inbound / Outbound Preference or Arterial / Cross Street Preference

Offset # 1

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6

Suppose your network volumes are "average" in all directions without any inbound/outbound or arterial/cross preference. However, you do want traffic responsive to vary the cycle length based on the *Cycle Index* (greatest of the inbound or outbound detectors). This pattern selection scheme can also be used when CIC operation is used to vary split times in patterns 1-6.

To force the traffic responsive system to use the Offset # 1 table, modify the *Offset Thresholds* under MM->9->4->7 so all indexes are 100. This will insure that the traffic responsive system never selects the Offset # 2, 3 or 4 tables.

7.4.2 No Inbound / Outbound Preference – 3 levels of Arterial vs. Cross Preference

Offset # 1

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	2	2	3	3	4	4
3	5	5	6	6	7	7
4	8	8	9	9	10	10
5	11	11	12	12	13	13
6	14	14	15	15	16	16

Suppose your arterial volumes are "average" in both directions and you do not have a strong inbound/outbound preference. However, there are significant fluctuations between arterial and cross street volumes and occupancy. In this situation, different split tables can be developed to provide a heavy arterial, average and heavy cross split distribution for each cycle length (table row).

To force the traffic responsive system to use the Offset # 1 table, modify the *Offset Thresholds* under MM->9->4->7 so all indexes are 100. This will insure that the traffic responsive system never selects the Offset # 2, 3 or 4 tables.

7.4.3 Medium Inbound / Outbound Preference – No Arterial vs. Cross Preference

Offset # 2

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6

Offset # 3

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	7	7	7	7	7	7
3	8	8	8	8	8	8
4	9	9	9	9	9	9
5	10	10	10	10	10	10
6	11	11	11	11	11	11

Offset # 4

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	12	12	12	12	12	12
3	13	13	13	13	13	13
4	14	14	14	14	14	14
5	15	15	15	15	15	15
6	16	16	16	16	16	16

These pattern lookup tables provide 3 levels of inbound versus outbound conditions using 16 patterns.

Note that there is no consideration made for arterial vs. cross street preferences because the patterns assigned to each row are the same.

The *Offset Thresholds* under MM->9->4->7 must be programmed so the indexes moving from Offset 3-4 are 100. This prevents *Offset Table# 4* table from being selected.

This scheme could be used to allow traffic responsive to select the inbound or outbound pattern and allow CIC to vary split times to favor an arterial or cross demand.

7.4.4 Strong Inbound / Outbound Preference - No Arterial vs. Cross Preference

Offset # 1

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	1	1	1	1	1	1
3	2	2	2	2	2	2
4	3	3	3	3	3	3
5	4	4	4	4	4	4
6	5	5	5	5	5	5

Offset # 2

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	1	1	1	1	1	1
3	6	6	6	6	6	6
4	7	7	7	7	7	7
5	8	8	8	8	8	8
6	9	9	9	9	9	9

Offset # 3

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	1	1	1	1	1	1
3	10	10	10	10	10	10
4	11	11	11	11	11	11
5	12	12	12	12	12	12
6	13	13	13	13	13	13

Offset # 4

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	1	1	1	1	1	1
3	14	14	14	14	14	14
4	15	15	15	15	15	15
5	16	16	16	16	16	16
6	17	17	17	17	17	17

These pattern lookup tables provide 4 levels of inbound versus outbound conditions using 17 patterns. However, there are 3 cycle lengths per table compared with 4 cycle length per offset table in 6.3.3.

Again, there is no consideration made for an arterial vs. cross street preference (all the patterns are the same for each *Split Index*).

This scheme could be used to allow traffic responsive to select the inbound or outbound pattern and allow CIC to vary split times to favor an arterial or cross demand.

7.5 The Traffic Responsive Mode Table (MM->9->4->2)

The lookup table for *Command #* and a *Coord Mode* is based on the current *Cycle Index* using the table below.

In the example below, note how SYS (time-of-day coordination) is assigned to the lower levels of *Cycle Index* and how TR (traffic responsive) is assigned to the higher *Cycle Index* values. This allows traffic responsive to be used for “incident response” when unusual events drive V+O higher than expected for day-to-day TBC operation.

```
Mode-INTRNL                Coor.Mode
            Cycle Indx-1   TR
                      2    TR
                      3    TR
                      4    TR
                      5    TR
                      6    TR
```

7.6 The Traffic Responsive Command Table

This table accessed from MM->9->4->2 associates the MTBC commands with the 16 timing patterns selected under traffic responsive operation.

Leaving command (Cmnd) set to zero disables command for that plan. Setting the Cmnd from 1 to 16 associates the traffic responsive pattern with the MTBC (Master TBC) command defined in the scheduler under MM->9->5->6.

```
Cmnd Table     .Plan..Cmnd.
                 1     0
                 2     0
                 3     0
                 4     0
                 5     0
                 6     0
                 7 +   0
```

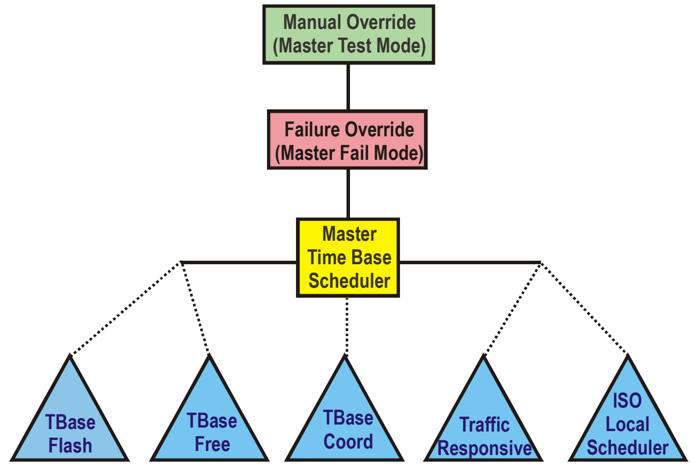
8 Master Configurations

```
           Master Configs
1.Mstr Test
2.Mstr Fail
```

The *Master Test Configuration* (MM->9->2) has the highest control priority in a closed loop system overriding the *Mstr Fail Configuration* and *Master Time Base Configuration* (MTBC). The *Master Test Configuration* is typically used only for test purposes because it can only be entered from the keyboard at the on-street master.

The *Master Fail Configuration* is the fallback operation that results from a loss of communications, detector failure, etc. The *Master Fail Configuration* will take control over the *Master Time Base Configuration* (MTBC) to revert the system to the operation defined in the *Failure Cnfg Table*.

The *Master Time Base Configuration* (MTBC) determines the day-to-day operation of the closed loop system when not overridden by the *Master Test Configuration* or *Master Fail Configuration*. The MTBC selects the normal operating move of the closed loop system. MTBC may select that the pattern for the subsystem is generated by MTBC or STBC, TRI, flash or free.



8.1 Master Test Configuration(MM->9->2->1)

```
Master Test ....Coord.....
            Mode Patn Ofst        Cmnd #
   Current  SBY    0    0              0
       New  SBY    0    0              0
```

The *Mstr Test Configuration* (or manual override) is accessed from screen MM->9->2->1.

The *Mode* options (AUT, TBC, TRI, TRE, and ISO) were defined in Chapter 5. Flash is implemented as *Patn* 255 and Free using *Patn* 254 (as per NTCIP). The *Mstr Test Configuration* includes an additional Stand-By mode (SBY) that passes control down the hierarchy to the *Mstr Test Configuration* and *Master Time Base Configuration*.

The *Mstr Test Configuration* can be used to manually select the coordination pattern (1-48, 254 or 255), offset (1-4) and command number (0 – 16). The manual coord mode overrides any time-of-day or traffic responsive coordination plan currently in effect in the closed loop system. Setting pattern, offset and command# values to zero reverts the system back to the mode currently implemented in the *Master Time Base Control Schedule (MTBC).*

8.2 Master Fail Configuration (MM->9->2->2)

```
Mstr Fail ..Coord.
          Mode.Pat     Cmnd.#     Cause
   Current SBY   0          0         0
       New SBY   0          0         0
```

The operation of the *Mstr Fail Configuration* is very similar to the *Mstr Test Configuration*. However, the *Mode, Pat* and *Command#* values are not entered manually, but are set by the system when failures occur and revert the system to a fallback mode of operation.

The *Mode, Pat* and *Command#* are fallback values specified in the *Failure Cnfg* table which will be discussed in the next chapter. The *Failure Cnfg Table* allows the user to specify the fallback mode when communication errors, detector failures, station failures and critical alarms degrade the system to the point that maintaining a progressive system is not possible.

When a system failure occurs, the *Mstr Fail Configuration* will implement the fallback modes and indicate the *Cause* of the failure. The *Cause* value refers to the Master Alarms defined in the next chapter.

8.3 Master MTBC Configuration

```
Mstr Fail ..Coord.
          Mode.Pat     Cmnd.#     Cause
   Current SBY   0          0         0
       New SBY   0          0         0
```

Master MTBC Configuration (or MTBC override) is accessed under the master scheduler menu MM->9->5->8.

