Operations Manual

For

TS2 Closed Loop Systems

Version 50.x/61.x – Cubic | Trafficware 981 TS2 Master

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

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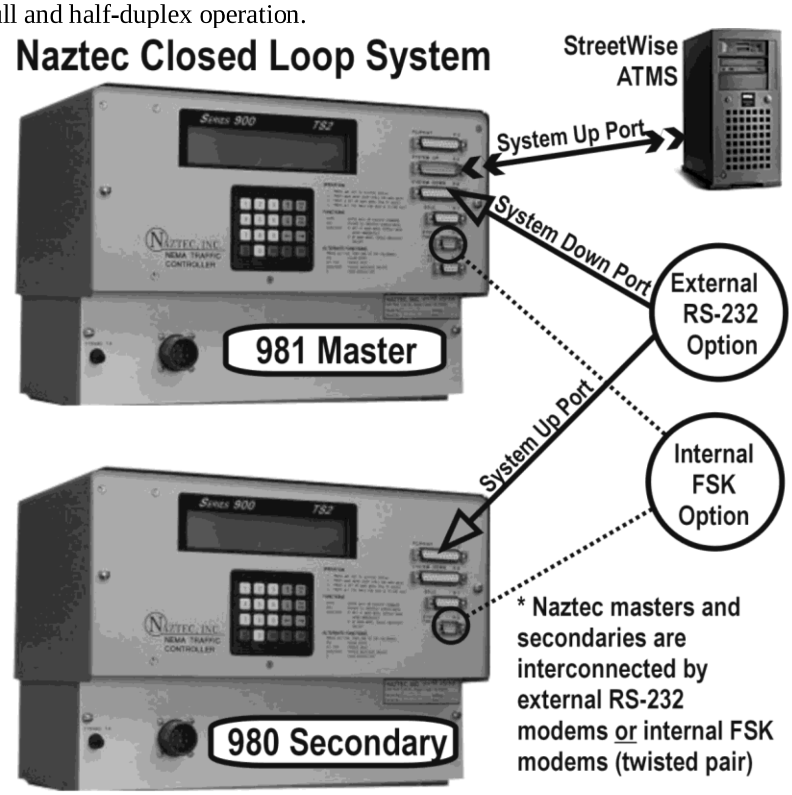
1 Introduction to Closed Loop Operation

Closed loop systems are distributed traffic control systems using on-street masters to share communication and supervisory control with a centralized computer. The Cubic | Trafficware Version TS2 controller software supports the following closed loop master functions within StreetWise or ATMS:

- Local intersection control – 16 phase / 16 overlap
- Time synchronization of interconnected secondary controllers
- Communication hub for all secondary controllers polled by the central system
- Alarm and event polling of secondary controllers forwarded to central
- Detector data (volume and occupancy) polled from secondaries and forwarded to central
- Time-of-day schedule capable of overriding time-of-day schedules in each secondary
- Traffic responsive operation capable of overriding time-of-day schedules using system detector data to select timing plans from a lookup table maintained in the on-street master

1.1 Cubic | Trafficware Closed Loop System

A Cubic | Trafficware closed loop system provides interconnection of a TS2 981 master with up to 32 secondary controllers or sub-master controllers. Communication is provided using RS-232 based modem devices with an adjustable data rate of 600 to 57.6 Kbaud. Cubic | Trafficware internal FSK modems for the TS2 provide data communication rates up to 9600 baud over twisted pair supporting full and half-duplex operation.



1.2 Closed Loop Master / Sub-master System

Each Cubic | Trafficware TS2 981 controller provides a separate StreetWise master and secondary database each addressed by a unique ID address within the ATMS. The master database contains all information related to closed loop and traffic responsive operation. The secondary database stored in a TS2 981 master controller is identical to the TS2 980 secondary controller database.

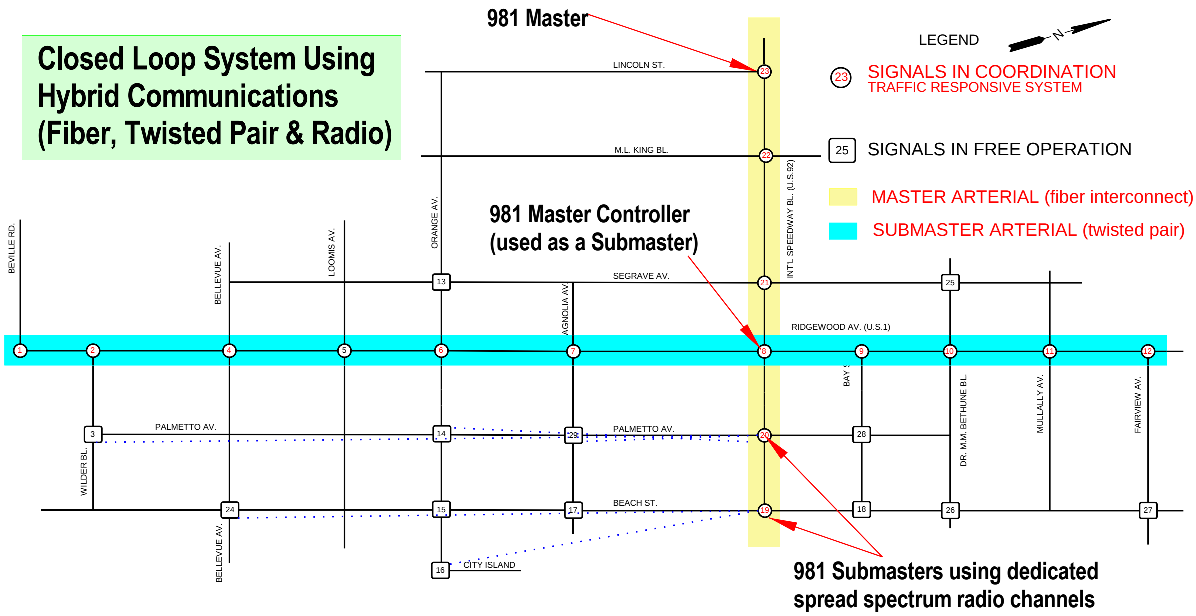
A master controller can also be programmed as one of the following types from MM->9->1:

- LOCAL – the local type disables all master based polling converting the master to a secondary controller
- MASTER – a primary master and is connected directly to the ATMS providing communication with 1-32 secondary and/or sub-masters defined in its subsystem
- SUBMSTR – a submaster is indirectly connected to the ATMS though a primary master

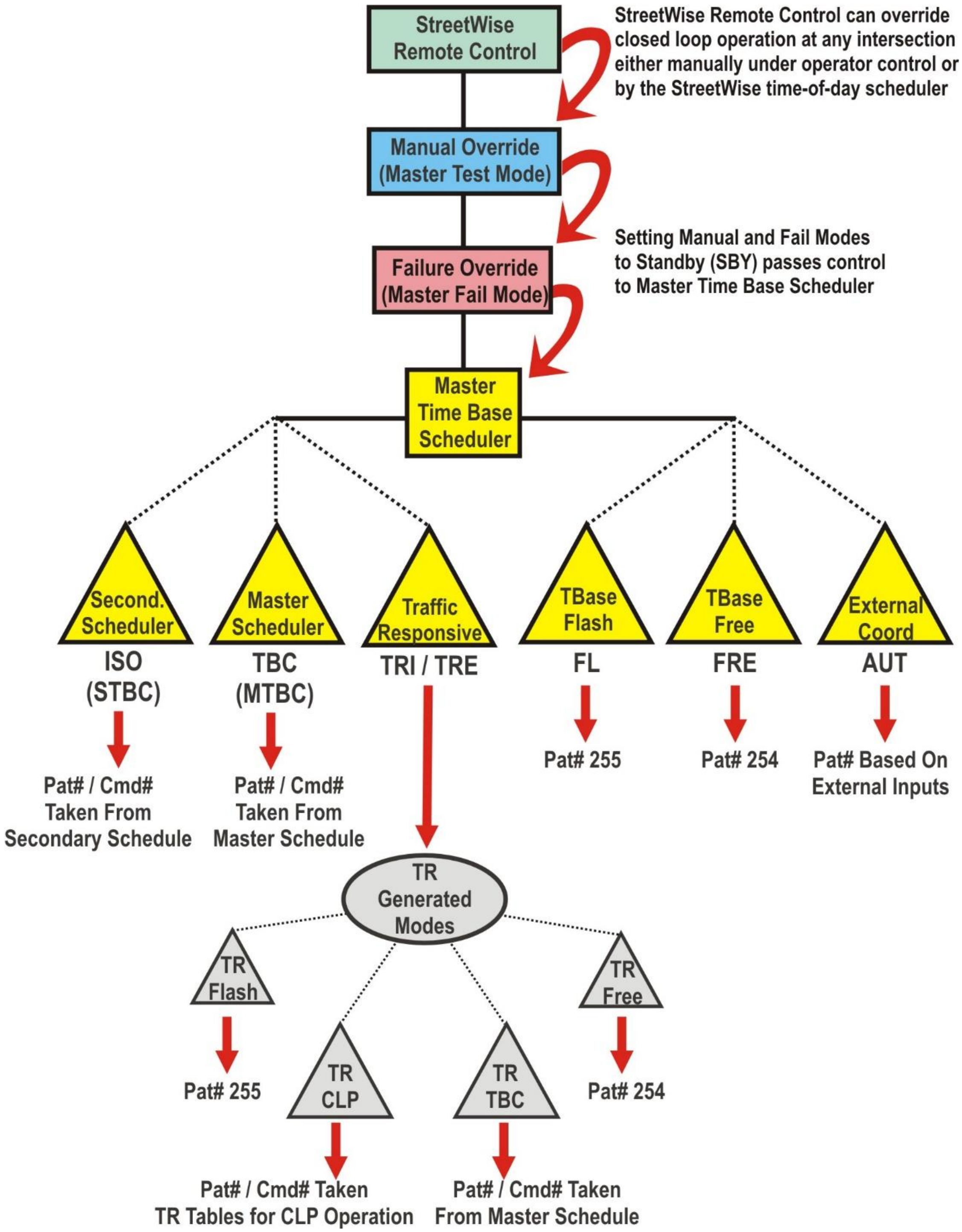
There can only be one primary MASTER per communication channel connected with the ATMS over the master SYSTEM UP port. Each MASTER can communicate with a maximum of 32 secondary or sub-master controllers assigned to its subsystem over the SYSTEM DOWN port.

Each SUBMSTR can communicate with a maximum of 32 secondary controller assigned to its subsystem. This scheme allows large complex networks to be chained together within a single communication path. However, keep in mind that each time data passes through a submaster, communication throughput to the secondary controllers assigned to the sub-master is reduced significantly.

Cubic | Trafficware closed loop masters are designed for a variety of applications and topologies. For example, a submaster located at the intersection of two arterials could be used to interconnect secondary controllers along the “blue” arterial shown below. However, it might be advisable to use separate masters and communication channels for each arterial to maximize bandwidth on the channel. Submasters could also be used in place of secondary controllers to supply a radio link with nearby intersections not interconnected with the system as shown below.



1.3 Hierarchy of Control in a Closed Loop System



StreetWise Remote Control is the highest level of control in a Cubic | Trafficware ATMS, overriding all closed loop control levels imposed by the primary masters and submasters. *StreetWise Remote Control* can be used to place individual intersections in flash, free or coordinated operation by downloading a pattern number and an optional timeout value that reverts the intersection to the current control level imposed by the closed loop system. *Remote control patterns* may be downloaded by the operator or through the StreetWise time-of-day scheduler. Downloading *remote control pattern* "0" effectively passes control from StreetWise to the primary master in the system.

The *Master Test Configuration* is the next highest level of control under the AMTS. The *Master Test Configuration* overrides all current operating levels in the closed loop system. Controllers assigned to the subsystem can be manually set to Flash, Free, a master schedule (MTBC), secondary schedule (STBC) or a traffic responsive pattern. Unless the *Master Test Configuration*, is programmed to stand-by (SBY), all lower control levels are suspended.

