In-Tunnel System

2.0 In-Tunnel System

2.1 INTRODUCTION

Motorola is providing VHF and 700/800 MHz RF coverage for the following six tunnels in the Commonwealth of Virginia STARS project. Table 2-1 identifies the name, length, and the number of tubes associated with each tunnel and is the basis of the RF coverage design requirement:

TUNNEL NAME	LOCATION	LENGTH
Big Walker Mountain	I 77, Bluefield, VA	2 tubes @ 4229 feet each
Hampton Roads	I 64, Hampton, VA	2 tubes @ 7479 feet each
Elizabeth River Downtown	I 264, Portsmouth, VA	East bound tube @ 3813 feet and West bound tube @ 3350 feet
Elizabeth River Midtown	Rt. 58, Portsmouth, VA	1 tube @ 4194 feet each
Monitor/ Merrimack	I 664, Newport News, VA	2 tubes @ 4800 feet each
East River Mountain	I 77, Bluefield, VA	2 tubes @ 5412 feet each

Table 2-1 – Tunnels/Location/Length

2.2 FREQUENCY BANDS

Table 2-2 illustrates the frequency bands and corresponding number of channels for the RF signals that will be extended into these tunnels.

Frequency Band	**Number of Channels**
VHF High Band	8
700/800 MHz	1

Table 2-2 Frequency Bands/# of Channels

Note: The VHF High Band channels are being designed to have a minimum spacing of 150 kHz between transmitter frequencies.

2.3 SYSTEM OVERVIEW

The system consists of a series of LinkNet (as specified in Appendix 5) channelized service modules which will be housed in 2 enclosed racks in the facilities located at each tunnel entrance. The system architecture will consist of the following items:

- Off-Air Signal Pickup Equipment
- 8-Channel VHF Headend System
- VHF/700/800 MHz Headend System
- Signal Distribution System: This system comprises in-tunnel radiating single-cable network for distributing the VHF and 700/800 MHz signals. (Some of the tunnels, i.e.; Monitor/Merrimack, presently have "leaky coax" already installed in them. Motorola will investigate as a cost savings whether this line can be used in the STARS as the distribution network.)

2.3.1 Off-Air Signal Pickup Equipment

Donor signals will be picked up off-air to support the new STARS VHF Integrated Voice and Data network. A VHF yagi-type antenna will be utilized and mounted at each tunnel's administration building. Yagi or other directional antennas will be pointed at the appropriate tower for the VHF service that will pass through the LinkNet service modules.

LMR Sites Providing Donor Signals to the Tunnel System

Tunnel Name	Closest LMR Site	2nd Closest LMR Site
East River Mtn Tunnel	1403 -- Dismal Mtn.	1406 -- East River Mtn.
Big Walker Tunnel	1406 -- East River Mtn.	1403 -- Dismal Mtn.
Hampton Roads	1502 – Hampton	1501 -- 5th Div HQ
Elizabeth River Downtown Eastbound	1501 -- 5th Div HQ	1502 -- Hampton
Elizabeth River Downtown Westbound	1501 -- 5th Div HQ	1502 -- Hampton
Elizabeth River Midtown Tunnel	1501 -- 5th Div HQ	1502 -- Hampton
Monitor/Merrimack	1502 -- Hampton	1501 -- 5th Div HQ

Table 2-3 LMR Sites Providing Donor Signals to the Tunnel System

2.3.2 8-Channel VHF Headend System

To achieve maximum Headend power output-per-channel and hence eliminate VHF Bi-Directional Line Amplifiers, the LinkNet channelized on-frequency repeaters are employed for the VHF service.

The LinkNet Headend will be housed in two 70" high x 23" wide x 31.5" deep floor mounted enclosed racks that includes 16 LinkNet™ Service Modules (LSMs), three power supplies, one Gateway Module and transmitter combiner with filtering. (Please refer to Headend block diagram Q6311-BLK-2-R1 later in this section). The LinkNet architecture provides dedicated filtering, combining, and controlled amplification, allowing selective monitoring and control (local and/or remote) of system parameters for the VHF service.