This menu is useful if you want to temporarily override the time-of-day operation of the MTBC scheduler. If you set the “Mode” to TBC, you can also select the current pattern that will be applied to the master and all secondary controllers in the subsystem running under closed loop operation.

9 Master Fail Configs & Alarms

9.1 The Failure Configuration Table

CATEGORY...	THRSHLD..	CUR-CNT...	NEW
Comm Errs	0	0	0
Stns Failed	0	0	0
Sys Dets	0	0	0
Stop Timng	0	0	0
Coor Fail	0	0	0
Loc Alm 5	0	0	0
Loc Alm 6 +	0	0	0

One function of a closed loop master is to detect failure in the system and revert the system to a fallback mode of operation if the system has degraded to a minimum level. The purpose of the master *Failure Cnfg* table is to set the maximum allowable failures and specify the fallback response for each failure condition.

Each failure category is assigned a user selectable *Threshold*. If the number of failures exceeds this *Threshold* within the TX ERR TIM, the system will revert to the *Coord Mode* defined in the *Master Failure Cnfg Table*.

TX ERR TIM was defined in section 3.1 and is programmed under MM->9->1.

The number of *Comm Errs* can be quite high if the interconnect system is "noisy" and the TX ERR TIM is assigned a value of 15 minutes, A *Comm Errs* threshold of 75 (5 com errors per minute during the 15 minute TX ERR TM) may be reasonable depending on the type of communication used. Setting *Comm Errs* higher can compensate for "noisy" environments where the number of retransmits is quite high.

The thresholds for the other categories can vary greatly with the number of stations (secondary controllers) assigned to the closed loop system. That is, a system with 32 secondary controllers can usually tolerate more station failures than a system with 3 secondary controllers.

Note that in the example above, each failure category reverts the system to ISO (Isolated) operation rather than TBC. Isolated (ISO) operation reverts control to the *Secondary Time Base Control (STBC) Schedule* in each secondary controller. Even if system communications degrade for a period of days or weeks, the system can operate satisfactorily under ISO because the time base in the secondary controllers and master should not vary significantly. ISO is preferred as the fallback mode over TBC, because when all communication is lost, each secondary is not dependent on the schedule residing in the master. In other words, each secondary STBC provides the backup schedule for the closed loop system.

9.2 Enabling Events and Alarms

The first 128 events and alarms apply to the secondary controller within the 2070 and are accessed from screen MM->1->6. These events and alarms are defined in Chapter 13 of the NTCIP Controller Manual for the TS2 and 2070 controllers.

The 2070 master provides an additional 128 events and alarms (129 – 256) that relate to the operation of the closed loop system supervised by the master. Master events and alarms are enabled from screen MM->9->9.

The first 128 events and alarms relate to MM->1->6 (secondary controller alarms within the 2070) and event and alarm 129-255 relate to the master closed loop operation within the 2070 (MM->9->9).

9.2.1 The Difference Between Events and Alarms

Alarms and events refer to the same conditions. For example, Event #1 and Alarm #1 both refer to 2070 "Power Up" condition. The primary difference between events and alarms is in the way they are forwarded to the closed loop master and The ATMS.

- *Events* are polled on a scheduled basis by the closed loop master and/or The ATMS (typically once per day and late at night when the communication system is not being used for other activities). For example, *Pattern Events* and *Preempt Events* are stored in the controller event buffer and typically uploaded once per day for record purposes.
- *Alarms* are polled more frequently by the closed loop master and/or ATMS so the system is notified quickly when they occur. Alarms must be enabled as both *events* <u>and</u> as *alarms*. Alarms/Events are referenced by number.

9.2.2 Secondary Controller Event and Alarm 1 – 128 (MM->1->6)

See chapter 13 in the 2070 controller manual for a complete alarm listing

9.2.3 Master Controller Event and Alarm 129-256 (MM->9->9)

These additional events and alarms are available in the 2070 master controller under MM->9->9.

Event/ Alarm #	Function
129	Excessive communication errors on downlink
130-132	Blank
133	Excessive number of stations have dropped off-line
134	Master event report buffer is full
135	Master event report buffer has overflowed
136	Master test configuration is active
137	Request master database download
138-152	Blank
153	System Detector Fault - Det # 1
154	System Detector Fault - Det # 2
155	System Detector Fault - Det # 3
156	System Detector Fault - Det # 4
157	System Detector Fault - Det # 5
158	System Detector Fault - Det # 6
159	System Detector Fault - Det # 7
160	System Detector Fault - Det # 8
161	System Detector Fault - Det # 9
162	System Detector Fault - Det # 10
163	System Detector Fault - Det # 11
164	System Detector Fault - Det # 12
165	System Detector Fault - Det # 13
166	System Detector Fault - Det # 14
167	System Detector Fault - Det # 15
168	System Detector Fault - Det # 16
169	System Detector Fault - Det # 17
170	System Detector Fault - Det # 18
171	System Detector Fault - Det # 19
172	System Detector Fault - Det # 20
173	System Detector Fault - Det # 21
174	System Detector Fault - Det # 22
175	System Detector Fault - Det # 23
176	System Detector Fault - Det # 24
177	System Detector Fault - Det # 25
178	System Detector Fault - Det # 26
179	System Detector Fault - Det # 27
180	System Detector Fault - Det # 28
181	System Detector Fault - Det # 29
182	System Detector Fault - Det # 30

183	System Detector Fault - Det # 31
184	System Detector Fault - Det # 32
185	System Detector Fault - Det # 33
186	System Detector Fault - Det # 34
187	System Detector Fault - Det # 35
188	System Detector Fault - Det # 36
189	System Detector Fault - Det # 37
190	System Detector Fault - Det # 38
191	System Detector Fault - Det # 39
192	System Detector Fault - Det # 40
193	System Detector Fault - Det # 41
194	System Detector Fault - Det # 42
195	System Detector Fault - Det # 43
196	System Detector Fault - Det # 44
197	System Detector Fault - Det # 45
198	System Detector Fault - Det # 46
199	System Detector Fault - Det # 47
200	System Detector Fault - Det # 48
201-256	Blank

10 Closed Loop Status Screens

```
        Status Displays
1.Mstr Coor  4.Sys Dets      7.Alms/Evts
2.Subsystem  5.Smthd Dets    8.Polling
3.Fail Cnfgs 6.TR Values
```

10.1 Mstr Coor (Master Coordination) Status Display (MM->9->7->1)

The *Master Coordination Status Display* shows the active configurations and modes of operation transmitted to all secondary controllers in the system.

```
Cnfg....Cor.Pat.Oft.Pln..Cmd..#.AOft.Mci
MTBC    TBC  0   1            0    0   1
MSYS    TBC  0   1            0    0   1
MCLP    TBC  0   1   1   TBC  0    0   1
MTRI    TR   0   1            0    0   1
MTRE    TR   0   1            0    0   1
DNLD    FRE  0   1   1   OFF  0    0   1
FAIL   +SBY  0   0            0    0   1
```

```
Cnfg....Cor.Pat.Oft.Pln..Cmd..#.AOft.Mci
MCLP   -TBC  0   1   1   TBC  0    0   1
MTRI    TR   0   1            0    0   1
MTRE    TR   0   1            0    0   1
DNLD    FRE  0   1   1   OFF  0    0   1
FAIL    SBY  0   0            0    0   1
MTST    SBY  0   0            0    0   1
Cur-MTBC Lock-OFF AOft-OFF SbDet-  0
```

MTBC *Master Time Base Configuration* generated from the current time-of-day (day plan) schedule

MSYS *Master System Configuration* that drives the master and determines how the MCLP will be built.

MCLP *Master Closed Loop Program* sent to all of the secondary controllers

MTRI *Master Traffic Responsive Internal* configuration of the FMS

FAIL *Fail* configuration shows the active fail configuration (if any) from the *Failure Cnfg* table (section 9.1)

MTST *Master Test Configuration* – current status of MM->9->2->1

Cur *Current operating level – MTST (master test), FAIL (fail condition) or MTBC(all other levels)*

10.2 Subsystem (Station Status) Display (MM->9->7->2)

Subsystem (Station Status) displays the current polling status of the stations entered under the Subsystem entry screen. The display shows the defined station number and the current status of one of the four possible communications states for each position.

```
STATION    POS..STN..CURRENT..CHANGE
 STATUS     1     0   NONE
            2     0   NONE
            3     0   NONE
            4     0   NONE
```

The STN value refers to the *Station ID* address programmed in section 2.1.1 for the secondary positions 1-32 that the master is in communication with. You can toggle the CHANGE entry using any number key to REESTABLISH communications or set the station OFFLINE:

OK	The communication to this station is operating OK
RETRY	The station communications failed to answer and the master is trying again.
REESTABLISH	The station is offline and the master is trying to communicate with the local again: Every half hour after a local is offline the master will try to establish communications again.
OFFLINE	Station communications has failed **-** the master has taken the station offline and is no longer polling it.