The *Failure Override* configuration is set when the master detects a failure in the closed loop system. The threshold (number of failures) for each alarm and the fallback response for each failure condition are user selectable. A closed loop system failure is invoked for the following alarm conditions:

- **Communication Errors** – typically reverts all secondaries back to their to local time-of-day schedule
- **System Detector / Station Failures** – the number of failures typically controls whether the system reverts back to time-of-day operation
- **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

The next level of control, *Master Time Base Schedule* is the heart of the closed loop system. The Master Time Base Schedule (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 level than STBC. The secondary scheduler may be selected as the current operating mode for the subsystem from the master schedule. However, MTBC may also select one of the operating modes below (flash, free or traffic responsive) by time-of-day overriding the secondary schedulers in the subsystem. Closed loop systems are typically designed so that the secondaries in the subsystem revert to their individual secondary schedules (STBC) during a communications during a *Failure Override* condition.

The following operating modes are defined later in chapter 6.

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

The Cubic | Trafficware primary master controller serves as the communications hub and supervisory controller within a closed loop system. Master controllers provide distributed control within a StreetWise ATMS and reduce communication costs by utilizing a variety of communication paths within the system.

2 Closed Loop Communications

The keystroke sequence notation used in this manual follows the same conventions as the Version 50/60 Controller manual. The controller Main Menu is accessed from the MAIN DISP key. The notation used for the Main Menu is "MM".

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

MM: Controller Main Menu

For example, the keystroke sequence **MM->9** begins at the Main Menu and calls for the user to enter the "9" digit from the keypad. The sequence **MM->9** provides access to the controller *Master Database*.

```
            Closed Loop Menu
 1.Parameters  4.TR Tables  7.Status
 2.Mstr Cnfgs  5.Scheduler  8.Subsystem
 3.Detectors   6.Copy Det   9.Alarms/Fail
```

MM->9: Closed Loop Main Menu

2.1 Assigning Secondary ID's to the Master Subsystem

Each master polls a maximum of 32 secondary and/or submaster ***Stations*** assigned to the master subsystem.

In the example screen below, three secondary controllers are interconnected in the master subsystem. The first secondary (Stn-ID 6) is the local controller within the 981 Master. The second (Stn-ID 7) is a secondary controller interconnected to the master. The third (Stn-ID 145) is another master controller programmed as a SUBMASTER that is capable of polling an additional 32 station ID's through it's separate subsystem.

```
Subsystem  ..Stn-ID..Type..Mod/Ver..
 Position- 1      6    LOC   DEFAULT
           2      7    LOC   DEFAULT
           3    145    SUB   DEFAULT
.....
          32      0    LOC   DEFAULT
```

MM->9->8: Master Subsystem

The *Mod/Ver* parameter should be set to DEFAULT unless you are interconnecting a master with Cubic | Trafficware TS1 controllers that require an older communication protocol.

2.2 Master and Secondary Communication Parameters

Communication settings for the master and secondary controllers must be set up properly for closed loop operation. Select MM->6 for either master or secondary controller to access the comm. settings. The following two sections discuss setting the *General Parameters* and *Port Parameters* programmed from this screen.

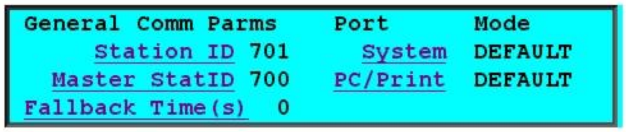
```
            Communication Menu
 1.General Parms  4.Req Downld  7.Status
 2.Port Parms
 3.Txfer Data
```

MM->9->6: Master Communications Menu

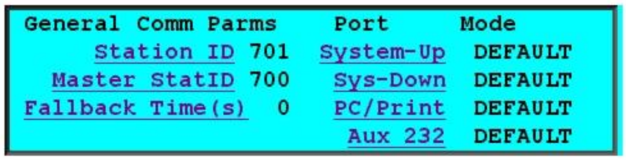
2.2.1 General Comm Parameters

Communication devices in a traffic control system use a "poll-response" mechanism based on a hierarchy between devices. The central system initiates all communication a poll to a secondary controllers either directly or through a master or submaster device. The response from the secondary controller returns to the central system either directly over the same comm channel or through a master or submaster. Controllers spend most of their time listening to messages on the communications channel, listening for their address or Station ID. Each controller in the system must be assigned a unique address to provide a single "poll-response" when the device is polled from central.

Com Port Settings - 980 Secondary



Com Port Settings - 981 Closed Loop Master



MM->6->1: Comm General Parameters

Station ID

The Station ID is a unique identification number (or address) assigned to every master and secondary controller in the system. When the StreetWise ATMS initiates a communication poll to a Station ID, all controllers on the same communication path (including the controllers in the master's subsystem) receive the same poll request. However, the only controller responding to each request is Station ID matching the ID contained in the poll request. This unique controller addressing provides the poll/response system typically found in point-to-point traffic control systems. The value of master station ID may range from 1 to 9999.

Master ID

A master controller requires a separate Master Station ID because within a TS2 981 master there are two distinct databases, one for the master and one for the secondary controller. The StreetWise ATMS polls these two databases separately and defines each database as a separate controller type in the StreetWise database. This allows the user to program the local controller database within the master in the same way as a secondary controller. All master related data under controller menu MM->9 are programmed as a separate controller type with a unique Master Station ID. The value of master station and secondary station ID's may range from 1 to 9999.

Just remember that two ID's must be provided for the master – one for the local controller and a separate ID for the master. Set Master Station ID to "0" for all secondary controllers.

Port Mode Settings

In the sample screen above, the *Mode* of each *Port* is set to DEFAULT which corresponds to the closed loop configuration in section 1. Cubic | Trafficware produces an NTCIP option for Version 50/60 software that allows you to program the com ports for NTCIP mode. However, NEMA is still developing the TSM NTCIP specification for Traffic Signal Masters, so currently you must use the DEFAULT Cubic | Trafficware protocol to communicate with the TS2 981 master. Cubic | Trafficware will provide the TSM NTCIP master protocol whenever, the NEMA specification is approved.

Backup Time

Backup Time (MM->1->2->1) is an NTCIP object used to revert a secondary controller to local time base control if system communication is lost. The *Backup Time* (specified in seconds) is reset by any communication poll whether the source of the poll is from the closed loop master or from the central office (StreetWise). Therefore, it is possible for a secondary controller operating under closed loop to continue to receive polls that reset the clock, poll the controller for status, etc. without receiving an updated closed loop pattern. Cubic | Trafficware provides a separate MIB called *Fallback Time* to insure that the secondary continues to receive pattern commands from the closed loop master.

Fallback Time

Fallback Time is the time (in seconds) that a secondary local controller waits to receive a closed loop or pattern from the master before reverting to time-of-day operation. A *Fallback Time* of 900 seconds (equivalent to 15 minutes) is typically used for secondary controllers operating in a closed loop system. If the secondary "Closed Loop" parameter is set ON (under menu MM->2->1), the secondary must receive a closed loop pattern from the master within the *Fallback Time* to remain under closed loop control. Otherwise, if the *Fallback Time* expires, the secondary will revert back to time-of-day operation using it's internal STBC schedule.

A continuous StreetWise scan (such as the "General Information" scan screen) will tend to lock out all polling from the master. However, the master software can interrupt a continuous StreetWise scan to pass the closed loop pattern to the secondaries to prevent their *Fallback Times* from reverting the controllers to time-of-day operation.

2.2.2 Comm Port Parameters

A master controller provides two RS-232 ports for data communications compared with a single communication port for the secondary controller. The communication ports for the TS2 master and secondary illustrated in section 1 are configured as follows.

- The master *"System-Up"* port connects to the central computer system or a laptop running the StreetWise ATMS. The master *"System-Up"* port settings must match the port settings of the StreetWise computer defined in the com server initialization file (com.ini).
- The master *"System-Down"* port connects to the secondary *"System-Up"* ports. The master recognizes the *"System-Down"* port as either the 25-pin RS-232 connector labeled *"System-Down"* or the 9-pin System FSK port. Think of these two connectors as the same *"System-Down"* port connected to the secondary controller *"System-Up"* port.
- The secondary *"System-Up"* port must be configured to match the comm. port settings of the master *"System-Down"* port.

```
    Port Parameters Menu (Secondary)
1. P-A, System-Up
2. P-2, PC/Print
```

MM->6->2: Comm Parameters – TS2 Secondary Controller

```
    Port Parameters Menu (Master)
1. P-A, System-Up     4.P-C, Aux 232
2. P-B, System-Down
3. P-2, PC/Print
```

MM->6->2: Comm Parameters – TS2 Master Controller

The secondary 980 controller menu does not provide a SYSTEM UP or AUX 232 port because these ports are only provided for the TS2 981 master controller. The PC/PRINT port may be used to connect to a serial printer or PC terminal interface. The AUX 232 port may be use to connect to a Cubic | Trafficware conflict monitor as discussed in the controller and conflict monitor manuals.

2.2.3 Comm Port Parameters By Example

In this example, the *"System-Up"* port on a 981 master is connected to StreetWise at 33.6 K baud (full duplex) and the *"System-Down"* port is connected to a series of secondary controllers over twisted pair using the Cubic | Trafficware internal FSK modem at 9600 baud (full duplex). Note in this example that the communication link from the master to central can operate at a different baud rate as the communication link from the master to the secondary controllers.

```
Port-SYS-UP   ------- AutoDial ----------
Mode DEFAULT  Enable  OFF  Modem  BAS-24
Baud    33.6  DialTime  0  ModmTime    5
MsgTime 3.0   Tel #1  0000 000 0000
Duplex  FULL  Tel #2  0000 000 0000
```

MM->6->2->1: Setting Up the TS2 Master System-Up Port

Note that the recommended *Msgtime* for the master SYSTEM UP port is 3.0 seconds. *MsgTime* for the SYSTEM UP port is a timer used by the master after sending a message to StreetWise. If StreetWise does not reply within 3.0 seconds, the master assumes that StreetWise did not hear the request and will re-transmit the message. *Enable* AutoDial should and "Loc Txmt Alrms" (MM->1->6->7) should be OFF for for closed loop operation. AutoDial features only apply to isolated secondary controllers programmed to dial-up StreetWise to report alarms. Otherwise, a secondary controller could disrupt communications when it attempts to report an alarm at the same time that StreetWise is in the process of polling other intersections.

```
Port-SYS-DOWN ------- AutoDial ----------
Mode DEFAULT  Enable  OFF  Modem  BAS-24
Baud    9600  DialTime  0  ModmTime    5
MsgTime 1.5   Tel #1  0000 000 0000
Duplex  FULL  Tel #2  0000 000 0000
```

MM->6->2->2: Setting Up the TS2 Master System-Down Port

Note that the recommended *Msgtime* for the master SYSTEM DOWN port is 1.5 seconds. *MsgTime* for the SYSTEM DOWN port is a timer used by the master after requesting a message from a secondary controller. If the secondary controller does not respond within 1.5 seconds, the master assumes that the secondary did not the request and will re-transmit the message.

```
Port-SYS-UP   ------- AutoDial ----------
Mode DEFAULT  Enable  OFF  Modem  BAS-24
Baud    33.6  DialTime  0  ModmTime    5
MsgTime 1.0   Tel #1  0000 000 0000
Duplex  FULL  Tel #2  0000 000 0000
```

MM->6->2->1: Setting Up the TS2 Secondary System-Up Port

Note the recommended *Msgtime* of 1.0 seconds for the secondary SYSTEM UP port. *MsgTime* is a timeout value used by the secondary after transmitting information to the master. If the master has not responded in 1.5 seconds, the secondary will assume that the master did not hear the message and will re-transmit.

Controller Type	Communication Port	Recommended MsgTime (sec.)
TS2 981 Master	SYSTEM UP	3.0
TS2 981 Master	SYSTEM DOWN	1.5
TS2 980 Secondary	SYSTEM UP	1.0

Summary of Recommended MsgTimes for Closed Loop Operation

2.2.4 FULL vs. HALF Duplex Settings

The com parameters FULL and HALF duplex seem quite confusing to the new user. The difference between FULL and HALF duplex is best explained by analogy comparing telephone communication (FULL duplex) with two-way radio communication (HALF duplex). The sender and receiver can both “talk” at the same time over telephone whereas only one party can be transmitting by radio while the other party “listens”.

In a similar way, communication between a master and secondary controller is FULL duplex if both master and secondary are allowed to transmit data while the other device is also transmitting data. HALF duplex communication requires that the secondary wait until the master has finished transmitting data before sending data back to the master.

