

Microwave Transmission Network

5.0 Microwave Transmission Network

5.1 SUMMARY

The Microwave Transmission Network (MTN) provided by Motorola will provide the Commonwealth of Virginia with the digital transport network required for interconnecting Land Mobile Radio, Mobile Data, Telephone, Alarm Networks, and the future Wide-Area Data Network (STARS Intranet) sites (see Appendix 6 for diagram). This digital network will ensure the STARS users have access to voice, mobile data, and intranet data communications across the Commonwealth.

5.2 MICROWAVE TRANSMISSION NETWORK

Motorola will provide the Commonwealth of Virginia a Microwave Transmission Network (MTN), which will consist of a total of 121 transmitter sites equipped with new or refurbished Digital Microwave equipment of various frequencies and capacities. This microwave network will connect all the LMR Integrated Voice and Data sites. Zone 1 Master Site will be served from the Virginia State Police Headquarters (SPHQ) in Richmond and Zone 2 Master Site will be served from the Virginia State Police (VSP) 6th Division Headquarters in Salem. The portion of the MTN routed to Zone 1 Master Site in Richmond will contain all sites geographically located in Divisions 1, 2, 5, and 7. The portion of the MTS network routed to Zone 2 Master Site in Salem will contain all sites geographically located in Divisions 3, 4, and 6.

The portion of the MTS network terminated at Zone 1 Master Site in Richmond will contain a total of 55 tower sites, 20 of which will be LMR co-locations. The portion of the MTS network terminated as Zone 2 Master Site in Salem will contain a total of 66 tower sites, 25 of which will be LMR co-locations. SPHQ in Richmond and the VSP 6th Division Headquarters in Salem will be connected together by a “partitioned” section of the MTS network routed through the 1st, 3rd, and 6th Divisions. The MTS network will consist of ten OC-3 Synchronous Optical Network (SONET) loops arranged in nine distinct and separate rings identified as R-1 through R-9. R-1 through R-4 and R-6 through R-8 will contain parallel OC-3 radio links on a combined six microwave paths sharing different rings. One path shared by R-7 and R-8 serving the VSP 6th Division Headquarters will contain three parallel OC-3 radio links on one common path. All other parallel paths will contain two OC-3 radio links. All paths in ring R-8 will be dual OC-3s except the aforementioned individual path, which will contain three OC-3s.

Total sites served (based on implementation)

Division 1	19 Sites	5 LMR	14 Microwave Only	9 Area Offices
Division 2	12 Sites	5 LMR	7 Microwave Only	4 Area Offices
Division 3	17 Sites	7 LMR	10 Microwave Only	6 Area Offices
Division 4	26 Sites	10 LMR	16 Microwave Only	5 Area Offices
Division 5	18 Sites	6 LMR	12 Microwave Only	8 Area Offices
Division 6	23 Sites	8 LMR	15 Microwave Only	6 Area Offices
Division 7	6 Sites	4 LMR	2 Microwave Only	3 Area Offices
Totals	121 Sites	45 LMR	76 Microwave Only	41 Area Offices

[Note: Five Area Offices are co-located with Division HQ, therefore, 46 AOs]

SPHQ in Richmond and all VSP Division Headquarters sites (Divisions 1 – 7) will be located on an OC-3 SONET-controlled ring providing diverse route protection (commonly referred to as “east–west route diversity”) to those locations.

A total of 56 hot-standby digital microwave spurs will be utilized to provide a minimum of four DS1s to the remaining sites in the Network.

Digital microwave radios operating in the 6-, 11-, and 18-GHz fixed microwave frequencies per FCC Part 101 Rules (USC 47) will be used in varying quantities and capacities.

All sites will be equipped and wired to provide a minimum of four DS1 terminations to accommodate network traffic, as identified in Table 5-1. All sites residing on a loop will be equipped with route-protected OC-3 digital radio and will use SONET-controlled alternate routing (“east-west switching”) for both path and equipment protection.

The same SONET multiplex and switching equipment will be utilized in front of all OC-3 digital radios to provide access to DS1 terminations. All spur routes will be equipped with fully-monitored hot-standby switching for equipment protection. One hot-standby OC-3 path (between Site 9502 Brunswick CC and Site 1505 Emporia Repeater AO) will be installed. This will be the only hot-standby OC-3 path employed, and is the only OC-3 radio operating without route diversity. This was done to provide additional diverse route connectivity in the future, if required, to relieve incoming route capacities to Master Site 1 at SPHQ in Richmond.

Service channels with orderwire will be configured as a minimum of one service channel orderwire per site equipped with handset. An external speaker will be provided at each site for “hands-off” monitoring of incoming signaling and voice messages. All sites will be DTMF addressable via the orderwire keypad on an individual basis or as an “all-call” function.