10.3 Fail Cnfg (Failure Configuration Display)

Screen MM->9->7->3 displays the programmed thresholds from the *Fail Cnfg* table (section 9.1), the current number of failures, and the NEW or programmed number of failures entered from the screen.

```
CATEGORY...THRSHLD..CUR-CNT...NEW
Comm Errs     0        0       0
Stns Failed   0        0       0
Sys Dets      0        0       0
Stop Timng    0        0       0
Coor Fail     0        0       0
Loc Alm 5     0        0       0
Loc Alm 6  +  0        0       0
```

```
CATEGORY...THRSHLD..CUR-CNT...NEW
Stop Timng -  0        0       0
Coor Fail     0        0       0
Loc Alm 5     0        0       0
Loc Alm 6     0        0       0
Loc Alm 7     0        0       0
Loc Alm 8     0        0       0
Stns Offln    0        0       0
```

10.4 Sys Dets (System Detectors) Display

Sys Dets displays the current status of the 48 system detectors and their operating conditions. Each of the detectors will show under the source column where the data in the display is originating.

```
System    Nbr..Src..New...Stat..New..
Detector   1   PRI  PRI   OK    OK
Status     2   PRI  PRI   OK    OK
           3   PRI  PRI   OK    OK
           4   PRI  PRI   OK    OK
           5   PRI  PRI   OK    OK
           6   PRI  PRI   OK    OK
           7 + PRI  PRI   OK    OK
```

The possible sources (**SRC**) of each detector are:

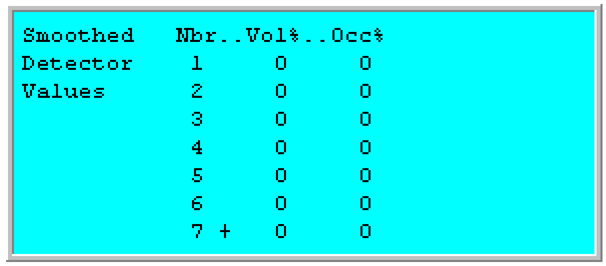
PRI	The master is gathering data from the primary detector defined for this system detector
SEC	The primary detector has failed and the secondary detector is being used in place of the primary detector
SUB	Both primary and secondary detectors have failed and the programmed SUB (substitution) values are being used.

You can manually change the value in the *NEW* column to reset a detector failure. For example, if a **SUB** (substitute) value is being used and the detector failure has been corrected, then select **PRI** or **SEC** to allow the master to begin scanning the system detector again.

Another item displayed in the detector status display is the scanning status of each system detector. The possible status displays for each detector are:

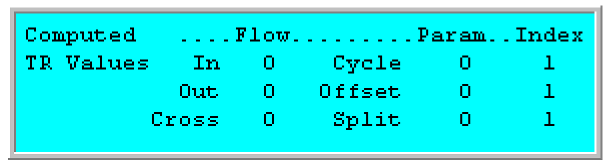
OK	Communications is fine and everything is operating as programmed
RETRY1	First retry communication with the primary or secondary detector.
RETRY2	Second retry communication with the primary or secondary detector.
RESTABLISH	Either the primary or both the primary and secondary detectors have failed and the master is trying establish communications

10.5 Smthd Det (Smoothed Detector) Display (MM->9->7->5)



This real-time screen displays the smoothed values of volume and occupancy for the 48 system detectors assigned to the FMS.

10.6 TR (Traffic Responsive) Values Display (MM->9->7->6)



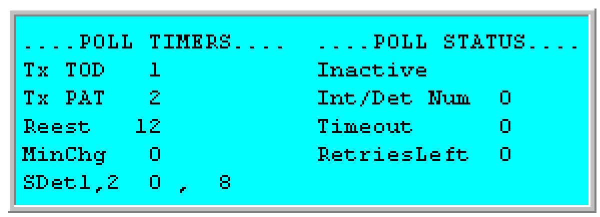
MM->9->7->6 is a display only screen that shows the:

- Real-time flow (V+O) values defined in section 7.1.2
- Calculated cycle, offset and split parameters defined in section 7.1.3
- Calculated cycle, offset and split indexes defined in section 7.1.4

10.7 Alms/Evnts (Alarms / Events) Status Displays

This selection shows the real-time status of the master alarms 128 – 256. Separate menus are also provided to display the last 50 alarms in the alarm buffer and the last 50 events in the event buffer.

10.8 Polling Status Display (MM->9->7->8)



The master polls the secondary stations in the subsystem at specified time intervals. Some poll intervals are fixed while others are adjustable. For example, *Local Sample Time* and *Detector Event Polling* control polling for system detectors (see Master Parameters, Chapter 3). However, most polling operations such as setting the real-time clock are fixed.

Poll frequency is controlled by the use of a ***timer*** that triggers the poll sequence when the timer counts down to zero. Therefore, a poll sequence is a communication task initiated by the master that is controlled by a repeatable countdown timer.

The polling status screen displays the real-time status of the polling ***timers*** and the status of each poll.

The *Polling Status Display* shows the real-time status of the following polls:

- Alarm Buffer, Secondary controllers
- Event Buffer, Secondary controllers
- Transmit the Time-of Day Clock
- Alarm Retry (forwarding alarms to the ATMS)
- Reset (attempt to bring failed detectors on-line)

Polls can be interrupted (and delayed) by higher priority communication tasks. For example, a database upload initiated from the ATMS can interrupt the polling mechanism in the master. When the upload is complete, the master will continue to service it's local master polling sequence. If the alarm or event buffer becomes full, the alarm and event polls are suspended.

The station ID number polled is displayed under the column heading POS and the status under STAT. The position number rests at 0 or 32 for an inactive poll. The status includes ACTIVE, INACTIVE and SUSPENDED. The suspended category applies only to alarm and event polls.

11 Field Management Stations by Example

The preceding chapters defined the various elements related to closed loop operation in the 2070 field master (FMS). This chapter provides programming examples of FMS operation for the following configurations:

- FMS used as a communications hub (no supervisory control)
- FMS used to supervise the controllers assigned to the subsystem

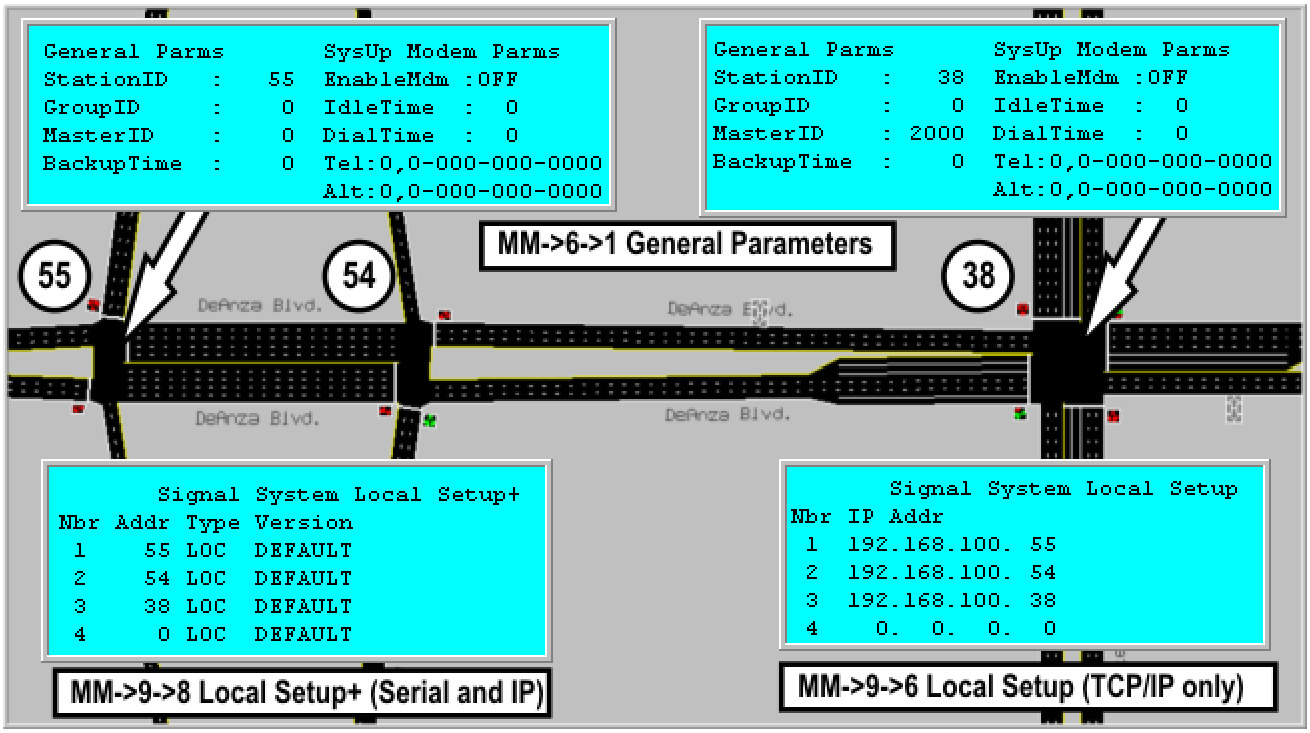
The last section of this chapter provides examples of how the Operational Modes are generated by the master to override the pattern selection in the controllers assigned to the subsystem

11.1 LOCAL Mode – No Supervisory Control

```
Closed Loop Parameters
        Stn Type:    LOCAL
Min Chg Tim(min):       0  Sample Accum  0
Loc Smpl Tm(min):       0  Spare:        0
Tx Err Time(min):       0  Spare:        0
```

The first example presents the minimum programming required to connect a central system to three secondary controllers through a FMS. In this configuration, all supervisory control, clock updates and alarm status is managed from the central system. The *Closed Loop* parameter is turned OFF for all controllers in the subsystem (MM->2->1).