FULL duplex communication over twisted pair interconnect requires one pair for transmit/receive between the master and secondary and a separate pair for transmit/receive between the secondary and the master controller.

HALF duplex communication allows a single communication pair to share transmit and receive messages between the master and secondary controllers.

3 Master and Secondary Parameters

3.1 Master Controller Parameters

```
Closed Loop Parameters
  Master Station ID:  5
       Stn Type:    MASTER
Min Chg Tim(min):     1  Sample Accum  10
Loc Smpl Tm(min):    10  OnLine Evnt    X
Tx Err Time(min):     0  Spare:         0
  Det Event Poll:    ON  Spare:         0
Mstr Ovrd Scan Tm     5
```

MM->9->1: Closed Loop Parameters

Master Station ID

The *Master Station ID* is the same value discussed above under controller menu MM->6->1. The value of master station ID may range from 1 to 9999.

Station Type

The *Stn Type* can be toggled through MASTER, LOCAL and SUBMSTR.

The MASTER type identifies the TS2 981 master as the primary master controller in the subsystem. This initiates master polling of all secondary controllers (station ID's) defined in the master subsystem. The master polls the secondaries for alarms, detector data and status and buffers alarm and event data until polled by StreetWise.

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

The SUBMSTR type allows the master to operate as a "subordinate" master to another MASTER on the same communication channel. This scheme allows a MASTER to communicate with an additional 32 secondary controllers through a SUBMSTR. Submasters are discussed later in this documentation.

Minimum Change Time

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

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.

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.

Detector Event Poll

This value turns detector event polling on and off. Turn detector polling off if you want the closed loop system to respond to the MTBC (master schedule) without polling any system detectors for traffic responsive operation.

Mstr Ovrd Scan Tm

Master Override Scan Time (0 – 99 minutes) allows the master to interrupt a continuous poll from central in order to poll the secondary controllers in it's closed loop system. *Master Override Scan Time* allows the master to interrupt a StreetWise scan to prevent the *Fallback Time* from expiring and reverting the secondary controllers to STBC.

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 StreetWise. 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 StreetWise at 15-minute intervals.

Online Evnt

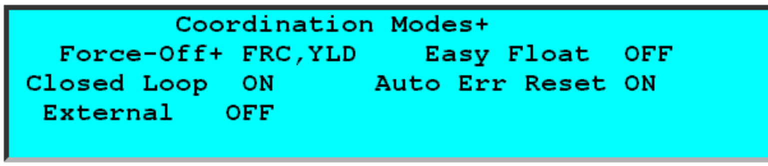
The *Online Event* parameter controls how the closed loop master sets the Station Off-line event (#133) reported to central. If the *Online Event* parameter is turned ON, then the master will report this event whenever any secondary in the subsystem that changes from “off-line” to “on-line” or vice versa. The event includes the time-stamp, the master station ID of the master that recorded the event, the secondary station ID of the station whose online/offline status changed, and the current status of the secondary station.

If the *Online Event* parameter is turned OFF, then the “Station Off-line” event (# 133) is generated when the first station in a master subsystem goes “off-line”. The alarm/event can be thought of as "at least one station is offline" or "all stations are on-line". The alarm forwarded to central and the alarm will not be reset until all intersections in the subsystem are return to the on-line state.

3.2 Secondary Controller Closed Loop Parameters

These controller settings are required for closed loop operation with TS2 980 secondary controllers.

3.2.1 Closed Loop Setting (Under Coord Modes+)



MM->2->1: Coordination Modes+ (right menu)

Setting *Closed Loop* ON allows the master controller’s DNLD (download) configuration to override the secondary time-base control schedule (STBC). Set this parameter ON if you want the secondary controller operation to be supervised by a 981 master or sub-master controller.

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 is you want the secondary included in the subsystem for clock updates and status and want all control to be derived STBC.

Also note that *External* must be programmed ON if you want the master and secondary controllers to select timing plans from external inputs (AUT mode discussed later in this documentation). This *External* feature allows the master to be integrated in older interconnect systems using external control lines to select cycle, split and offset.

3.2.2 Detector Sampling Period

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.

4 Master Time Base Scheduler

The *Master Time Base Scheduler* (MTBC) is the heart of the closed loop system because the master scheduler selects the coord mode for all secondary controllers in the closed loop "sub-system". The master scheduler (MTBC) has a higher priority than the secondary schedules (STBC). Therefore, MTBC decides whether to run a time-of-day pattern from it's own schedule or the secondary schedules or to enable traffic responsive operation, external coordination, flash or free operation.

Every secondary controller in the subsystem responds to master closed loop commands 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 (see section 3.2.1). Secondaries with the *Closed Loop* option turned OFF operate under their own secondary scheduler (STBC).

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

```
      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
```

MM->9->5: Master Time Based Scheduler (MTBC)

4.1 NTCIP Based Time-of-Day Schedules

The master date and time can be set under the MTBC menu (MM->9->5->1) or the STBC menu (MM->4->1).

```
Set Date & Time
            Date      Day    Time    Secs
 Current    05-29-01  TUE    02:44    27
  Set To    00-00-00         00:00    00
```

MM->9->5->1 or MM->4->1: Set Date & Time

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 calndar 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.

```
 #  Day   Mo:From-Thru  DOM:From-Thru  Plan
 1  ALL      01-12         01-31        1
 2  OFF      00-00         00-00        1
 3  OFF      00-00         00-00        1
 4  OFF      00-00         00-00        1
 5  OFF      00-00         00-00        1
 6  OFF      00-00         00-00        1
 7  OFF      00-00         00-00        1
.....
95  OFF      00-00         00-00        1
```

MM->9->5->2: MTBC Easy Schedule

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  XXXXXXX   XXXXXXXXXXXX
  2  .......   ............
  3  .......   ............
  4  .......   ............
  5  .......   ............
  6  .......   ............
  7  .......   ............
....
 95  .......   ............
```

```
<-       Date  1         2         3   Day
     #  1234567890123456789012345678901 Plan
     1  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   1
     2  ...............................   1
     3  ...............................   1
     4  ...............................   1
     5  ...............................   1
     6  ...............................   1
     7  ...............................   1
.....
    95  ...............................   1
```

MM->9->5->3: MTBC Advanced Schedule

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.

Plan-24	Evt	Time	Actn	Evt	Time	Actn
Link: 0	1	00:00	0	2	00:00	0
	3	00:00	0	4	00:00	0
	5	00:00	0	6	00:00	0
	7	00:00	0	8	00:00	0
	9	00:00	0	10	00:00	0
	11	00:00	0	12	00:00	0
	13	00:00	0	14	00:00	0
	15	00:00	0	16	00:00	0

MM->9->5->4: MTBC Based Day Plans

"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 <u>coord</u> 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	Pattrn	Aux-123	Spec-12345678
1	1	...	....
2	2	...	....
3	3	...	....
4	0	...	....
5	0	...	....
6	254	...	....
7	255	...	....
....			
100	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 254 or 255 places all controllers in the subsystem to FREE or FLASH from the master
- Selecting TRI runs Traffic Responsive from the internal TR calculations in the master
- Selecting TRE runs Traffic Responsive from the external TR calculations in the master
- Selecting TBC mode allows you to specify Pattern, Offset (Ofst) and Command # in the MTBC overriding the coordination pattern in the secondary controllers time base control schedule (STBC) if the secondary Closed Loop parameter is ON (section 3.2.1).

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

4.3 Master TBC Commands (Command #)

MTBC Commands are specified by "Command #" in the *Action Table* discussed in section 4.2. The *Command #* is defined in the *Master Time Base Scheduler* under menu MM->9->5->6.

```
MTBC Cmds   #.Sub_SDet..AOF..Lock
             1        1   ON   ON
             2        1   OFF  OFF
             3        1   OFF  OFE
...
            32        1   OFF  OFF
```

MM->9->5->6: MTBC Commands

Substitution System Detector (Sub_SDet)

Each system detector provides 3 separate min and max thresholds to test for detector failures. In addition, each detector provides 3 substitution values for volume and occupancy if the current sample lies outside of the min and max range (failed detector). See section 6.1 for more information on detector failure ranges and substitution values.

Accumulated Offset (AOF)

Accumulated Offset adjusts the offsets of secondary controllers tied to a submaster so the signals along the two crossing arterials can be synchronized.

For example, consider the two arterials shown in section 1.2 under coordination with a common cycle length. The submaster is synchronized to either the beginning or end of the Coord-Ø associated with the master arterial. The *Accumulated Offset* adjusts the offsets of the secondaries on the crossing arterial to "sync" with a phase perpendicular to the Coord-Ø. This adjustment is necessary to synch the offsets on the cross arterial correctly with the offsets on the master arterial.

Lock

The internal traffic responsive (TRI) calculations and external traffic responsive (TRE) calculations are performed simultaneously in the TS2 981 master. Typically, TRI is called by an action in the primary master MTBC and TRE is called by an action in the sub-master MTBC. This allows the primary master to calculate the Cycle Index for the entire system if *Lock* is set forcing the sub-master to use the primary master's Master Cycle Index (Mci) for the TRE calculation. The term TRE (external traffic responsive) operation refers to a master that derives the Mci from an external source. Since the primary master does not obtain the Mci from an external source, it must use the TRI (internal traffic responsive) calculations.

Therefore, if *Lock* is set, the submaster selects a cycle length in it's TRE (external traffic responsive) calculation using the same Master Cycle Index (Mci) calculated by the primary master running under TRI (internal traffic responsive) mode. This allows a sub-master to select a cycle length under traffic responsive operation that follows the cycle length selected by the primary master. The traffic responsive calculations will be fully discussed in Chapter 7.

The following Lock modes can be used to control how tightly coupled the sub-master is to the primary controller:

- OFF - Lock is disabled, but TRE continues to be based on the Mci from the higher level (primary) master.
- ON - TRE is calculated from the MCI, offset, and split index downloaded from the primary master
- OFT - The *offset* downloaded from the primary master is used for closed loop operation
- OFTE - TRE is calculated using the MCI, download offset, and the internal split index

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 and TRE are two forms of traffic responsive (TR) operation covered in depth in chapter 7. TR Internal programming refers to the primary master controller and TR External refers to a sub-master deriving the master cycle index (Mci) from the primary master.

It is also possible for a sub-master to run under TRI mode and "break cycle lengths" with the primary master. TRI and TRE programming is accessed from MM->9->4 where the selection INTRNL or EXTRNL is selects either the internal or external traffic responsive tables.

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). TRI operation can be called from the primary master or a sub-master defined in the subsystem.
TRE	Selects pattern/offset from the Traffic Responsive External program (see MM->9->4->EXTRNL). This mode only applies to sub-masters. The Lock command (section 7.1.4) can be used to force the sub-master to use the master cycle index (Mci) calculated by the primary master.
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

Local intersection detectors may be assigned as system detectors in the closed loop master. 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 values for TRI and TRE modes of operation.

The Version 50/60 controllers provide a maximum of 64 detectors inputs following NTCIP object definitions. However, only vehicle detectors 1 – 16 can be assigned as system detectors in the TS2 Master if you are using Ver 50/60 software. If using Version 61 software than any of the 64 local detectors may be utilized.

Customers are currently using TS2 (type 2) controllers in TS-1 cabinets and providing system detector inputs through the D-connector or via the TS2 mode settings. TS2 detector racks and BIU's may also be used in type 1 and type 2 cabinets to provide up to 64 detectors per intersection. However, many agencies do not provide separate detector channels for each travel lane to insure accurate count measurement for traffic responsive operation.

TS2 secondary controllers can store a maximum of 99 volume and occupancy samples. This allows the controller to store a 24 hours of data (15-minute samples) before the data is overwritten by the next day sample. As noted in sections 2.3 and 2.4.2, the *Local Sample Time* and *Vol/Occ Period* must be the same.

6.1 System Detector Assignment

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#.