The VHF LSMs are channel-specific amplifiers with a gain range of 65-95 dB for VHF modules. The LSMs are both analog and APCO P25-compliant channelized amplifiers. All control connections are made via card-edge connectors and semi-rigid jumper cables inside the floor-mounted rack, allowing for quick and easy module insertion and removal for maintenance. The Gateway Module permits remote and on-site diagnostics, control and configuration of the RF system. Where point-to-point wireless broadband links are not feasible, the Commonwealth will be responsible for providing a DSL connection or a dedicated POTS line to each of the tunnel Headend systems.

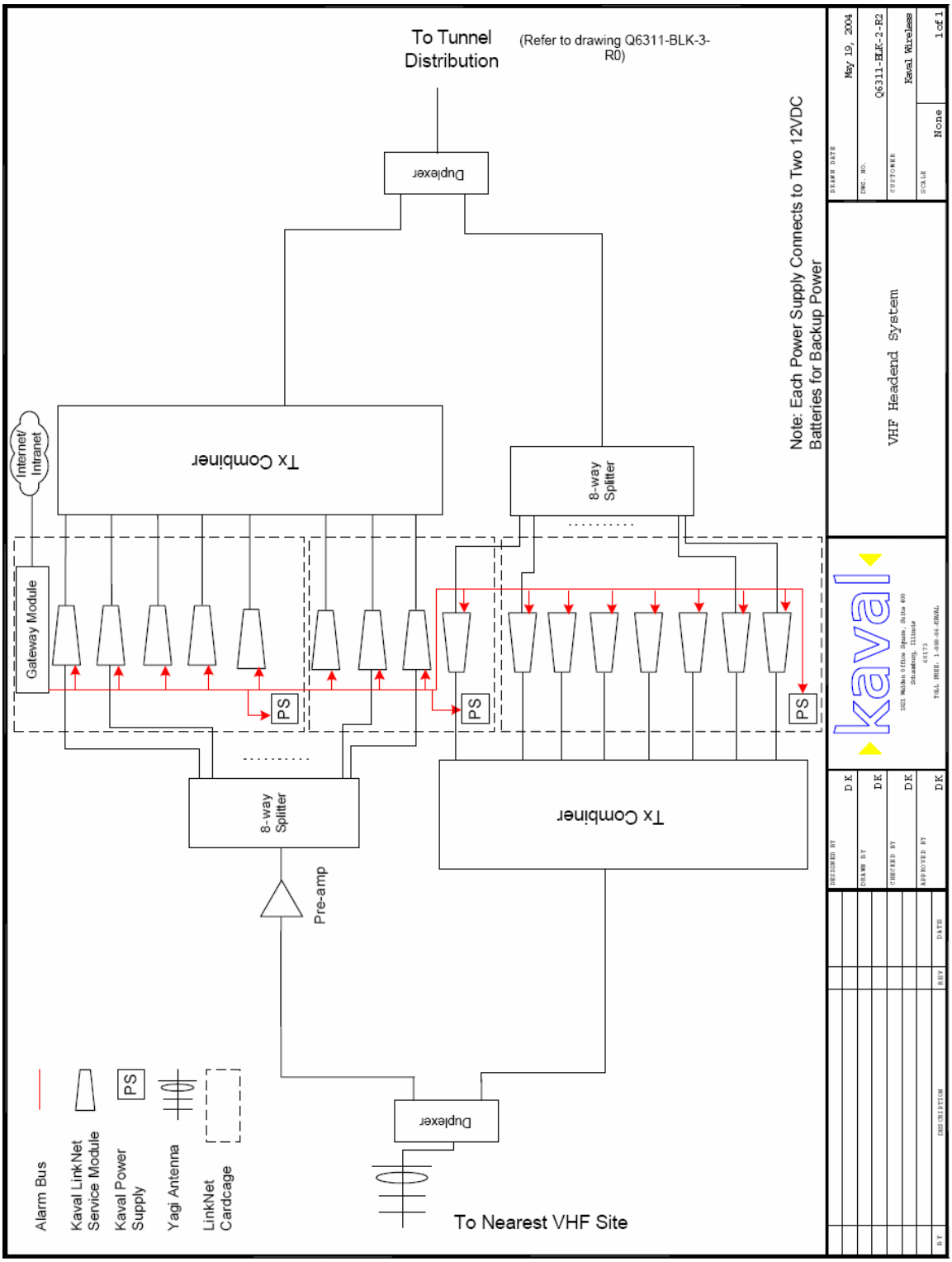
The system design assumes that the Commonwealth will provide a secure communications room with sufficient space for the 2 enclosed racks, adequate power for the Headend equipment, and provide sufficient ventilation to maintain room temperature between 14° and 95° F and non-condensing humidity. The Headend will accept standard 120V AC input from standard 15A sockets. The VHF Headend power should not exceed 1200 Watts. Motorola will provide the R56 audit and all grounding and electrical work will be provided by the Commonwealth.