A master database must be assigned a *Master ID* with the secondary controller connected to the central system. In this example, assume that *Master ID* 2000 resides in the controller with *Station ID* 38 as shown below. Note that the *Master ID* need only be assigned to the controller where the master database resides. Secondary controllers 54 and 55 do not need to specify the *Master ID* address. Backup LOCAL Mode is enabled in the master by setting *Stn Type* to LOCAL under *Closed Loop Parameters* (MM->9->1) as shown above.



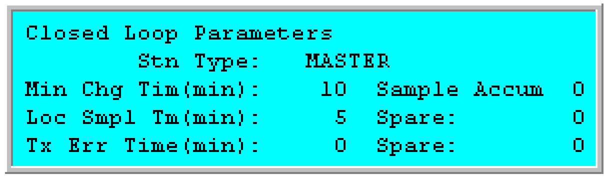
The *Station ID* of each secondary controller (including the secondary in the master), must be assigned under *Local Setup+* (MM->9->8). If an IP based network is used, then each secondary controller IP address in the subsystem must also be assigned under MM->9->6. If no IP addresses are assigned to the master, it is implied that serial based communication is desired through the *SysUp* and *SysDown* ports of the master/secondary controller (in this case Master ID 2000 / Station ID 38). The port binding used for serial based communication normally assigns *SysUp* to Async1 (physical port SP1) and *SysDown* to Async2 (physical port SP2) on the 2070-7A card. The port binding under MM->6->6 in the master/secondary controller for serial based communications is shown below.

```
             Port Binding
Async    Hdwr                 Sync     Hdwr
Chan     Port   Echo/Mode     Chan     Port
Async1:  SP1    NONE    0     Sync1:  SP5S
Async2:  SP2    NONE    0     Sync2:  SP3S
Async3:  SP8    NONE    0
Async4:  OFF    NONE    0
                                          +
```

```
              Port Binding
Opticom: NONE                      -
LoopDet: NONE
GPS    : NONE
SysUp  : ASYNC1
SysDown: ASYNC2
FIO20  : SYNC1
TS2IO  : SYNC2
```

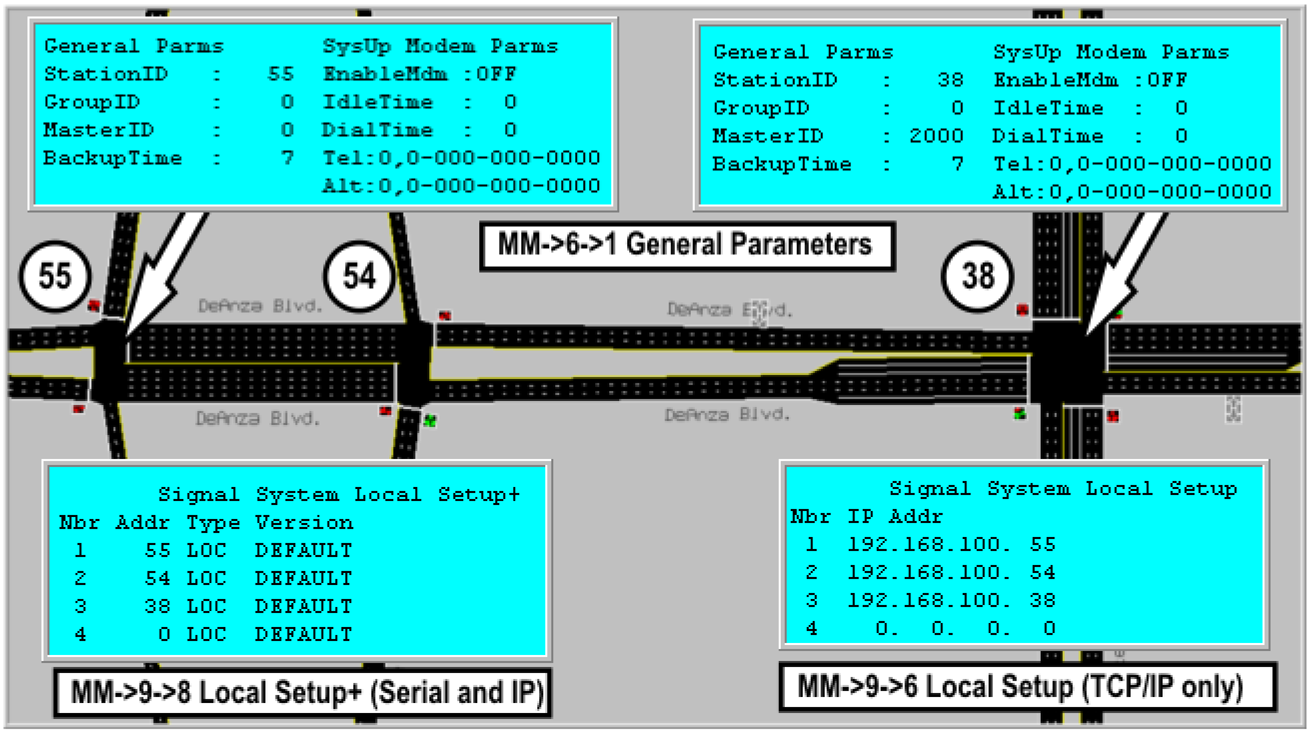
11.2 MASTER Mode – Master Level Supervisory Control

The FMS performs the following functions when the *Stn Type* field under *Closed Loop Parameters* (MM->9->1) is set to MASTER.



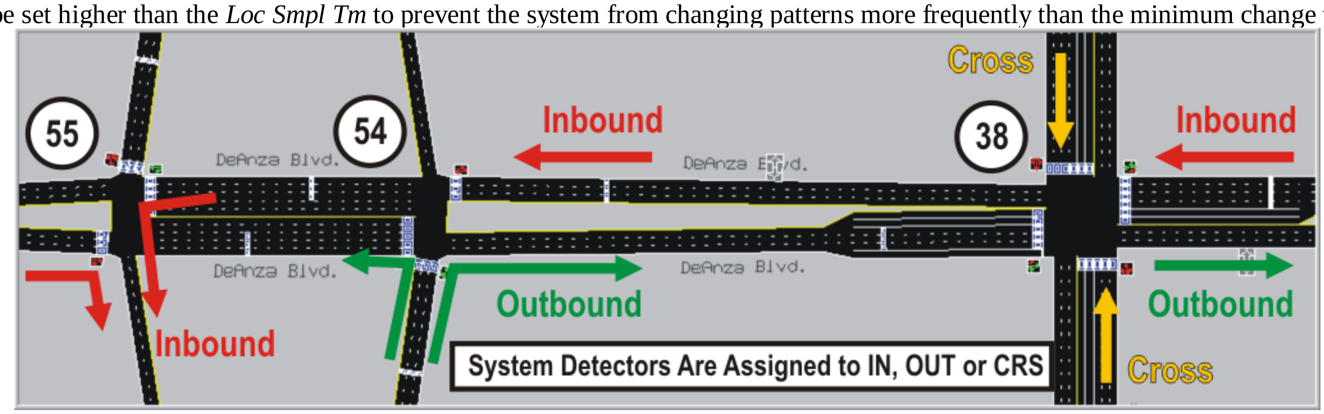
- Time base synchronization between the master clock and the secondary controllers assigned to the subsystem
- *System Detector* data collection (volume and occupancy)
- *Coord Action* based on the master scheduler
- Traffic responsive operation (specific *Coord Action* selected by the master scheduler)
- Alarms and failure detection/recovery

Time base synchronization is automatically performed under MASTER mode. All other functions require additional programming under the MM->9, *System Master*. In this example Master ID 2000 supervises three secondary Station IDs (54, 55 and 38) with *Closed Loop* set ON under MM->2->1 in each secondary. In addition, each secondary requires a *BackupTime* under general com parameters (MM->6->1 as shown below. NTCIP requires that each secondary controller fall back to TBC operation if a valid system message is not received from the FMS before the *BackupTime* expires. Other than *Closed Loop* ON and *BackupTime*, the programming required to establish communications between a master and the secondary controllers assigned to the master is identical.