```
System  Det#   1                 ..Vol..Occ.
        ..Pri..Sec   Full Rate/%   15    40
Stn ID:   7      0     Fail #1 >  100   100
Det #:   16      0             <    0     0
 Det Group:  IN        Fail #2 >  100   100
Smooth Val:  50                <    0     0
                      Fail  #3 >  100   100
                               <    0     0
                      Sub Val #1    0     0
                               2    0     0
                               3    0     0
                          Scaler    2     1
```

MM->9->3->DET#: System Detector Detectors 1-32

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.

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 *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:

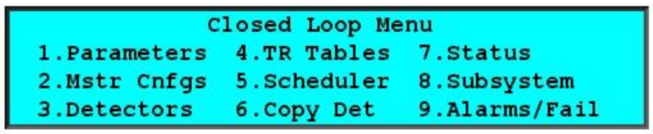
Volume (Veh/Min)	%Occupancy
2	1.66
5	4.16
10	8.33
15	12.5
30	25

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

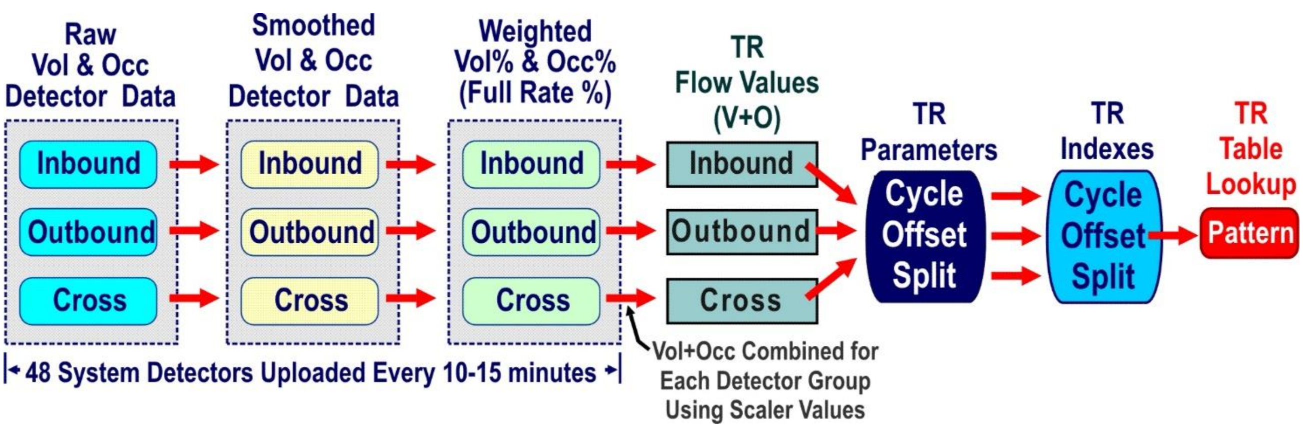
The detector programming required for TR (Traffic Responsive) operation was covered in Chapter 6 (item 3. on the closed loop main menu). The TR Tables are accessed from item 4 on the CLP main menu.



MM->9: Closed Loop Main Menu

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 are summarized as follows:



Traffic Responsive Calculations Performed by the Closed Loop Master to Select a Traffic Responsive Pattern

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.

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

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
...
             48     0     0
```

MM->9->7->5: Real-time Smoothed Detector Values

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* (kx) and a volume *Scaler* (cx). *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.

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

MM->9->7->6: Real-time TR Flow Values (Greatest V+O by Direction)

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. 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 (FV)* 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 FV <or> Max. Outbound FV

Offset Index = ((Out FV – In FV) / (Out FV + In FV)) * 50 + 50

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

7.1.4 Cycle, Offset and Split Index

The TRI and TRE 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 increased during the last 15 minute sample period from 52% to 55%. A lookup from the increasing 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.

Submaster TRE Operation and Lock Mode

A closed loop master maintains two separate traffic responsive calculations at the same time (see Chapter 5):

- TRI (Traffic Responsive INTRL) **-** used by a primary master to select pattern for the master subsystem.
- TRE (Traffic Responsive EXTRNL) **-** used by a submaster to select a pattern for the submaster's subsystem

The MTBC scheduler in the master and submaster is used to select either traffic responsive calculation (TRI or TRE) by time-of-day. "Locking" controls whether a submaster follows the master generated pattern (Mci) or uses its own traffic responsive pattern.

```
        Traffic Responsive Tables
1.Plan Table   3.Mode Table   5.Cyc Thr
2.Cmnd Table   4.Copy Tables  6.Spl Thr
  For? INTRNL                 7.Oft Thr
```

MM->9->4: Master Traffic Responsive Tables

Menu MM->9->4 above accesses both INTRNL and EXTRNL traffic responsive databases (be sure to toggle the value "For?" in the above menu to select the desired database).

Keep in mind that each primary master and submaster in the system performs a separate TRI (traffic responsive internal) calculation and TRE (traffic responsive external) calculation. Each TRI and TRE calculation is based on a different set of threshold tables to calculate a separate *Cycle, Offset and Split Index.*

A primary master typically runs TRI to calculate an internal "Master cycle index", (Mci) from the system detectors assigned to the primary master subsystem. A submaster may run TRI to calculate it's own Mci or apply TRE and use the external Mci from the primary master. The following *Lock* modes control the coupling between a primary master cycle index and submaster cycle index:

- OFF **-** Lock is disabled, but TRE continues to be based on the Mci from the higher level (primary) master.
- ON – TRE is calculated from the MCI, offset, and split index downloaded from the primary master
- OFT – The *offset* downloaded from the primary master is used for closed loop operation
- OFTE **-** TRE is calculated using the MCI, download offset, and the internal split index

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. 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":

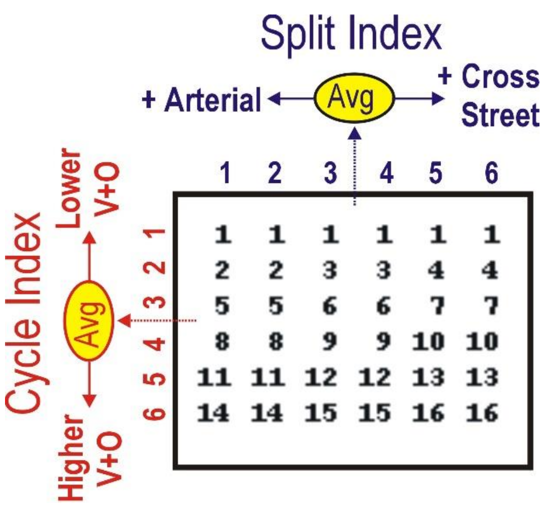
```
INT. OFT-1     Spl-Indx.1..2..3..4..5..6.
         Cycle Indx-1    1  1  1  1  1  1
                    2    2  2  3  3  4  4
                    3    5  5  6  6  7  7
                    4    8  8  9  9 10 10
                    5   11 11 12 12 13 13
                    6   14 14 15 15 16 16
```

MM->9->4->1: Traffic Responsive Lookup Tables

Suppose the current *Cycle Index* is "4" and the *Split Inde*x 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.



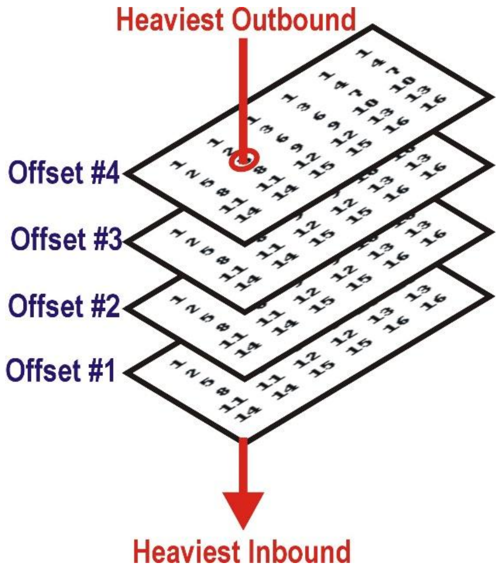
1) *Cycle Index* varies cycle length as a function of arterial V+O

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 144 patterns that can be assigned to this matrix (4 offset tables * 6 cycles * 6 splits). The Version 61 tables allow a maximum of 48 patterns with 24 split tables assignable as unique patterns.

7.3 Traffic Responsive Lookup Table Examples

These examples illustrate ways to configure traffic responsive for different conditions. In each example, pattern #1 the free pattern. There are many other combinations that you can use to set up a traffic responsive system. Hopefully, these examples will provide you with some ideas that you can apply to your application.

7.3.1 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

Plan #1 is a free plan (by convention) and is never implemented.

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.

7.3.2 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

Plan #1 is the free plan (by convention) and is never implemented.

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.

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

Offset # 2

	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 # 3

	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

Offset # 4

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

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.

7.3.4 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.

7.4 The Traffic Responsive Mode Table

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

MM->9->4->3: TR Command and Coord Mode Lookup

7.5 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.

```
Cmnd Table        .Plan..Cmnd.
                     1     0
                     2     0
                     3     0
...
                    16     0
```

MM->9->4->2: TR Command Table

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.

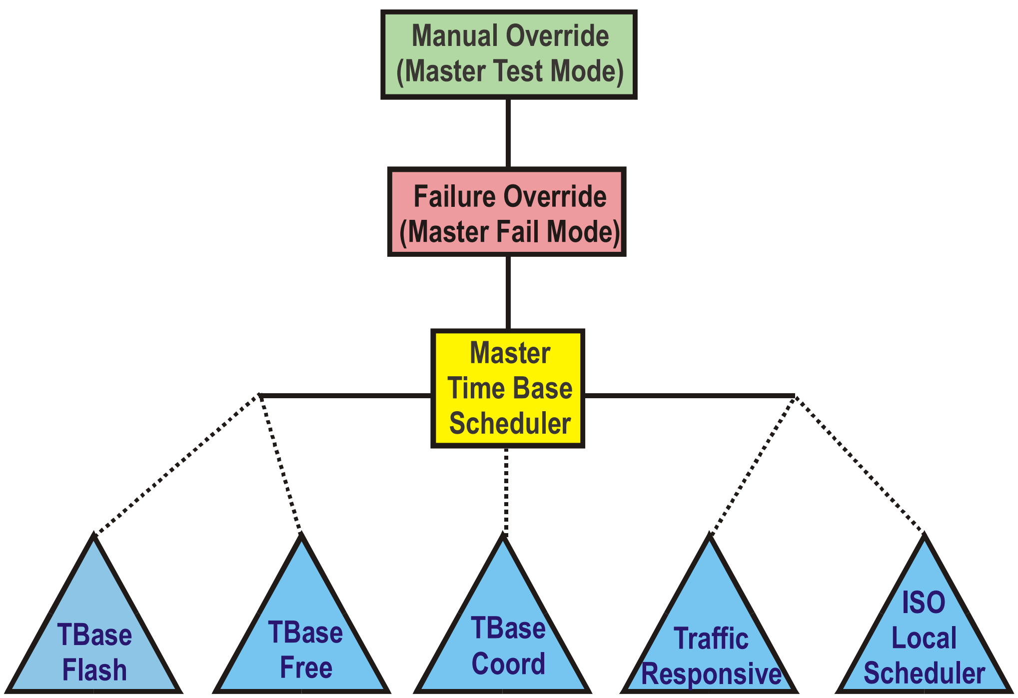
8 Master Configurations

The *Master Test Configuration* 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 for test purposes because it can only be entered from the keyboard at the on-street master.

MM->9->2: Master Test and Fail Configuration

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) and 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 or TRE, flash or free.



The Master Time Base Scheduler selects the mode by time-of-day

7.2 Master Test Configuration

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

```
Master Test ....Coord.....  .Command.
            Mode Patn Ofst   Mode  #
   Current  TBC     0    0   TBC   0
       New  TBC     0    0   TBC   0
```

MM->9->2->1: Master Test Configuration

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).*

7.3 Master Test Configuration

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.

```
Master Fail ..Coord.    ..Command..
            Mode.Pat    Mode...#       Cause
   Current   SBY   0    SBY     0        0
       New   SBY   0    SBY     0        0
```

MM->9->2->2: Master Fail Configuration

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.

7.4 Master MTBC Configuration

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

```
 Master TBC  ..Coord.          .Command.
            Mode Patn Ofst     Mode...#
   Current  TRI   0    1       TRI    0
       New  TRI   0    1       TRI    0
```

MM->9->5->8: Master TBC Configuration

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 secondaries in the subsystem running under closed loop operation.

9 Closed Loop Fail Configs & Alarms

9.1 The Failure Configuration Table

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.