2.3.3 VHF/700/800 MHz Headend System

Performing the headend function for 700/800 MHz service, one VHF/700/800 MHz crossband Digital Vehicular Repeater System (DVRS) per tunnel will be provided and installed by Motorola. This unit will signal other DVRS units on scene to avoid contention for the priority repeater.

The 700/800 MHz RF signals from the tunnel are fed to the DVRS for conversion to VHF. This will allow 700/800MHz portables for the Commonwealth to communicate using the VHF network. The 700/800MHz RF signals are coupled into the distribution system using a crossband coupler as shown in drawing Q6311-BLK-3-R0.

VHF Headend System



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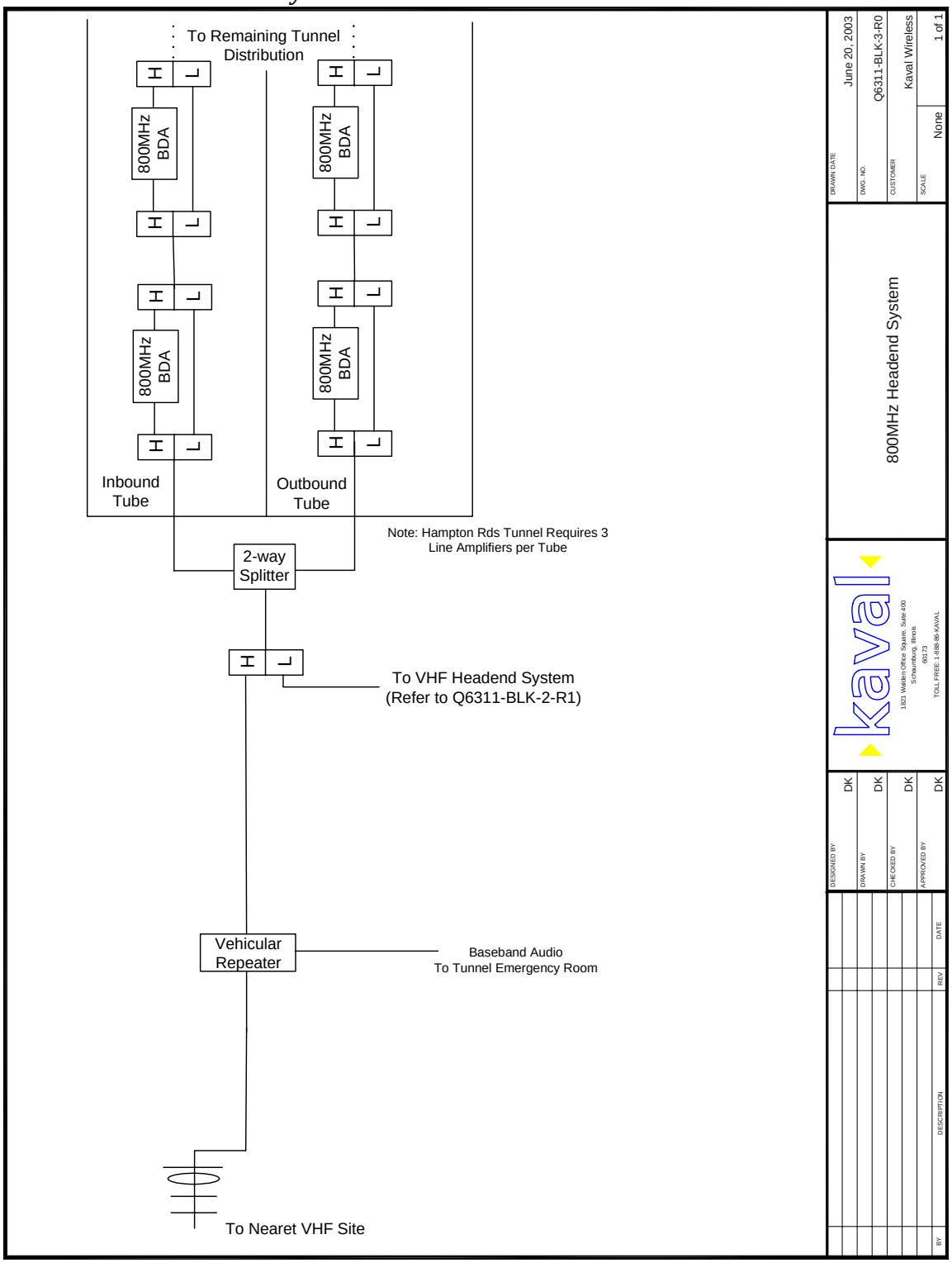
VHF/800 MHz Headend System