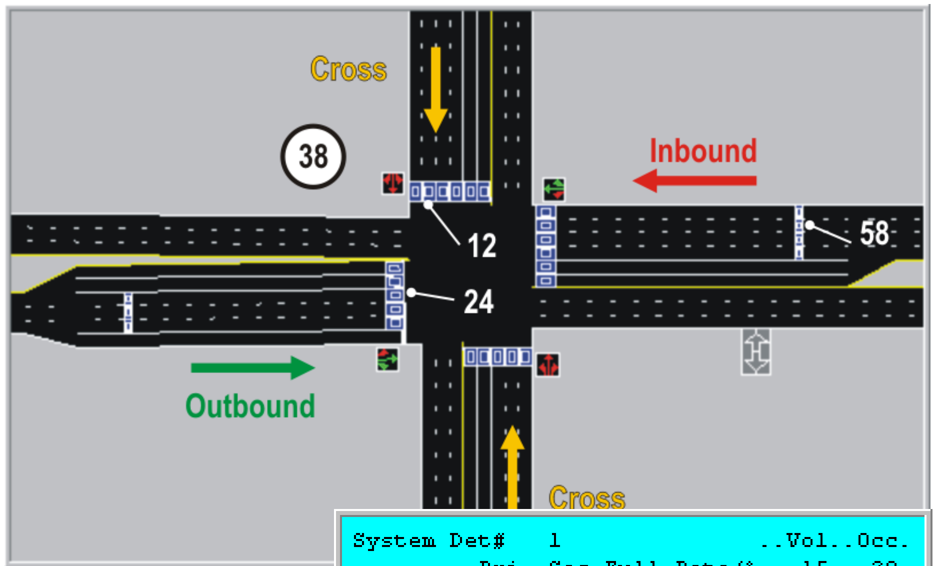
11.2.1 System Detector Assignments (MM->9->3)

System detectors are required to drive traffic responsive operation in the FMS. The master polls the system detectors based on the sample time rate specified under Closed Loop Parameters, MM->9->1 (see *Loc Smpl Tm(min)* above). The *Min Chg Tim(min)* value may be set higher than the *Loc Smpl Tm* to prevent the system from changing patterns more frequently than the minimum change time.



Traffic responsive operation requires a good understanding of the origin and destination of traffic within subsystem and works especially well if there are strong inbound/outbound demand changes that are unpredictable by time-of-day. In the example above, the major generator of traffic resides along the arterial and traffic entering the freeway at *Station ID* 55 is inbound. Outbound traffic exits the freeway and re-enters the arterial at *Station ID* 54. In this example, trips originate from the arterial and destinations are areas south of the arterial serviced by the freeway. Other combinations exist where the origin of trip is primarily from the freeway and also situations when freeway bound trips and arterial bound trips are approximately the same. This example only serves to illustrate the types of system detectors assigned to traffic responsive.

Each system detector must be assigned as as an inbound, outbound or cross street detector under MM->9->3. The *Traffic Responsive Parameters* defined in Chapter 7 calculated from these detectors determine Cycle/Offset/Split (COS) indexes used to lookup the traffic responsive pattern for the subsystem.



The master is capable of polling 48 system detectors from the subsystem.
In this example, we will review three system detectors assigned to the master from *Station ID* 38 as shown to the right. Any of the 64 detectors from the secondary controller may be assigned as one an inbound, outbound or cross street detector in the master.
System detector # 1 in this example is *Detector # 58* from *Station ID* 38 and is assigned as the inbound (IN) detector group.

```
System Det#   1                 ..Vol..Occ.
       ..Pri..Sec Full Rate/%    15    20
Stn ID:    38    0   Fail #1 >   100   100
Det #:     58    0           <     0     0
 Det Group: IN       Sub Val #1    0     0
Smooth Val: 50                2    0     0
                              3    0     0
                  +      Scaler    2     1
```

The traffic responsive algorithm normalizes volume and occupancy to one minute samples before dividing these values with the specified *Full Rate %.* For example, a raw 15 minute volume of 150 vehicles is equivalent to 10 cpm (150 / 15 = 10 counts per minute). If the specified *Full Rate%* for volume is 15, then Vol% is 67%.

Raw occupancy is the total accumulated ON time of the detector over the sample time in seconds. Raw occupancy is converted to occupancy per minute and applied to the *Full Rate %* for occupancy to calculate *Occ%.* Both *Vol%* and *Occ%* are used to calculate the flow parameters that drive the pattern lookup for traffic responsive operation.

Full Rate% values depend on the size and location of the detector from the stopbar and whether the detector samples a single lane or multiple (adjacent) lanes. Compare the Full Rate% values for *System Det# 1* which is a 6'x6' setback detector and System *Det# 2* which is a 30' presence detector located at the stopbar. System detectors should sample occupancy only during the green and yellow (G+Y) intervals of the phase they are assigned to (*Veh Parms+* MM->5->3) unless the detector is upstream of queuing during the red interval.

```
System Det#   2                 ..Vol..Occ.
       ..Pri..Sec Full Rate/%    10    30
Stn ID:    38    0   Fail #1 >   100   100
Det #:     24    0           <     0     0
 Det Group: OUT      Sub Val #1    0     0
Smooth Val: 50                2    0     0
                              3    0     0
                  +      Scaler    2     1
```

Full Rate% values can be used to correlate volume and occupancy data from different size detectors with varying placements relative to the stopbar. *Scaler* values can be used to increase or decrease the relative weight of *Vol%* and *Occ%* for each detector in the flow parameter calculations (see section 7.1.2). Scaling volume:occupancy as 2:1 is a good starting point if the Full Rate% values have been selected to normalize each system detector.

System Det# 3 in this example is located at the stopbar and assigned to the cross street (CROSS) detector group. Failure thresholds may be assigned to test each detector based on maximum and minimum values for *Vol%* and *Occ%.* If a fail condition is detected, the algorithm will attempt to substitute *Vol%* and *Occ%* with the Secondary Det# for the specified Secondary ID address. In these examples, detector substitution is disabled by setting the maximum failure thresholds to 100 and the minimum thresholds to zero.

```
System Det#   3                 ..Vol..Occ.
       ..Pri..Sec Full Rate/%    10    30
Stn ID:    38    0   Fail #1 >   100   100
Det #:     12    0           <     0     0
 Det Group: CROSS    Sub Val #1    0     0
Smooth Val: 50                2    0     0
                              3    0     0
                  +      Scaler    2     1
```

11.2.2 Master Scheduler (MTBC) – MM->9->5

The master scheduler (MTBC) under MM->9->5 is a separate schedule from the secondary controller scheduler (STBC) under MM->4. MTBC is contained in the master database assigned to the *Master ID* and STBC is contained in the secondary controller database assigned to the *Station ID*. Programming the MTBC and STBC schedules is identical with the following two exceptions:

1) The secondary schedule (STBC) in each secondary controller selects actions that set the secondary TBC pattern
2) The master schedule (MTBC) selects actions that set the *Coord* mode and MTBC pattern of the subsystem

```
 # Day  Mo:From-Thru DOM:From-Thru Plan
 1 M-F        01-12         01-31    1
 2 ***        **-**         01-15    2
 3 OFF        00-00         00-00    1
```

Both schedules select a *Day Plan* from the current day-of-week, month of year (MOY) and day-of-month (DOM). *Easy Schedule* programming (MM->9->5->2) is provided in the controller to select the *Day Plan* from these ranges. The same schedule may be viewed and modified from the advanced scheduler (MM->9->5->3).

```
        Day       Month          more~
 #    SMTWTFS  JFMAMJJASOND
 1    .XXXXX.  XXXXXXXXXXXX
 2    .XX.XX.  XXX.XX......
 3    .......  ............
```

Notice in the example above that the *Easy Schedule* day and month range for Event# 2 is labeled as "***". *Easy Schedule* will always display a discontinuous range as three asterisks. The programming for Event# 2 is shown in the *Advanced Scheduler* to the right. Notice how the *Day* and *Month* ranges are continuous for *Event#* 1, but not for *Event#* 2.

```
Plan- 1      Evt Time Actn   Evt Time Actn
Link: 0        1 00:00 100     3 06:00   1
               3 09:00   2     4 16:00   3
               5 19:00   2     6 23:00 100
               7 00:00   0     8 00:00   0
```

The master scheduler selects a *Day Plan* programmed under MM->9->5->4 that selects the current action (Actn). There are 100 separate actions in the MTBC *Action Table* (MM->9->5->5). The MTBC action drives the *Coord* mode of the subsystem while the STBC action selected by each secondary controller sets each local TBC pattern.

```
Actn  Coord..Patrn..
   1   TBC      48
   2   TBC     254
   3   TBC       0
   4   TRI       0
```