Category	Threshld	Coord..Pat		Comnd..#	
Comm Errs	75	ISO	0	ISO	0
Stns Failed	1	ISO	0	ISO	0
Sys Dets	2	ISO	0	ISO	0
Stop Timng	1	ISO	0	ISO	0
Coor Fail	1	ISO	0	ISO	0
Loc Alm 5	1	ISO	0	ISO	0
Loc Alm 6	1	ISO	0	ISO	0
Loc Alm 7	1	ISO	0	ISO	0
Loc Alm 8	1	ISO	0	ISO	0
Stns Offln	3	ISO	0	ISO	0

MM->9->9->1: Master*Failure Cnfg* table

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 (or submaster and secondary controllers) assigned to the closed loop system. That is, a system with 32 secondary controllers can tolerate more station failures than a system with 3 secondaries.

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 secondaries 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 Model 980 secondary and 981 master controllers provide the same 128 events and alarms (1-128) accessed from screen MM->1->6. Event and alarm 1 - 128 are discussed in section 4.7 of the Version 50 Software Manual.

The Model 981 master controller provides an additional 128 events and alarms (129 – 256) related to the operation of the closed loop system. Master alarms and events are enabled from screen MM->9->9. Therefore, if a 981 controller is used as a primary system *master* and a *secondary* controller, the master related events and alarms are enabled from screen MM->9->9 and the secondary events and alarms are enabled from MM->1->6.

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 a 980 and 981 controller "Power Up" condition. The primary difference between events and alarms is in the way they are forwarded to the closed loop master and StreetWise ATMS.

- *Events* are polled on a scheduled basis by the closed loop master and/or StreetWise (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 StreetWise ATMS so the system is notified quickly when they occur. Alarms must be enabled as both *events* and as *alarms*. Alarms/Events are referenced by number.

9.2.2 Secondary Controller Events and Alarms (MM->1->6)

These events and alarms are documented in section 4.7 of the Version 50/60 Controller Manual and apply to TS2 981 master controllers operated as a secondary controller.

Event/ Alarm #	Function
1	Power Up (Alarm OFF) / Power Down (Alarm ON)
2	Stop Timing - Manual Control Enable (indicates conflict monitor flash in a TS1 cabinet)
3	Cabinet Door Open (TS1)
4	Coordination Failure
5	External Alarm #1: Cabinet door open (TS2 type 1), or External alarm #1 (D-connector pin 18)
6	External Alarm #2: Free operation (TS2 type 1), or External alarm #1 (D-connector pin 29)
7	External Alarm #3: D-connector pin 26
8	External Alarm #4: D-connector pin 27
9	Closed Loop Disabled
10	External Alarm #5: D-connector pin 28
11	External Alarm #6: D-connector pin 36
12	Manual Control Enable
13	Coordination Free Switch Input
14	Local Flash Input
15	MMU Flash Input
16	MMU Fault - calculated from stop time and CVM
17	Cycle Fault
18	Cycle Failure
19	Coordination Fault
20	Controller Fault - Intersection in Flash
21	Detector SDLC Failure - No Detection
22	MMU SDLC Failure - Intersection in Flash
23	Critical SDLC Failure
24	SDLC Response Frame Fault - Critical
25	EEPROM CRC Fault

26	Local Detector Failure - Monitored
27	Local Detector Failure - Reported
28-32	blank
33	Street Lamp Failure (Channel B)
34	Signal Lamp Failure (Channel A)
35	reserved
36	reserved
37	Request Database Download From Field
38-40	blank
41	Temperature Alert #1 - temp/status
42	Temperature Alert #2 - temp/status
43-48	blank
49	Preempt 1 Input
50	Preempt 2 Input
51	Preempt 3 Input
52	Preempt 4 Input
53	Preempt 5 Input
54	Preempt 6 Input
55	Preempt 7 Input - Transit or Low Priority
56	Preempt 8 Input - Transit or Low Priority
57	Preempt 9 Input - Transit or Low Priority
58	Preempt 10 Input - Transit or Low Priority
59	blank
60	CRFAIL- Coord Failure
61	blank
62-64	reserved
65-68	Light Rail
69-128	blank

9.2.3 Master Controller Events and Alarms (MM->9->9)

These additional events and alarms are available in the TS2 981 master controllers.

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
```

MM->9->7: Master Closed Loop Status Screens

10.1 Mstr Coor (Master Coordination) Status Display

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

```
Cnfg....Cor.Pat.Oft.Pln..Cmd..#.AOFt.Mci
 MTBC    TRI   0   1   1  TRI  0    0   1
 MSYS    TRI   0   1   1  TRI  0    0   1
 MCLP    CLP   2   1   1  TBC  4    0   1
 MTRI    CLP   2   1   1  TBC  4    0   1
 MTRE    CLP   0   0   1  TBC  0    0   1
 DNLD    FRE   0   1   1  FRE  1    0   1
 FAIL    SBY   0   0   1  SBY  0    0   1
 MTST    SBY   0   0   1  SBY  0    0   1
 Cur-MTBC Lock-OFF AOFt-OFF SbDet-  2
```

MM->9->7->1: The Master Coordination Status Display

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 and submasters
MTRI	*Master Traffic Responsive Internal* configuration of the primary master in the closed loop system
MTRE	*Master Traffic Responsive External* configuration of the primary master in the closed loop system
DNLD	*Down-Loaded* configuration which is used only by a submaster during Lock mode
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)*
Lock	*Lock mode (see section 7.1.2)*
AOFt	*Accumulated Offset*
SbDet	*Substitution Detector level (1-3) generated by the current master command*

10.2 Subsystem (Station Status) Display

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   701  OK       ONLINE
             2     0  OK       OFFLINE
             3     0  OK       OFFLINE
             4     0  OK       OFFLINE
...
            32     0  OK       OFFLINE
```

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

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      75        0        0
 Stns Failed     1        0        0
 Sys Dets        2        0        0
 Stop Timng      1        0        0
 Coor Fail       1        0        0
 Loc Alm 5       1        0        0
 Loc Alm 6       1        0        0
 Loc Alm 7       1        0        0
 Loc Alm 8       1        0        0
 Stns Offln      3        0        0
```

MM->9->7->3: Failure Configuration Thresholds

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   SEC  SEC  OK    OK
            3   SUB  SUB  OK    OK
...
           48   OFF  OFF  OK    OK
```

MM->9->7->4: System Detector Status

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 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

This screen displays the smoothed values of volume and occupancy for the up to 48 system detectors. The display is updated in real time.

```
 Smoothed     Nbr..Vol%..Occ%
 Detector       1     0     0
 Values         2     0     0
                3     0     0
...
               48     0     0
```

MM->9->7->5: Smoothed Detector Values

10.6 TR (Traffic Responsive) Values Display

The TR Display (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

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

MM->9->7->6: Traffic Responsive Values

10.7 Alms/Evnts (Alarms / Events) Status Displays

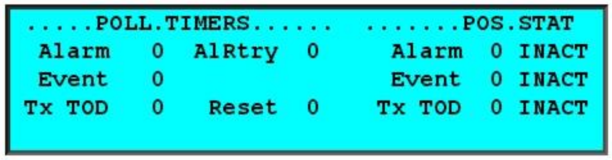
This selection shows the real-time status of the master alarms 128 – 256. Separate menus are also provided to display the last 50 alarms in the alarm buffer and the last 50 events in the event buffer.

10.8 Polling Status Display

The master polls the secondary stations in its subsystem at timed intervals. Some poll intervals are <u>fixed</u> while others are <u>adjustable</u>. 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 ***<u>timer</u>*** that triggers the poll sequence when the timer counts down to zero. Therefore, a poll sequence is a communication task initiated by the primary master (or submaster) that is controlled by a repeatable countdown timer.

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



MM->9->7->8: Master Polling Status Screen

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

- Alarm Buffer, Secondaries
- Event Buffer, Secondaries
- Transmit the Time-of Day Clock
- Alarm Retry (forwarding alarms to StreetWise)
- 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 StreetWise 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 AUT - External Coordination

<u>This chapter is under development</u>

12 Understanding CLP Operation

The preceding chapters defined the various elements related to CLP (closed loop) operation using the TS2 981 Master. This chapter provides examples of CLP operation so you can understand how the various operating modes and configurations interplay to create the master closed loop program (MCLP).

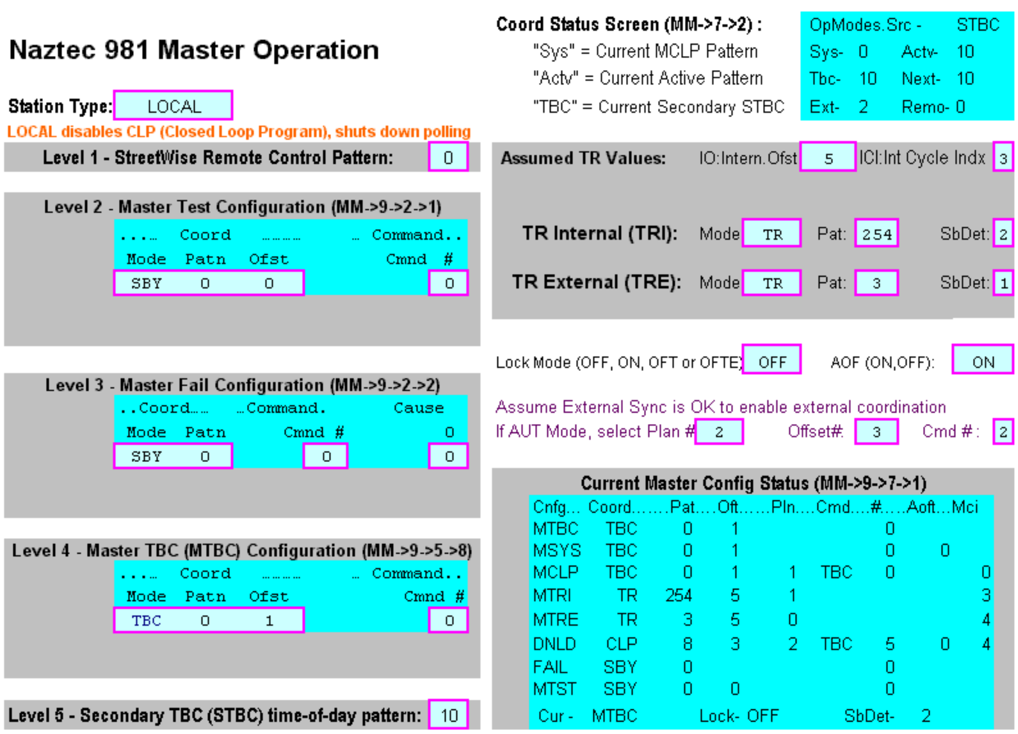
The following examples were generated with a spreadsheet model available on Cubic | Trafficware's web site as TecNote 1201 – Understanding Closed Loop Operation. This spreadsheet is highly interactive and can provide a good understanding of the selection of various modes of operation in the 981 Master related using the following examples. The best way to understand closed loop operation is to download the spreadsheet and enter the examples presented in this chapter.

12.1 Example 1 – Selecting the Station Type

The spreadsheet allows you to model a LOCAL, MASTER and SUBMSTR station type just like the master parameter under menu MM->9->1.