2.3.4 Signal Distribution System

The distribution systems for the tunnels have been designed with the intent that no VHF line amplifiers will be used to provide STARS coverage in the tunnels. 7/8-inch fire-retardant radiating cable will be used in the Big Walker Mountain, Elizabeth River Downtown Tunnel and the Elizabeth River Midtown Tunnel. To meet the design requirement of the Hampton Roads Tunnel, Monitor Merrimack Tunnel, and the East River Mountain Tunnel, 1¼ inch fire retardant cable will be utilized. Special attention will be given to cable connectors to assure stable conductivity in a salt environment.

The distribution inside the tunnels will also facilitate 700/800 MHz coverage for the following scenario.

- The person walks away from their vehicle and uses their 700/800 MHz portable. The 700/800 MHz RF signals will couple onto the distribution system and will be transported to the Kaval Headend where they will be converted to VHF using a Digital Vehicular Repeater System (DVRS). This will allow the person to continue communication on the VHF system with a 700/800 MHz portable anywhere within the tunnel coverage area defined in Section 4. The 700/800 MHz coverage within the tunnel facility is independent of the vehicle being located inside the tunnel. The 700/800 MHz Bi-Directional Amplifiers (BDAs) will operate in the 764-776 or 851-869 MHz range for the downlink path and 794-806 or 806-824 MHz range for the uplink path. This is illustrated in drawing Q6311-BLK-2-R1. The VHF RF signals will bypass each BDA within the tunnel by using crossband couplers as shown in the diagram. The operation of the DVRS in Tunnel configuration is described in the DVRS Section 10.3.1 and 10.3.2. Additionally, the DVRS has the ability to be programmed as a “Master”.

All grounding and electrical work within the tunnels will be provided by the Commonwealth.

2.3.5 Expandability of the System Channels

The system architecture is modular in nature and is expandable based on the number of additional channels required. Additional channels can be added to the transmitter combiner in groups of 1, 2 or 4 as long as the minimum frequency spacing is kept to 150 kHz.

2.3.6 System Monitoring and Alarming

The in-tunnel RF system will be monitored by the STARS alarm monitoring and control system that allows 24-hour visibility and control of all active equipment installed within a system location by the SPHQ NOC. The InView Management System (IMS) provides remote access to the in-tunnel RF system for the purpose of Status Monitoring and Control of various entities in the system. This includes any LinkNet Service Modules (LSMs), as well as auxiliary inputs such as general-purpose contact closures, UPS status indicators, etc. The system's Gateway Module permits remote and on-site command capability for all elements of the equipment for immediate notification of a problem, should it arise. The connection to the Gateway module will be done with VPN access for added security.

Where point-to-point wireless broadband links are not feasible, the Commonwealth will be responsible for providing a DSL connection or a dedicated POTS line to each of the tunnel Headend systems. Alarm conditions reported for service modules include power failures, loss of contact, and module-specific alarm conditions (including over-current, low input signal power, over temperature, loss of lock and others). An event is also reported and logged when a fault is cleared.

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