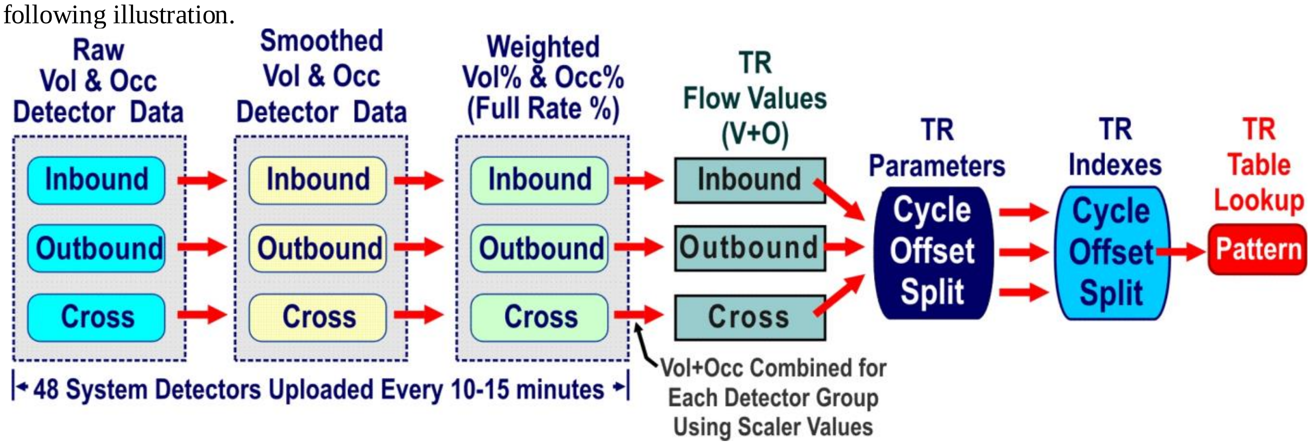
A sample MTBC *Action Table* (MM->9->5->5) is shown to the right. If *Action 1* is active, the current Coord mode is TBC and the MTBC pattern 48 is downloaded to each secondary controller defined in the master subsystem. All secondary controllers with their *Closed Loop* parameter set ON (MM->2->1) will respond to *Sys* pattern 48 from the master. Because Sys has a higher priority than local TBC, the master will effectively override the local pattern generated by each STBC schedule in the secondary controllers. The master scheduler may override the secondary schedules with the NTCIP free pattern (254) or flash patter (255). However, setting *Coord* to TBC and *Patrn* to zero places the master in standby operation, thus giving control to the secondary schedules (STBC) in each local controller.

```
Mode-INTRNL              Coor.Mode
               Cycle Indx-1  TR
                          2  TR
                          3  TR
                          4  SYS
                          5  SYS
                          6  SYS
```

If the current *Action* in the master scheduler is TRI, the pattern generated by the traffic responsive algorithm will be downloaded to the secondary controllers defined in the master subsystem. Under traffic responsive, the *Cycle Index* determines the *Coord Mode* and whether the pattern generated by traffic responsive (TR) or the master system pattern (SYS) is downloaded to the subsystem. This can be used to set the lower cycle levels to run traffic responsive (TR) at the lower cycle levels and TBC (SYS) at the higher levels as shown in the figure to the right (*TR Mode Table*, MM->9->4->3). Setting Coord Mode to SYS in the *TR Mode Table* and *Coord* to TBC with *Pattern* 0 in the MTBC *Action Table* will place the master into standby at that cycle level, reverting all controllers in the subsystem to their local TBC schedules.

11.2.3 Traffic Responsive Operation

Chapter 7 defines the flow parameters and indexes calculated from the inbound, outbound and cross street system detectors that are used to select the traffic responsive pattern. This pattern is downloaded to the controllers defined in the master subsystem when the master time base scheduler (MTBC) calls for traffic responsive (TR) as shown in the last section. This pattern selection process is summarized by the following illustration.



The *Offset Index* selects the current *Offset Table.* The *Cycle Index* and *Split Index* select the TR pattern assigned to the *Offset Table*. An *Offset Index* from 1-2 represents an *inbound* traffic demand based on the inbound and outbound system detectors assigned to the master. An *Offset Index* from 4-5 represents an *outbound* demand in the system and an *Offset Index* equal to 3 is considered average.

In all cases, it is the responsibility of the user to develop timing patterns and populate the lookup tables so that each pattern selected by traffic responsive favors the current Offset Index. Many users vary only the offset values in these patterns to reflect a preferred flow direction along the arterial. However, any parameter assignable to a pattern may be modified by traffic responsive using this process.

The following is an example of three *Offset Tables* (inbound, average and outbound) populated in a master (see section 7.3.3). *Offset Tables* 1 and 5 can be "deselected" by programming their threshold values for *Offset Index* as shown to the right (MM->9->4->7). In this case table 1 will never be selected because the *Offset Index* will always be greater than zero. Table 5 will never be selected because the *Offset Index* will always be less than 100.

Offset Thresholds	Threshold..... Index	Incr..	Decr
	1-2	0	0
	2-3	45	40
	3-4	55	50
	4-5	100	100

These *Offset Tables* were programmed under MM->9->4->1. Patterns in table 2 are inbound, table 3 is average and 4 is outbound.

INT,OFT-2 Spl-Indx.	1	2	3	4	5	6
Cycle Indx-1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6

INT,OFT-3 Spl-Indx.	1	2	3	4	5	6
Cycle Indx-1	1	1	1	1	1	1
2	7	7	7	7	7	7
3	8	8	8	8	8	8
4	9	9	9	9	9	9
5	10	10	0	10	10	10
6	11	11	11	11	11	11

INT,OFT-4 Spl-Indx.	1	2	3	4	5	6
Cycle Indx-1	1	1	1	1	1	1
2	12	12	12	12	12	12
3	13	13	13	13	13	13
4	14	14	14	14	14	14
5	15	15	15	15	15	15
6	16	16	16	16	16	16

Once the *Offset Table* is selected, the *Cycle Index* and *Split Index* may be used to select the pattern from the rows (CI) and columns (SI) of the table. User specified *Cycle* thresholds (MM->9->4-5) and *Split* thresholds (MM->9->4->6) determine the indexes used to perform the table lookup. Larger *Cycle Index* values are used to select patterns with longer cycle lengths.

INT,OFT-3 Spl-Indx.	1	2	3	4	5	6
Cycle Indx-1	1	1	1	1	1	1
2	7	7	7	7	7	7
3	8	8	17	17	18	18
4	9	9	19	19	20	20
5	10	10	21	21	22	22
6	11	11	23	23	24	24

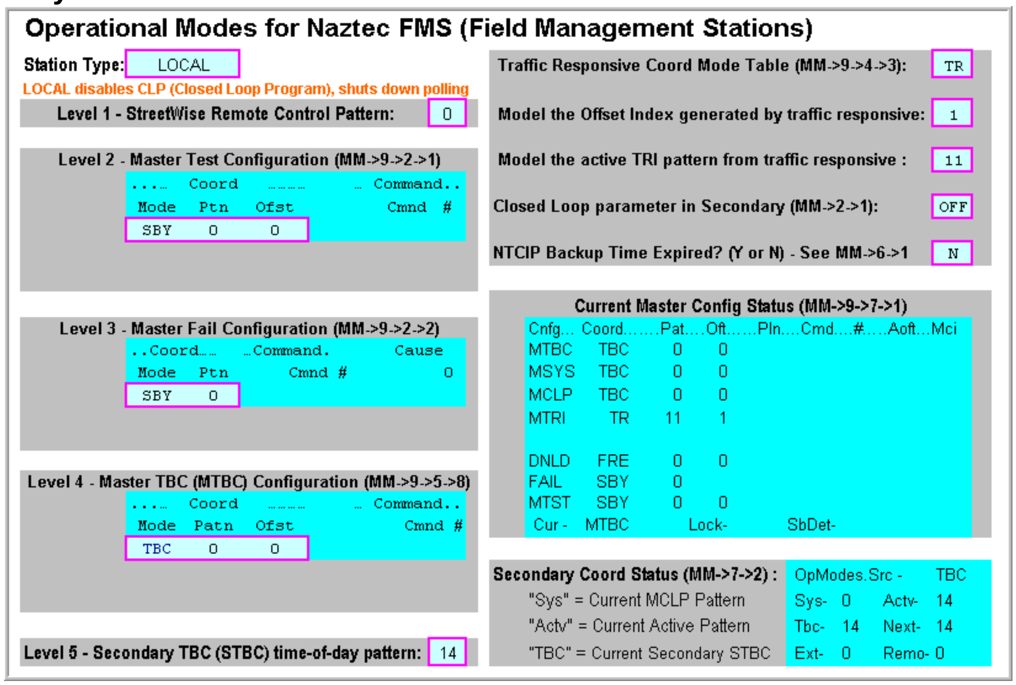
In the example above, the patterns assigned to each table do not vary by column. Therefore, any *Split Index* value will select the same pattern assigned to each row. You could modify the *Offset Table* as shown to the right to select patterns with different splits to favor the arterial or cross street phases. If used, low *Split Index* values should select patterns that favor the arterial splits. High *Split Index* values should select patterns that favor the cross street phases.

11.2.4 Understanding Coord Modes and the ATMS / FMS Control Hierarchy

Cubic | Trafficware has developed an excel spreadsheet that models the *Coord Modes* within the system as presented in section 1.3. The following examples were developed from this spreadsheet to illustrate the status within the master and secondary controllers as changes are made to the control hierarchy within the system.