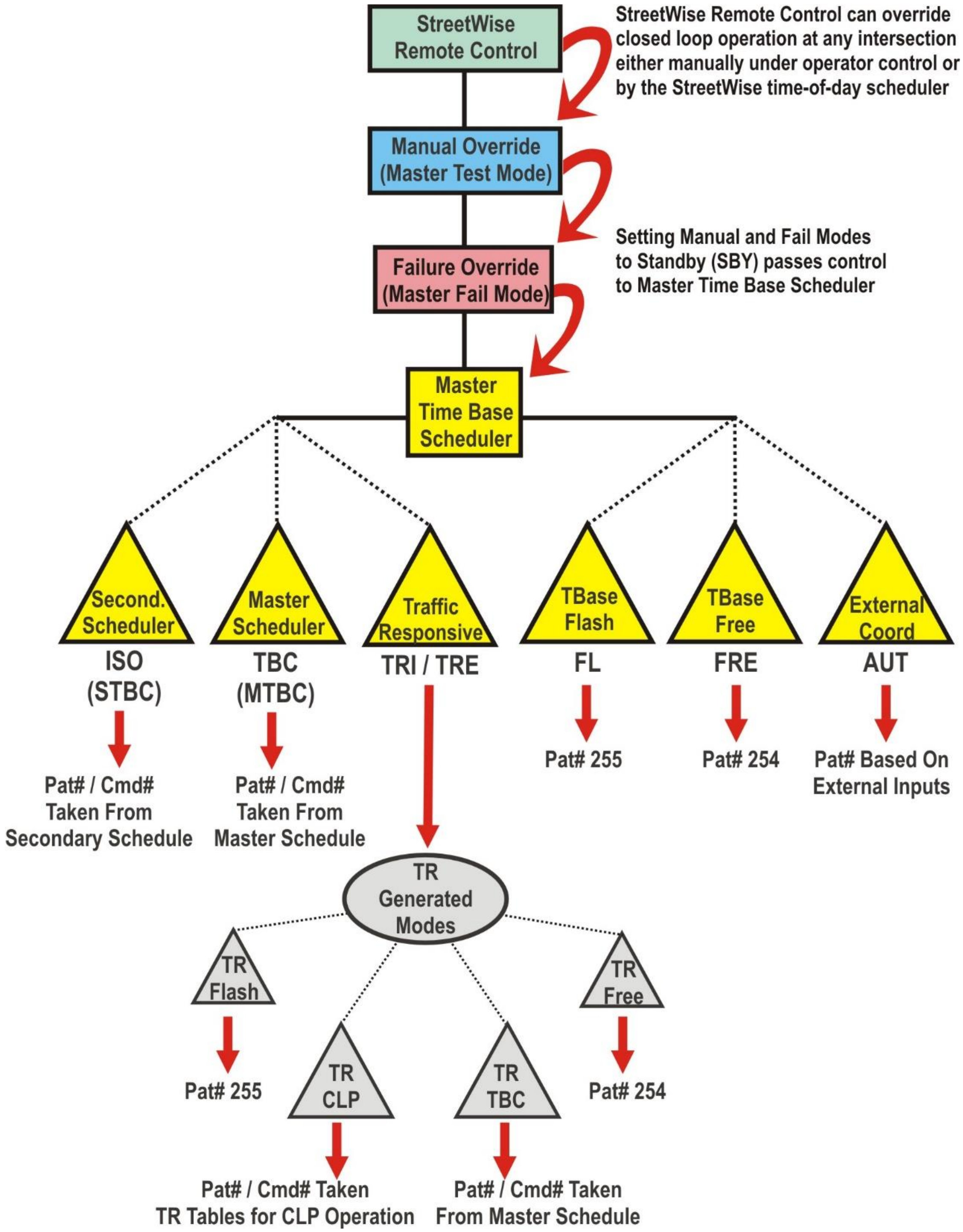
When you select the *Station Type* to be LOCAL, a message informs you that the "Local disables CLP and shuts down all polling from the master". This configuration is used when the master system-up port is tied to a StreetWise ATMS and the system-down port is communicating with a secondary sub-system.

The *Coord Status Screen* (MM->7->2) shows the current state of the master controller and all secondary controllers defined in the master's subsystem. Notice that the active operation mode (*OpModes, Src* in the top right corner) is STBC – Secondary Time Base Coordination. The master and all secondaries in this system are running off the LOCAL STBC schedule. The master is serving as a communications hub between the secondary sub-system and the StreetWise ATMS.



12.2 Example 2 – Understanding Levels of Control

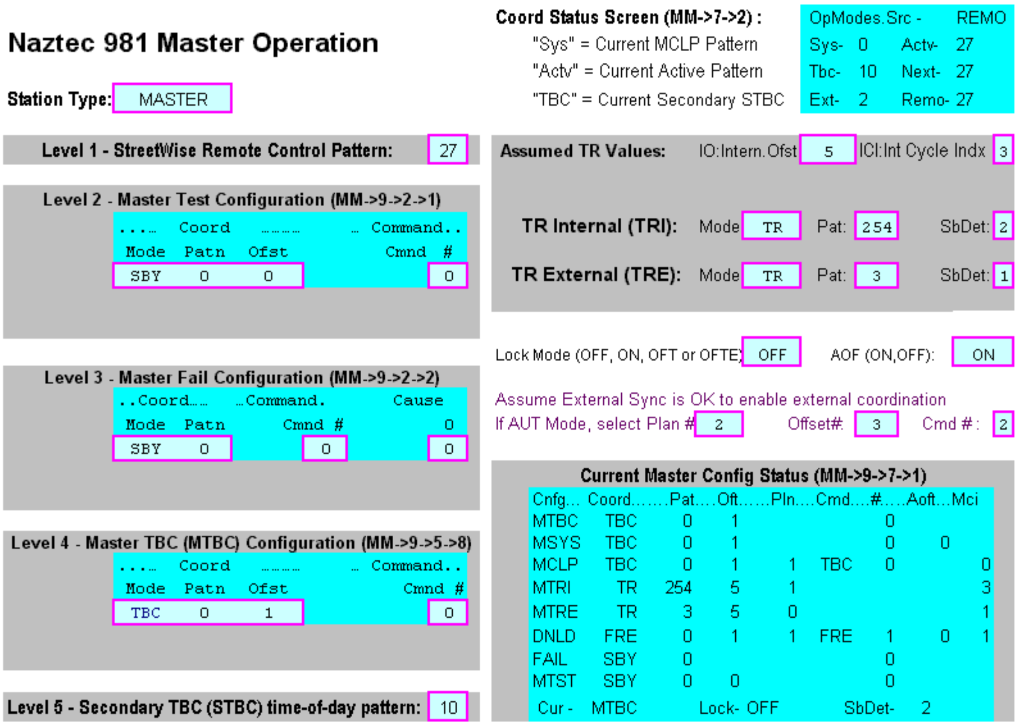
Section 1.3 presented the following illustration of control levels in a Cubic | Trafficware CLP system.



12.2.1 Example 2a – StreetWise Remote Control Level

The following example simulates a primary master when StreetWise issues a "remote control" pattern. StreetWise can override the current closed loop and STBC operation of the master and any (or all) secondary controllers in the master's sub-system.

The *Coord Status Screen* (MM->7->2) shows the current state of the master controller and all secondary controllers defined in the master's subsystem. Note that this control is operating under REMO (remote) mode and that pattern 27 is the Actv (Active) pattern. The closed loop Sys is shut down (value of zero in the *Coord Status Screen*) and the controller's background time base (STBC) pattern is pattern 10.

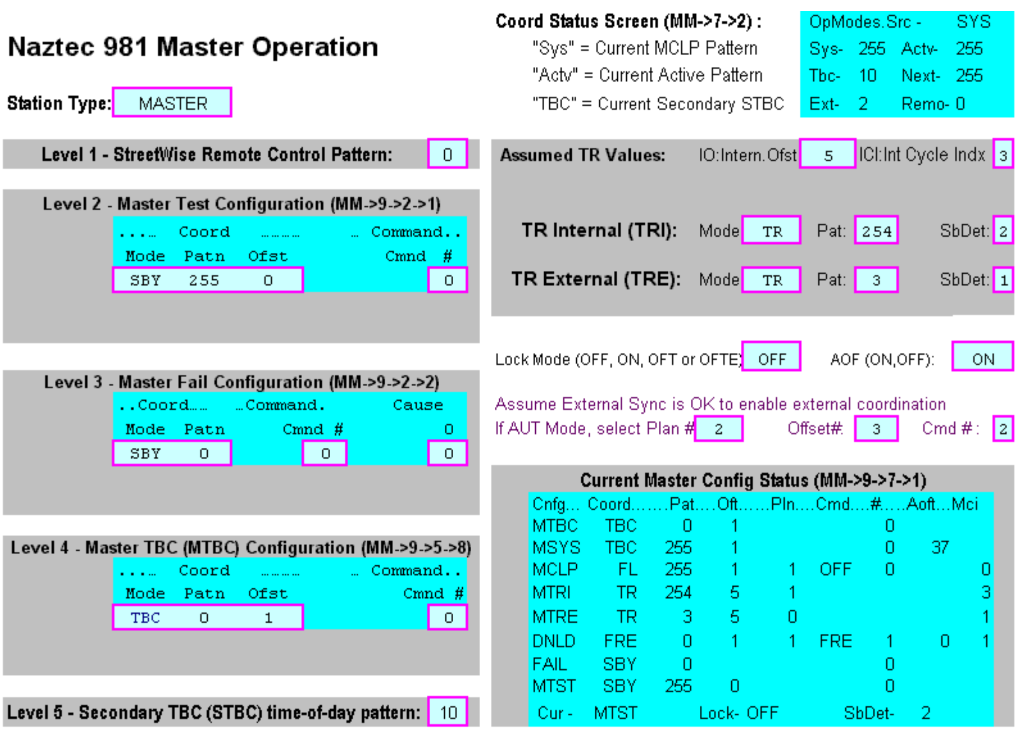


Pattern 27 REMO (remote control) will stay active until the timeout value downloaded from StreetWise expires. This timeout value is specified in minutes from 0-254 (a timeout value of 255 never expires).

12.2.2 Example 2b – Master Test Configuration

This is an example of "manual override" of the closed loop system executed from the primary master. Notice that the *StreetWise Remote Control Pattern* discussed in our last example has been changed from 27 to zero which passes the level of control down to the *Master Test Configuration*.

The *Master Test Configuration* can override the *Master Fail Configuration* and the *Master TBC Configuration* because of the hierarchy of control discussed in section 1.3 and 11.2. In the example below, the *Master Test Configuration* sets the master and secondary controllers to *Pattern* 255 (NTCIP flash).

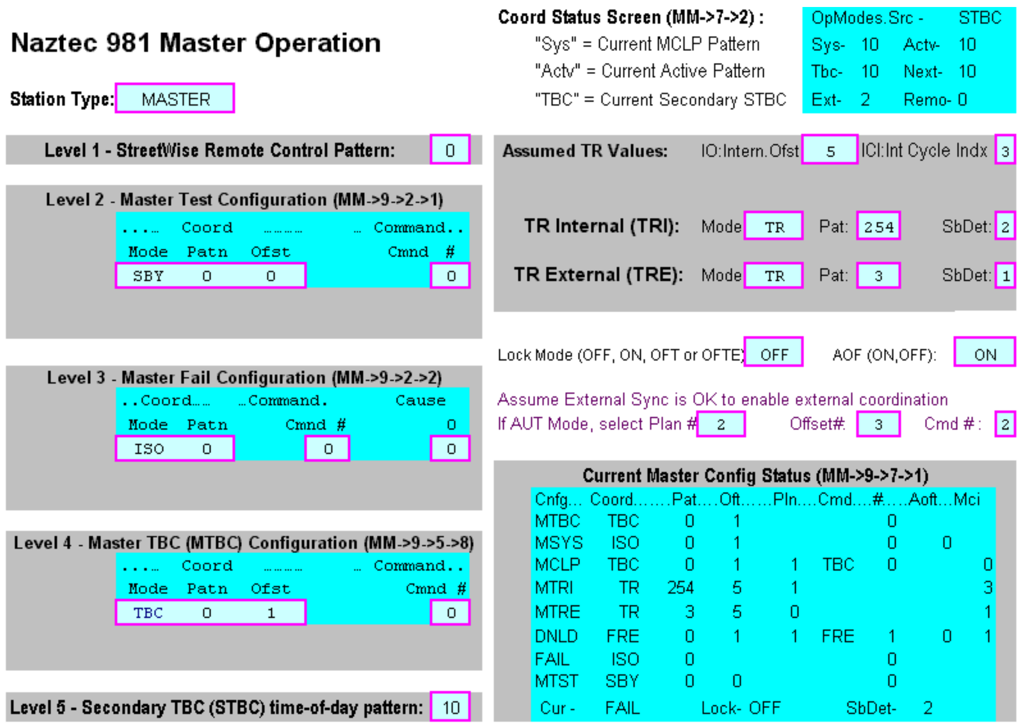


Note that the <u>*Sys*</u> pattern in the *Coord Status Screen* is 255. The <u>*Sys*</u> pattern corresponds to the MCLP (Master Closed Loop Program) in the *Current Master Config Status Screen*.

Also note that the <u>*Cur*</u> (Current) status of the master is MTST because the master is operating under the *Master Test Configuration* (lower left corner of the *Master Config Status Screen*).