In addition to orderwire service, Motorola will equip each microwave site with one analog telephone circuit via the microwave system. This phone circuit will allow on-site personnel to place and receive telephone calls over the microwave network to the Commonwealth’s private branch exchange (PBX) and to the public-switched telephone system (PSTN). At each microwave site and at the VSP Division Headquarters locations, Motorola will equip the respective Telecommunications Network Server (TeNSr) channel banks with the required telephone circuit cards and Ring Generators for this telephone functionality. Each VSP Area Office, Division Headquarters, and SPHQ office building is also being served with this microwave telephone network.

Password-protected Telescan Network Management Systems (network monitoring, control, and configuration software) will be located at the SPHQ NOC in Richmond and at 6th Division Headquarters in Salem for all microwave radio equipment. This will be configured in a Master/Slave Slave/Master (manually selectable via password protection) for back-up (redundant) purposes and allow configuration, monitoring, troubleshooting and switch control of any microwave radio terminal in the network to be accessed from either the Richmond or Salem location, and interfaced to the HP OpenView network monitoring system. For remote monitoring and alarm reporting, the microwave radios will be connected to the corresponding site's MOSCAD Remote Terminal Unit (RTU). Refer to the Alarm and Control System Description section of this contract for further details on remote monitoring via the MOSCAD Fault Management system to be provided by Motorola.

All radio racks will be equipped with individual fuse -48 VDC fuse panels providing individual fusing for all rack mounted equipment as well as A-side supply power and B-side supply power from the site main DC source.

5.2.1. Microwave Radio Performance

The microwave system has been engineered using industry database information and coordinates provided in Appendix 6. Paths are assigned specific transmitter powers and antenna systems to guarantee the grade of service for one-way annual availability levels of not less than 99.9995%.

The preliminary calculations for all path performance for all frequencies are based on FCC-documented receiver threshold levels and are calculated using a bit error rate (BER) of 10^{-6} or better. Bell Company Standard Transmission Engineering Practices, Formulas, and Geographical Historical Data are the foundation of these calculations and are generally accepted nationwide.

Twenty-five (25) hops (listed in Appendix 6 of VSP's existing digital microwave radio equipment (3.75 MHz and 10 MHz bandwidths) will be re-used and have been incorporated into this design. All re-used radios will be factory reconditioned and provided with a "New Radio" warranty. All antenna systems will be FCC Category A designated.

A Microwave Path Engineering Survey will be conducted on all paths. All paths to date have been profiled for acceptable clearance criteria in Appendix 6 and in-house computer software employing commercially-available topographical database information. These computer-generated Path Profiles (PP) will be used as the baseline information to be verified during the actual in-field path survey.

The objective of this in-field path survey is to crosscheck and confirm the information to be used for clearance and performance engineering objectives. This confirmation includes site location (latitude/longitude coordinates), elevation above mean sea level (AMSL), accurate measurement of unmapped path obstructions along the path (e.g., trees and buildings, electrical transmission lines, cellular towers and the presence of reflective bodies of water) and general compilation of historical local climate information. At locations utilizing existing towers, pre-determined azimuths and centerlines will be checked for availability/adaptability in terms of antenna mounting.

5.2.2. Transmission Engineering

After confirmed data from the field has been verified by Microwave Networks Incorporated (MNI) this data will be used in conjunction with established industry-standard statistical information to establish final individual Path Performance calculations to meet the performance requirements specified above. This performance will be calculated using the Field Path Data information from the survey, manufacturers guaranteed microwave radio performance specifications and manufacturers guaranteed microwave antenna system performance specifications.

A Digital Microwave Path Data Sheet (PDS) -- showing the resultant guaranteed path performance based on the specific path, radio and antenna system listed -- will be provided for each path on the system diagram –Appendix 6a.

These path data sheets are required by the FCC to conduct frequency coordination and license processing.

5.2.3. Frequency Coordination

The path data sheets will allow for frequency coordination to be conducted for establishing frequency availability at selective locations. These will be largely selected based on network logistics and critical path/operation and availability. A pre-field path survey analysis will be conducted to provide baseline information on the critical path/network sites/paths to insure initial availability prior to field efforts being expended. All path engineering work will be completed prior to the filing for new frequencies.

5.2.4. Documentation

Final and formalized survey reports will be provided containing all information collected for each of the surveyed path, PP, PDS, and site information. This will be provided on a site and path basis. Also to be provided will be the frequency information reserved at selected locations.

This information will be used for comparison purposes for path acceptance testing and will be updated to reflect “as-built” conditions.