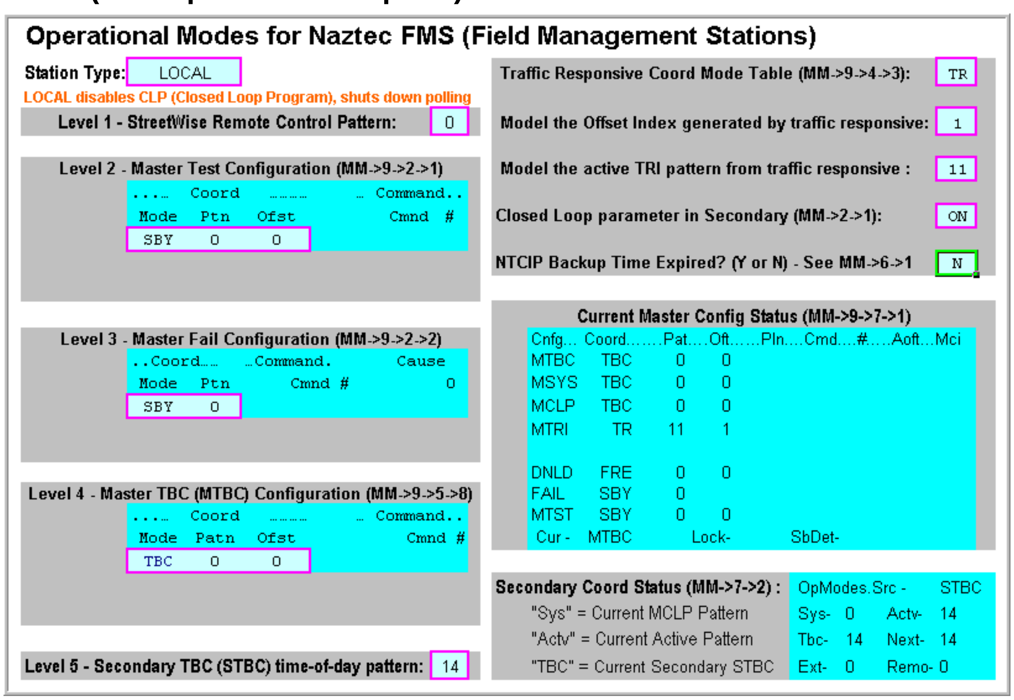
LOCAL Master Example – Secondary TBC Mode

The first example below models the LOCAL master discussed in section 11.1 above. A LOCAL master basically passes all communications to the secondary controllers assigned to the master subsystem. When you set *Station Type* to LOCAL, a message informs you that the "Local disables CLP and shuts down all polling from the master". All control aspects and polling status from the master is shut down because the *Closed Loop* parameter in each secondary controller is turned OFF as shown below. Unless the ATMS overrides the local pattern, each secondary will implement the TBC pattern from the local time base scheduler (OpModes, Src – TBC).



MASTER Example – Master TBC Mode (Backup Time Not Expired)

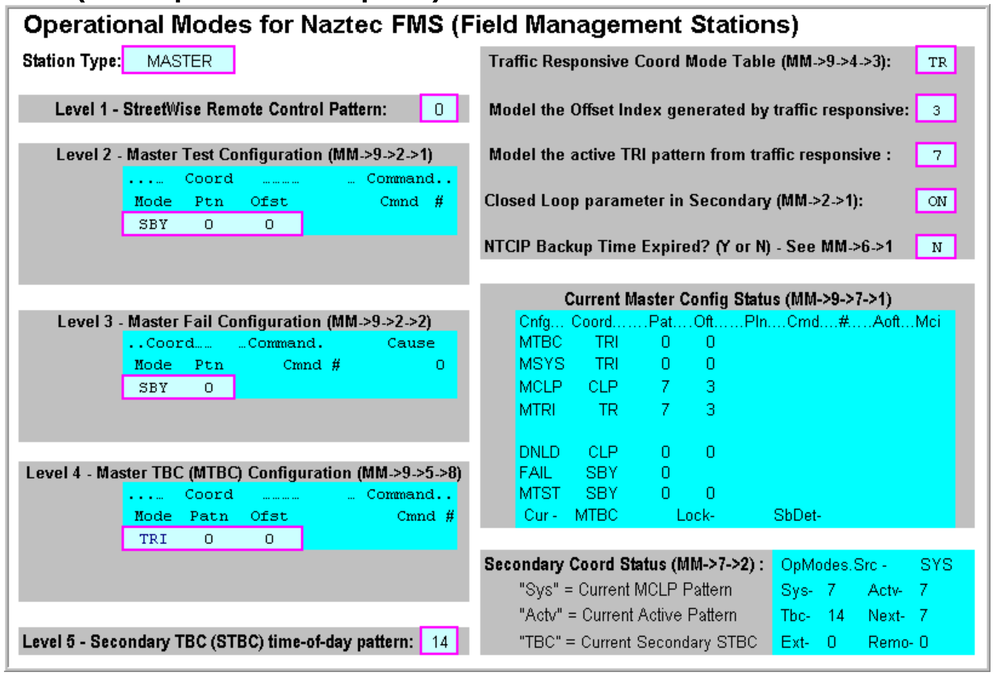
If the *Station Type* is set to MASTER and the *Closed Loop* parameter of the secondary controllers is turned ON, the subsystem will respond to the closed loop MCLP pattern from the master as shown below. In this example, the local Backup Time has not expired. The master scheduler MTBC sets the local time-of-day scheduler by downloading Sys pattern 0. This forces each secondary controller to system TBC (OpModes, Src – TBC).



MASTER Example – Master TRI Mode (BackupTime Not Expired)

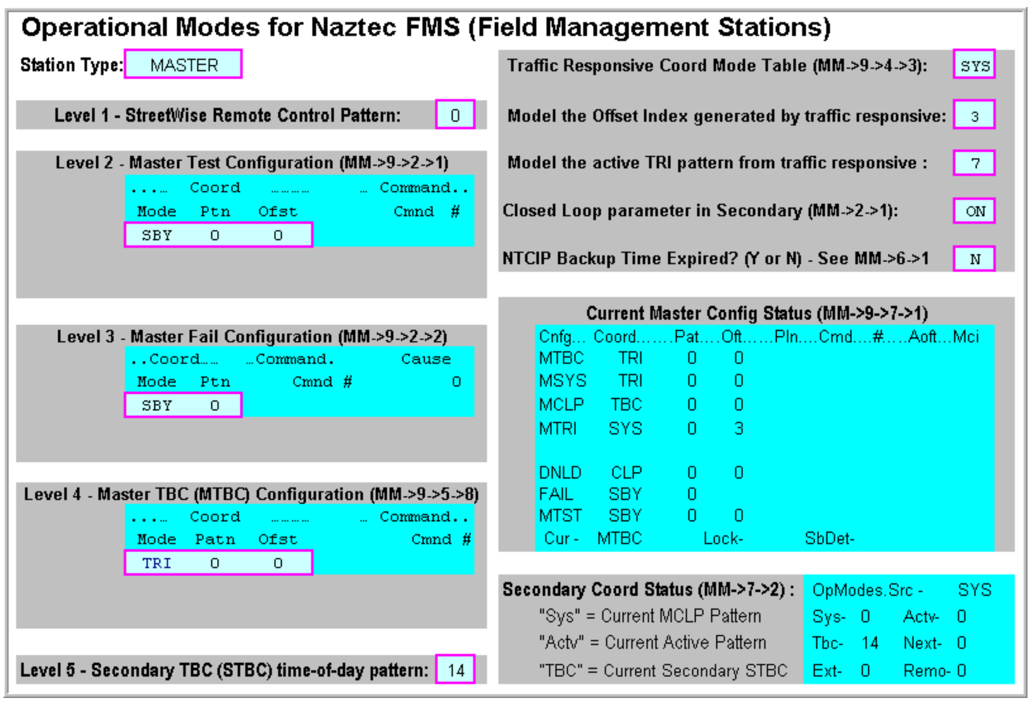
In this example, traffic responsive (TRI) is setting the *Sys* pattern downloaded to the secondary controllers. The spreadsheet lets you model the *Offset Index* and TRI pattern generated by the traffic responsive algorithm in the master.

Note that the *Traffic Responsive Coord Mode* under MM->9->4->3 is set to "TR". Space does not permit showing every combination of modes available from this model; however, if the *Traffic Responsive Coord Mode* is set to "SYS", the master will download the active TBC pattern (Sys=0) reverting the secondary to the local time-of-day schedule.

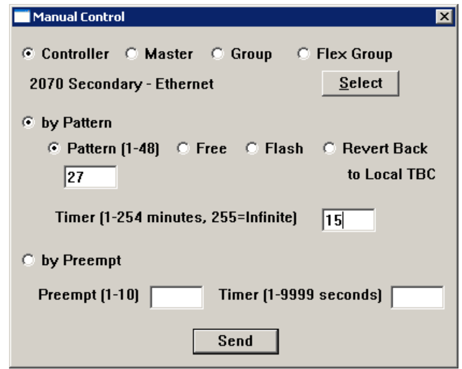


Sys=0 will also be download to the secondary if the *Backup Time* expires. This is a fallback mechanism required by NTCIP to insure that all secondary controllers which lose communication with the master revert back to their local time-of-day schedules.

In each case, the master Sys plan controls each secondary. Therefore the active source of the pattern (OpModes, Src) is SYS.