12.2.3 Example 2c – Master Fail Configuration

In this example, the *StreetWise Remote Control Pattern* is zero and the *Master Test Configuration* is in SBY (Stand By) running *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.

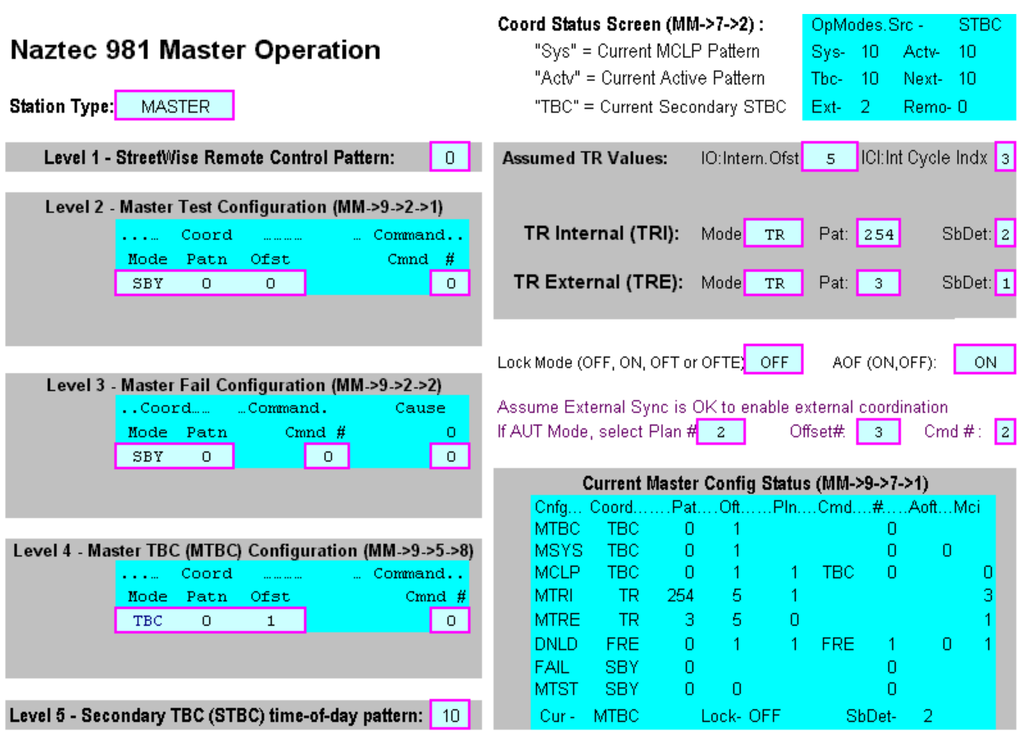
Notice that the current *Coord Status Screen* indicates that the controller is in STBC and that the Sys pattern (MCLP) has selected the local time base schedule (STBC).

Also note that the <u>*Cur*</u> (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).

12.2.4 Example 2d – Master TBC (MTBC) Configuration

If the *StreetWise Remote Control Pattern* is zero and the *Master Test Configuration* and *Master Fail Configuration* are in SBY (Stand By), control is passed to the *Master TBC (MTBC) Configuration*.

The *MTBC Configuration* is set by the *MTBC Schedule* and is the heart of the closed loop system. *MTBC* sets the coord mode of the closed loop system by time-of-day and can also pass control to the secondary *STBC Schedule*. The *MTBC Coord Mode* is set to TBC, traffic responsive (TRI or TRE) or external coordination (AUT mode).



If TBC is selected as the current *Coord Mode*, the pattern is determined as follows:

- Patrn 0 - use the current pattern from the STBC Schedule
- Pattern 1-48 - pattern set by the MTBC Schedule
- Pattern 254 - NTCIP pattern for free operation
- Pattern 255 - NTCIP pattern for flash operation

In the example below, assume that the current *Day Plan* in the *MTBC Schedule* has set the *Coord Mode* to TBC and Patn (pattern#) 0. This *MTBC Configuration* will force the master and all the secondary controllers and sub-masters in the closed loop system to run the current pattern from their own *STBC Schedule*.

Note that the *Coord Status Screen* shows the active mode is STBC and that the Sys pattern (MCLP) has selected pattern# 10 from the *STBC Schedule*. The *Coord Status Screen* in this example is identical to the status screen in our last example because both cases fall back to STBC operation. However, in this example, the system is running STBC under MTBC control, not as a fail mode. The Cur (Current) status in this example is MTBC not FAIL as in example 11.2.3

Also, note that the *Master Test Configuration* and *Master Fail Configuration* in the last 2 examples each provide an ISO *Coord Mode*, but the *MTBC Configuration* calls isolated (STBC) using TBC *Coord Mode* with *Pattern 0*.

12.3 Example 3 – Normal Operation Using the MTBC

The *Master TBC (MTBC) Configuration and MTBC Schedule* are the heart of the closed loop system and vary current coord mode of the system by time-of-day. Chapter 4 discussed setting up the MTBC schedule using "Easy Schedule", *Day Plans* and *Action* events to build a master *MTBC Schedule* similar to the secondary *STBC Schedule*.

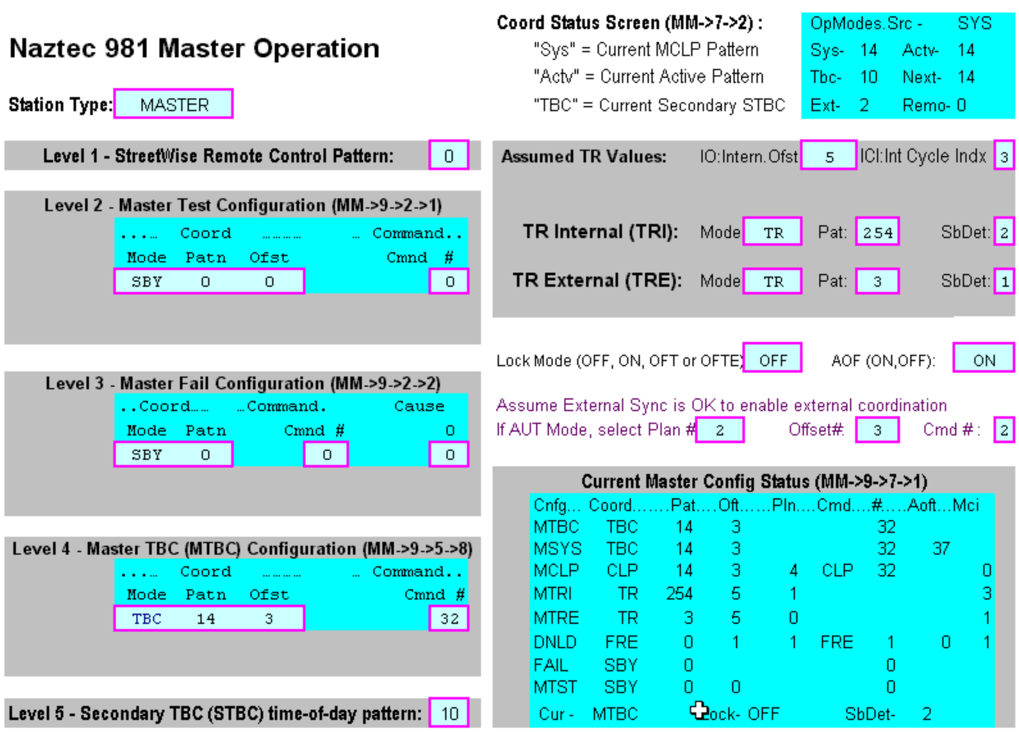
The *Master TBC (MTBC) Configuration* provides a "test configuration" (MM->9->5->8) that allows the user to manually set the current modes and patterns for test purposes. The spreadsheet developed in this chapter allows you to simulate the *Master TBC (MTBC) Configuration* and instantly see the results in the *Current Master Config Status Screen* and *Coord Status Screen*. The spreadsheet will be used to study the following additional *Coord Modes* set in the *MTBC Configurations*:

- TBC Master Time Base Operation (all secondaries follow the MTBC schedule)
- AUT Auto Mode - cycle, split and offset selected from external inputs (hardwire interconnect)
- TRI Traffic Responsive (Internal)
- TRE Traffic Responsive (External)

12.3.1 MTBC Example 3a – Specifying TBC Pattern, Offset and Command

In this example, assume that the *MTBC Schedule* has set the *Coord Mode* to TBC and selected pattern 14 and offset 3. All secondary controllers defined in the master's sub-system will continue to run pattern 14 until another *MTBC Schedule* or a higher level of control command is issued. In this case, any time-of-day events from thesecondary *STBC Schedules* will be ignored because the *MTBC Schedule* is not calling for Pattern 0.

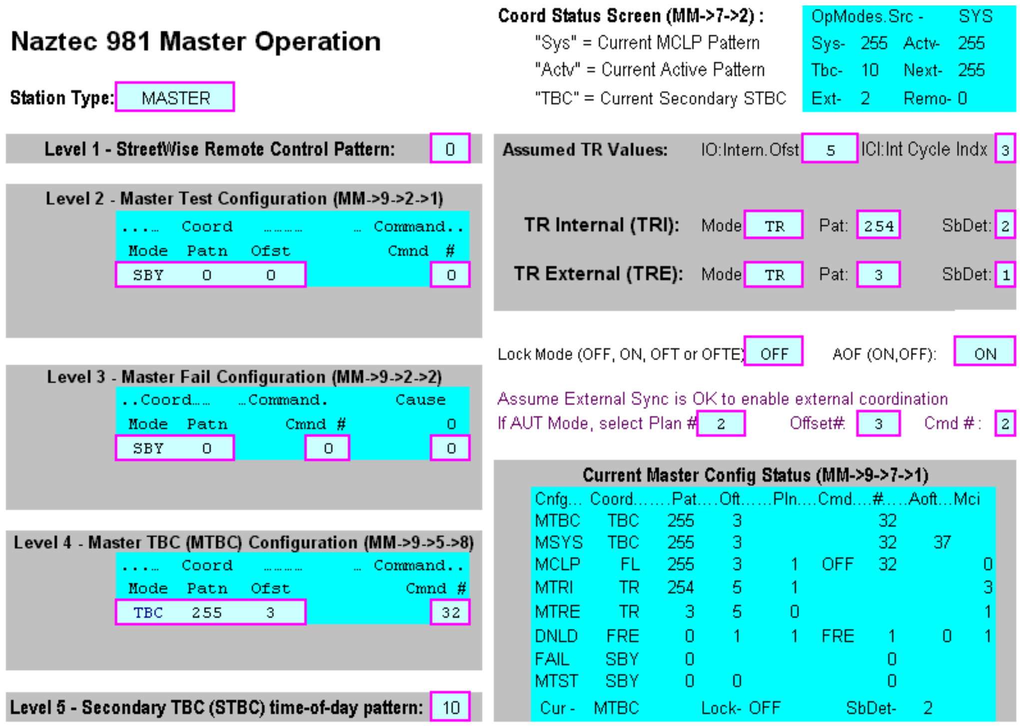
Note: The Master's MCLP configuration is downloaded to all controllers defined in the master's sub-system. Each secondary controller in the subsystem will implement the MCLP configuration if the "Closed Loop" parameter (under MM->2->1 is set ON). Each sub-master in the sub-system will implement this download (DNLD) configuration if the lock mode is set.



This example assumes that the Command# for the *MTBC Configuration* is 32. *Command #* allows you to vary system detector substitution values, accumulate offset and lock mode by time of day The command number set by the *MTBC Configuration* is also downloaded to the secondary controllers through the MCLP configuration.