5.2.5. Network/Site Bandwidth Performance

Site capacities are all fixed based on FCC Part 101 licensing and were established based on Appendix 6. A minimum of eight DS1s is available at any one site for drop terminations on any spur route. The 8DS1 radios (FCC 3.75 MHz BW) will be provided in a 4DS1 configuration. This will provide 100% “plug and play” expandability at the low-density sites without requiring new wiring or FCC license modification. The CM 6 GHz and 11 GHz radios are expandable to 12 DS1 by replacing one Signal Processing Module in each Transceiver Terminal, thus providing future expandability of an additional 50%.

In the same manner, all existing CM radios to be refurbished will be configured and re-installed as 28 DS1 radios to provide the same expansion capabilities as stated in the previous paragraph.

All OC-3 sites are expandable by the addition of 14-port access cards to the Fujitsu Flashwave SONET multiplexer. All SONET multiplexers are equipped with sufficient 14-port access cards to handle the initial capacity and allow room for future capacity with additional 14-port access cards. When calculated across all sites, this equates to approximately a 36.7% expansion capability at all site terminations located on rings, except for SPHQ in Richmond, the VSP Division Headquarters locations, and one or two other high-density junctions on the network.

All rings have unused capacity which will allow for future expansion (adding more DS1s), as shown in Table 5-1 which follows.

STARS - TABLE T1

Refer to Microwave Figure 1									
	<u>Ring 1</u>	<u>Ring 2</u>	<u>Ring 3</u>	<u>Ring 4</u>	<u>Ring 5</u>	<u>Ring 6</u>	<u>Ring 7</u>	<u>Ring 8</u>	<u>Ring 9</u>
Division Served	1	5	1	1, 2, 7	2	3, 6	1, 3	4, 6	4
Ring Capacity	OC-3	2 OC-3s	OC-3						
Number of Sites	7	7	4	11	9	9	11	13	7
Number of LMR Sites	4	5	3	5	4	5	5	7	4
Initial DS1s Assigned	60	43	48	51	35	50	59	119	73
Unused DS1s	24	41	36	33	49	34	25	49	11
Total Mbps Consumed	92.64	66.39	74.11	78.74	54.04	77.2	91.1	183.74	112.71
Current % Capacity	71%	51%	57%	61%	42%	60%	70%	71%	87%
Initial DS1s plus 25%	75	54	60	64	44	63	74	149	92
Future Unused DS1s @ +25%	9	30	24	20	40	21	10	19	(8)
Future Mbps Consumed @+25%	115.8	83.38	92.64	98.82	67.94	97.27	114.26	230.06	142.05
Future % Capacity	89%	64%	71%	76%	52%	75%	44%	89%	110%

Notes:

- 1) Table T1 8/01/03 Rev. 1
- 2) Minimum capacity calculated for any site is 1DS1.

Table 5-1

5.2.6. Microwave Antenna Systems

The 99.9995% path availability, the confirmed Field Path Survey data and FCC Part 101 Rules for frequency selection will determine the “final” antenna system selection for each microwave path. On OC-3 parallel paths (paths with more than one OC-3 in initial operation), a single antenna system will be used with the radios sharing the single antenna utilizing a Low-Loss RF Combiner to couple the radios onto a single antenna and waveguide. The combiner including circulator and filter losses were considered in the preliminary path calculation. The use of the combiner saves both antenna mounting space on the tower, reduces tower loading due to antenna, waveguide and ice shield tower loading and reduces equipment, hardware and installation cost significantly.

Various antenna diameters will be supplied (2, 4, 6, 8, 10 and 12 feet), and each will be fitted with a radome and where applicable, a protective ice shield. All antennas 6 feet and larger will be equipped with a minimum of two side struts. Sites with high frequency allocation quantities will utilize high-performance antennas with shrouds, if required to comply with FCC frequency licensing. Most of the four-foot antennas will be utilized for the 18 GHz paths. The remaining 4-foot antennas will be used in diversity receives applications only.

Pressurized elliptical waveguide will be used throughout the system on all radios at all frequencies. Flexible CMR to CPR 24-inch waveguide transitions will be used to connect the waveguide to the radio terminal.

Automatically-regulating and regenerating AC-powered dehydrators will be provided at all new or refurbished radio installations. The dehydrators will be supplied with wall-mounting shelves for conservation of floor and rack space as well as for noise and vibration isolation. The appropriate gas manifolds, pressure regulators, and gauges will be provided. All dehydrators will be equipped with low-pressure alarm indicators for remote monitoring (refer to the Alarm and Control System Description section of this contract for further details on remote monitoring via the MOSCAD Fault Management system to be provided by Motorola).