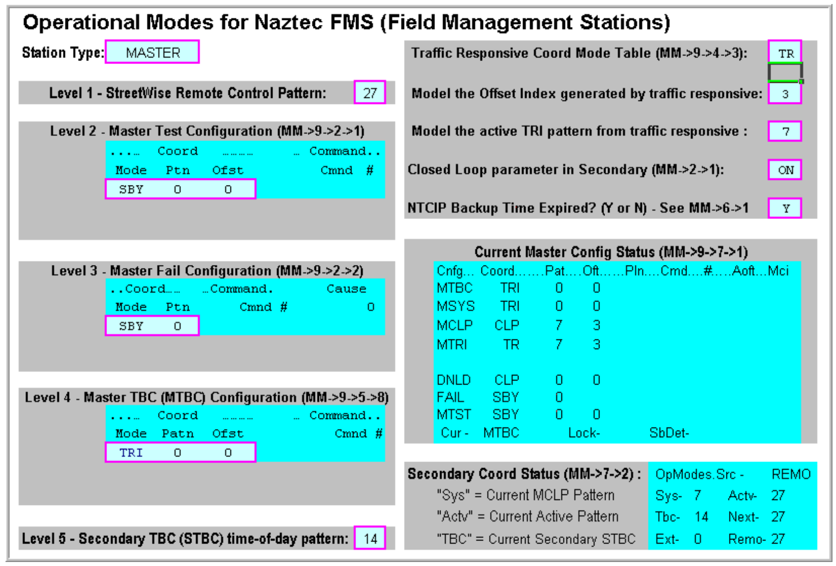
ATMS Remote Control Level (BackupTime Not Expired)



The following example simulates an FMS when the ATMS issues a "remote control" pattern to download Pattern 27 to a secondary controller for 15 minutes. Pattern 27 will stay active until the timeout value downloaded from the ATMS expires in the secondary controller. This timeout value is specified in in minutes from 0-254 (a timeout value of 255 never expires).

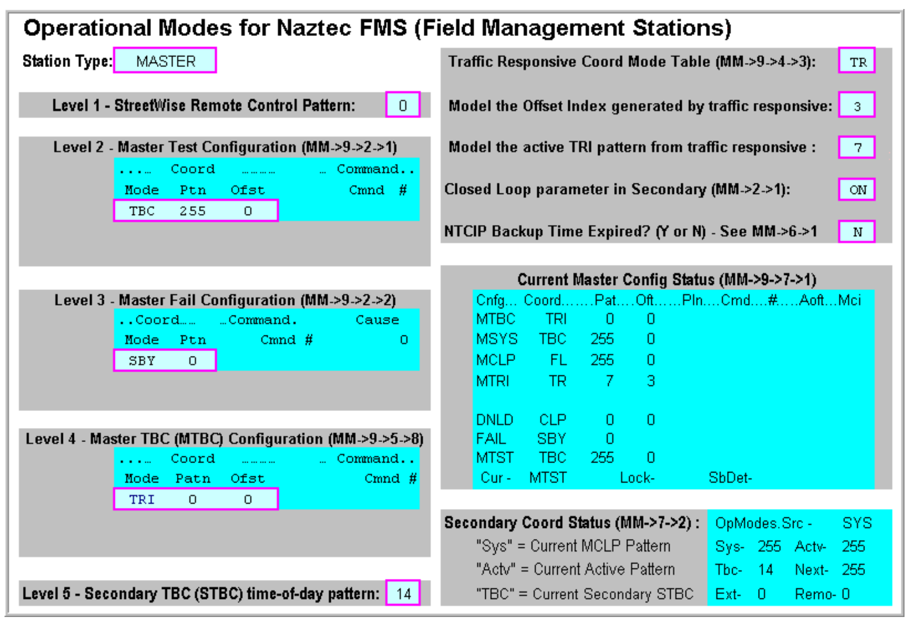
The *Coord Status Screen* (MM->7->2) shows that the source of the active pattern is REMO even though traffic responsive is generating a master Sys pattern 7 and the local STBC schedule is calling for pattern 14.

ATMS Remote Control provides the highest level of control within the hierarchy presented in section 1.3. The only control mode that can override REMO is local TEST (MM->2-1). A local operator entering any valid pattern other than zero overrides any of the operational modes shown on MM->7->2.



Master Test Configuration

The FMS also provides a Test Configuration that provides a user override feature from the field master (FMS) keyboard. In this example, REMO from our last example has been placed in standby (Pattern zero) which passes control down to the *Master Test Configuration* which is next in the hierarchy. The *Master Test Configuration* can override the *Master Fail Configuration* and the *Master TBC Configuration*. In the example below, the *Master Test Configuration* sets the master and secondary controllers to *Pattern* 255 (NTCIP flash).

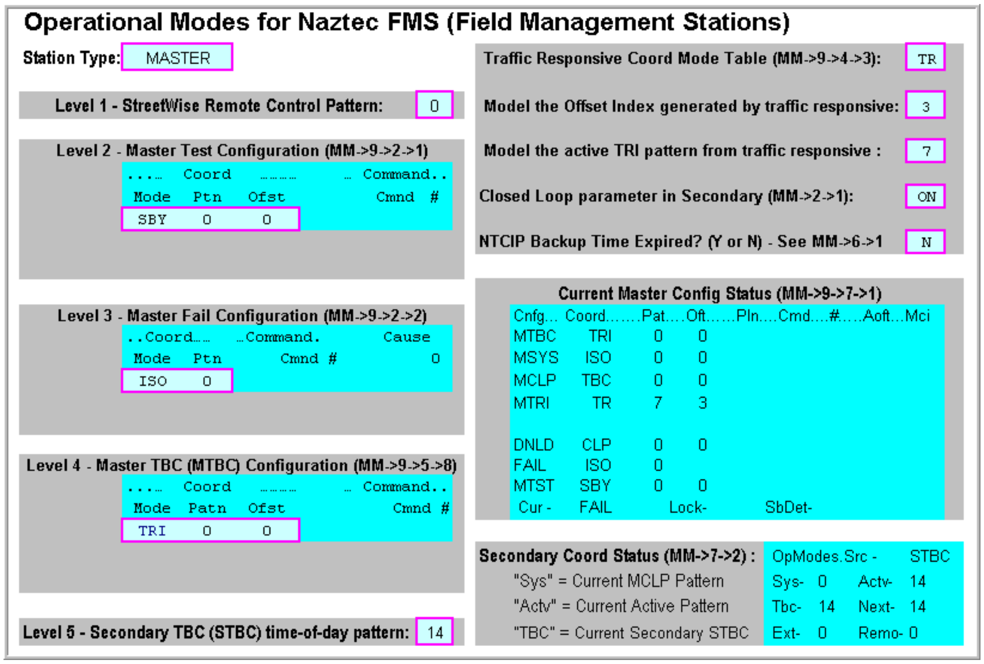


Master Fail Configuration

In this example, the *ATMS Remote Control Pattern* is zero and the *Master Test Configuration* is in SBY (Standby *Pattern 0.* This passes control to the *Master Fail Configuration* which is typically rests in SBY (Stand By) mode until a system failures occurs. (see *Fail Configs*, MM->9->9->1).

Let's assume in this example that a system failure has occurred and that a programmed *Fail Config* has set the *Master Fail Configuration* to ISO mode as programmed into the spreadsheet below. This will cause all secondary controllers defined in the master's sub-system to revert back to their secondary time base schedules (STBC). Any secondary controller that has lost communications with the master will also revert back to STBC when the *Fallback Time* expires.

Notice that the current *Coord Status Screen* indicates that the controller is in STBC and that the SYS pattern (MCLP) has selected the local time base schedule (STBC). Also note that the Cur (Current) status of the master is FAIL because the master is operating under the *Master Fail Configuration* (lower left corner of the Master Config Status Screen).



Operational Modes for Naztec FMS (Field Management Stations)

Station Type: MASTER

Level 1 - StreetWise Remote Control Pattern: 0

Level 2 - Master Test Configuration (MM->9->2->1)
.... Coord .... Command..
Mode Ptn Ofst Cmnd #
SBY 0 0

Level 3 - Master Fail Configuration (MM->9->2->2)
..Coord.... ..Command. Cause
Mode Ptn Cmnd # 0
ISO 0

Level 4 - Master TBC (MTBC) Configuration (MM->9->5->8)
.... Coord .... Command..
Mode Patn Ofst Cmnd #
TRI 0 0

Level 5 - Secondary TBC (STBC) time-of-day pattern: 14

Traffic Responsive Coord Mode Table (MM->9->4->3): TR

Model the Offset Index generated by traffic responsive: 3

Model the active TRI pattern from traffic responsive : 7

Closed Loop parameter in Secondary (MM->2->1): ON

NTCIP Backup Time Expired? (Y or N) - See MM->6->1 N

Current Master Config Status (MM->9->7->1)

Cnfg...	Coord......	Pat....	Oft......	Pln....Cmd....#.....Aoft...Mci
MTBC	TRI	0	0	
MSYS	ISO	0	0	
MCLP	TBC	0	0	
MTRI	TR	7	3	
DNLD	CLP	0	0	
FAIL	ISO	0		
MTST	SBY	0	0	
Cur -	FAIL	Lock-		SbDet-

Secondary Coord Status (MM->7->2) :
"Sys" = Current MCLP Pattern
"Actv" = Current Active Pattern
"TBC" = Current Secondary STBC

OpModes.Src -		STBC	
Sys-	0	Actv-	14
Tbc-	14	Next-	14
Ext-	0	Remo-	0

12 Index