12.3.2 MTBC Example 3b – Flashing the Closed Loop System By Time-of-Day

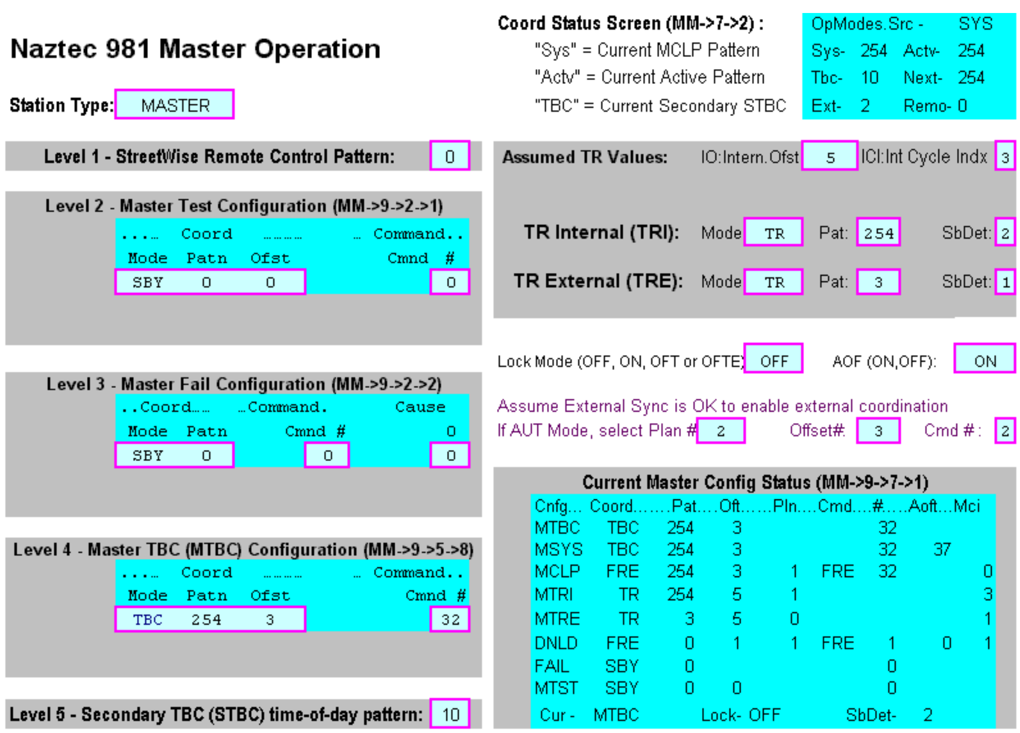
This example uses an MTBC Schedule to set the MTBC Configuration to TBC and pattern 255. This causes the master and all controllers in the sub-system to go to NTCIP flash.



12.3.3 MTBC Example 3c – Putting the Closed Loop System into Free By Time-of-Day

This example is very similar to our last example. Setting the *MTBC Configuration* to TBC and pattern# 254 places the master and all controllers in the closed loop system into free operation.

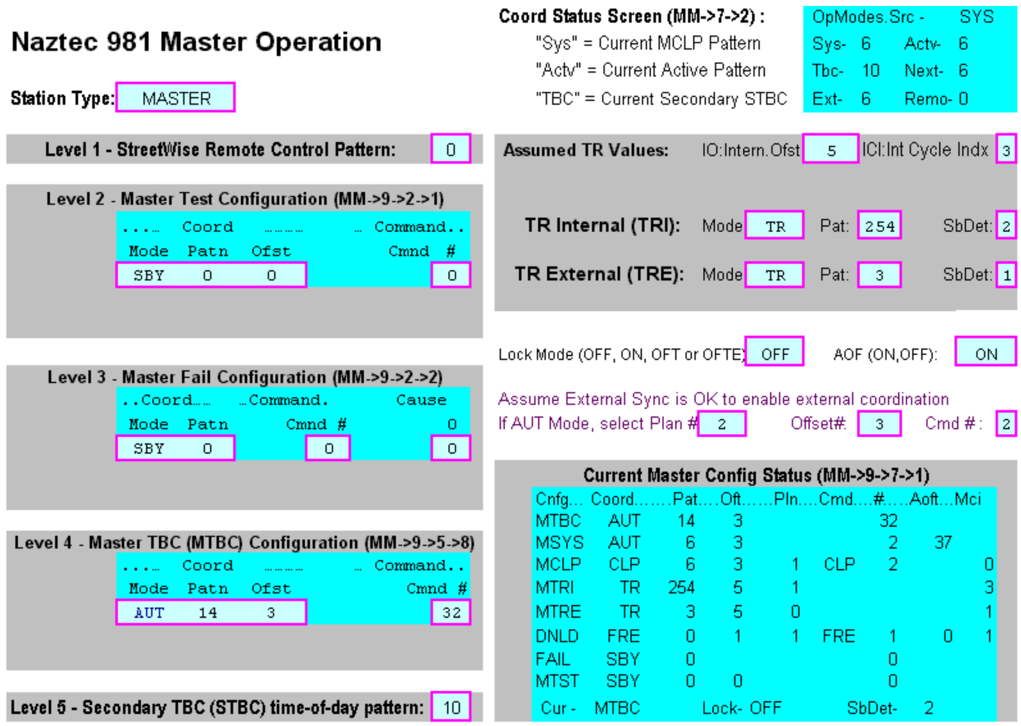
But what if you wanted to put some of the controllers in the subsystem into FL (Flash), some in FRE (Free) and others running a coordination pattern?



This is best accomplished by programming the operation desired into each secondary *STBC Schedule* and setting the *Coord Mode* to TBC and pattern 0 in the *MTBC Configuration*. Programming separate time-of-day schedules for each secondary also allows the system to stay coordinated when communications fail. If each secondary were tied to the MTBC schedule with no backup *STBC Schedule*, the only fall-back mode would be free operation. A closed loop system can operate quite well if each secondary is provided with a fallback *STBC Schedule* because the time-base drift is typically only 2-3 seconds per month.

12.3.4 MTBC Example 3d – Selecting Aut Mode (External Coord) By Time-of-Day

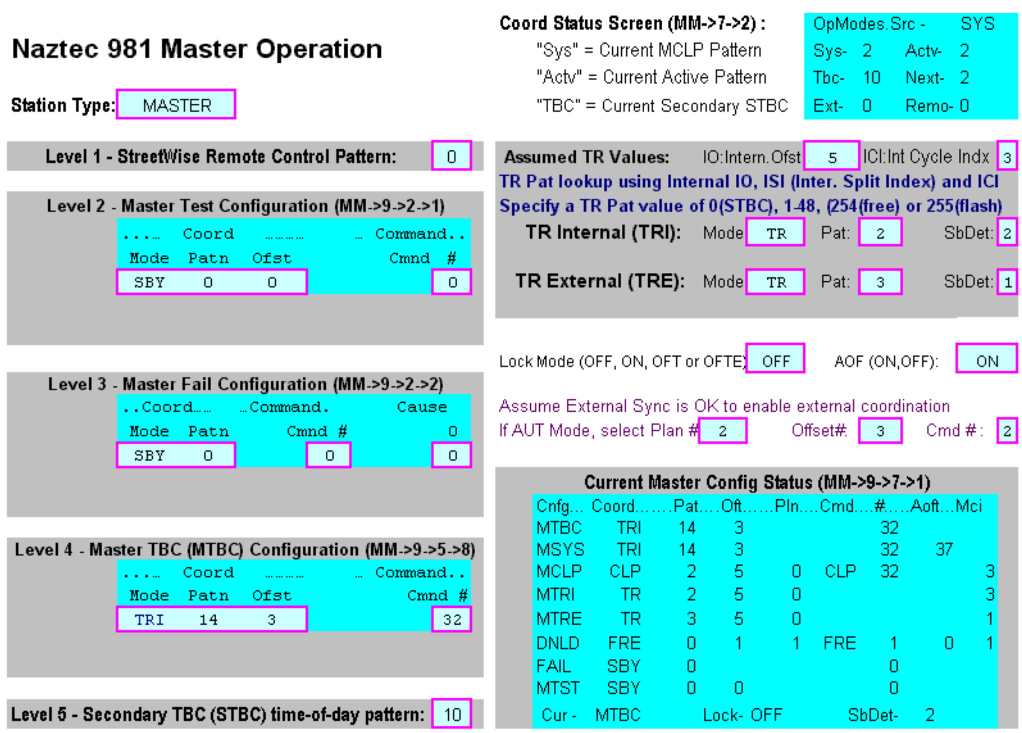
Chapter 11 discusses the external coordination features in the closed loop Master. This spreadsheet allows you to set the *Coord Mode* in the *MTBC Configuration* to AUT which uses the *Plan#, Offset#* and *Cmd#* to calculate the pattern for the closed loop system. The spreadsheet allows you to vary the *Plan#, Offset#* and *Cmd#* to set the *Ext*. pattern in the *Coord Status Screen.*



We have intentionally left the *MTBC Configuration* pattern (14) and offset (3) the same as our earlier example to show that TRI *Coord Mode* uses it's own pattern and offset calculation to determine the current MCLP plan. The pattern and offset values in the *MTBC Configuration* are only used if the *Coord Mode* is TBC.

12.3.5 MTBC Example 3e – Selecting TRI (Internal) By Time-of-Day

TRI (Traffic Responsive Internal) operation can be called by time-of-day by setting the *Coord Mode* in the *MTBC Configuration* to TRI. Many users set up the master schedule to run traffic responsive during off peak conditions and time-of-day (TBC) during peak periods to keep the system from going through transition during the peak hours.



The spreadsheet output below simulates TRI in a 981 Master controller using assumed values for pattern, offset, command # and Mci. These are normally calculated values based on the V+O calculations discussed in Chapter 7.

We have intentionally left the *MTBC Configuration* pattern (14) and offset (3) the same as our earlier example to show that TRI *Coord Mode* uses it's own pattern and offset calculation to determine the current MCLP plan. The pattern and offset values in the *MTBC Configuration* are only used if the *Coord Mode* is TBC.

12.3.6 MTBC Example 3f – Selecting TRE (External) By Time-of-Day

TRE (Traffic Responsive External) operation only applies to SUBMSTR, not MASTER controllers.

In the spreadsheet output below, note that the DNLD configuration can be varied. The DNLD configuration is the MCLP configuration of the primary master that the sub-mastery is assigned to. The reason why primary masters cannot run TRE is because the primary master does not receive a DNLD configuration from a higher order master (or StreetWise).

Naztec 981 Master Operation

Station Type: MASTER

"Sys" = Current MCLP Pattern
"Actv" = Current Active Pattern
"TBC" = Current Secondary STBC

Sys-	3	Actv-	3
Tbc-	10	Next-	3
Ext-	0	Remo-	0

Level 1 - StreetWise Remote Control Pattern: 0

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

.....	Coord	....	... Command..
Mode	Patn	Ofst	Cmnd #
SBY	0	0	0

Level 3 - Master Fail Configuration (MM->9->2->2)

..Coord.....		...Command.	Cause
Mode	Patn	Cmnd #	0
SBY	0	0	0

Level 4 - Master TBC (MTBC) Configuration (MM->9->5->8)

.....	Coord	....	... Command..
Mode	Patn	Ofst	Cmnd #
TRE	14	3	32

Level 5 - Secondary TBC (STBC) time-of-day pattern: 10

Assumed TR Values: IO:Intern.Ofst 5 ICI:Int Cycle Indx 3

TR Pat lookup using External IO, ISI (Inter. Split Index) and ICI
Specify a TR Pat value of 0(STBC), 1-48, (254(free) or 255(flash)

TR Internal (TRI): Mode TR Pat: 2 SbDet: 2

TR External (TRE): Mode TR Pat: 3 SbDet: 1

Lock Mode (OFF, ON, OFT or OFTE) OFF AOF (ON,OFF): ON

Assume External Sync is OK to enable external coordination
If AUT Mode, select Plan # 2 Offset#: 3 Cmd #: 2

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

Cnfg...	Coord.......	Pat....	Oft......	Pln....	Cmd....	#.....	Aoft...	Mci
MTBC	TRE	14	3			32		
MSYS	TRE	14	3			32	37	
MCLP	CLP	3	5	0	CLP	32		1
MTRI	TR	2	5	0				3
MTRE	TR	3	5	0				1
DNLD	FRE	0	1	1	FRE	1	0	1
FAIL	SBY	0				0		
MTST	SBY	0	0			0		

Cur - MTBC Lock- OFF SbDet- 2

Notes: 1) You must enter the Station Type as a MASTER, SUBMSTR or LOCAL as specified on controller menu MM->9->1.
The "primary" MASTER type does not receive a download (DNLD) configuration from StreetWise under closed loop.

The SUBMSTR type receives the DNLD config which is the MCLP from the primary MASTER it is assigned to.
If Lock Mode is ON, the SUBMSTR uses the DNLD config for it's MCP Operation.

Play with the DNLD config for the SUMSTR using these cells -> Pat: 8 EO: 3 Cmd# 5 Eci: 4