5.2.7. Network Multiplexing

All OC-3 radios (located on rings R1 through R9 except the OC-3 radio from Site 1505 Emporia Repeater AO to Site 9502 Brunswick CC) will be equipped with SONET OC-3 Multiplexers on the drop side of the radio using direct high-speed OC-3 interfaces to the inputs of the CM radio terminals. These multiplexers will function as the SONET loop-switching platform, providing diverse-route protection as well as protection against any transport equipment failure. The multiplexer will also function as a de-multiplexer for OC-3-to-DS1 partitioning and DS1 distribution at the site level and at the network level.

The “site level” DS1 distribution will be for local site equipment connection and the “network level” DS1 distribution will be for dynamic “through site” routing to the network level at 2-, 3-, 4-, and 5-way radio junctions via DS1 drops with physical cross-connects.

All radios off the rings both directly adjacent to the ring and/or downstream from the ring will have internal DS1 multiplexers built into the radio equipment. The built-in multiplex will be equipped in a hot-standby configuration consistent with the corresponding radio assembly and will provide direct DS1 connectivity to the radio. Once the DS1 signal is placed on the ring it then becomes route- and equipment-protected via the SONET Ring multiplex equipment.

Fujitsu Flashwave Terminal shelves will be installed at all SONET-based locations, with specific shelf model based on the quantity of DS1 terminations required at each individual site. All terminations provided for the multiplex equipment (as well as all radios with built in multiplexers) are DS1 level.

Password-protected Network Management Systems (network configuration software) for the Fujitsu Multiplex equipment will be located at SPHQ in Richmond and at VSP 6th Division Headquarters in Salem. This will be programmed in a master/slave or slave/master configuration (manually selectable via password protection) for back-up (redundancy) purposes and allow configuration of any Fujitsu Flashwave element in the network to be accessed from either the Richmond or Salem location.

5.2.8. DACS (Digital Access and Cross-Connect System)

The Digital Access and Cross-Connect System (DACS) consist of Zhone Arca-DACS terminals to be provided at SPHQ and all seven VSP Division Headquarters for DS0-to-DS1 grooming for bandwidth consolidation. This bandwidth consolidation provides efficient bundling of all similar and dissimilar sub-rate DS0 signals to be passed through the Division Headquarters locations to the Master Sites.

All sites within a division headquarters will be connected via DS1s to the Division Headquarters and each Division Headquarters will subsequently be connected to the assigned Master Site. Some DS1s will be a direct through-connection at the Division Headquarters and sent to the respective Master Site location (Zone 1 Master Site in Richmond or Zone 2 Master Site in Salem). The remaining DS1s will be terminated in the DACS where the DS0s will be dropped (for connection to equipment at the Division Headquarters), groomed, and bundled with other DS1s for a through-connection leaving the Division Headquarters.

The Zhone Arca-DACS terminals located at the Richmond and Salem locations will terminate all groomed and bundled DS1s from their respective Division Headquarters to provide the same function but in reverse. In so doing, fewer DS1s are consumed while connecting the Division Headquarters to the Master sites across the network and around the rings.

Password-protected Network Management Systems (network configuration software) will be located at SPHQ in Richmond and at 6th Division Headquarters in Salem for configuring the Zhone Arca-DACS terminal equipment over the network.

5.2.9. Batteries and Rectifiers

All Microwave sites will be equipped with new -48 VDC power systems. The system will consist of GNB Absolyte IIP 20-year sealed batteries and PCP Power Boards equipped with redundant chargers.

The PCP power boards will be equipped and configured as factory racked wired and tested assemblies. The assembly will contain individual DC Circuit Breaker Distribution Panel(s), Voltage and Load (Amps) continuous metering capabilities, High/Low DC Voltage Disconnect switching and all necessary maintenance and management alarm and control functions. For remote monitoring and alarm reporting, the DC power system alarm terminals will be connected to the corresponding site's MOSCAD Remote Terminal Unit (RTU). Refer to the Alarm and Control System Description section of this contract for further details on remote monitoring via the MOSCAD Fault Management system to be provided by Motorola.

Chargers will be provided in redundant arrangement with units of identical capacity and type working on a load-sharing basis during normal operation. Solid-state monitoring by the power board will be continuous and automatic switchover employed in the event of failure of either unit. Upon switchover the surviving rectifier will be able to carry the entire site load and provide 24-hour recharge in the event of any loss of AC power.

The GNB Absolyte IIP 20 year sealed batteries have been sized to provide a minimum 8 hours of -48VDC reserve based on initial site load plus a minimum of 30% additional loading from future requirements. The chargers will be capable of continuous site load while providing complete recharge capability within a 24-hour period.

Batteries will be rack mounted in EIA Standard relay racks for floor space conservation. The DC distribution circuit breaker panels and main -48VDC ground (return) bus will be isolated in this rack as part of the PCP power board assembly.