CONTRACT MODIFICATION # 18

CONTRACT MODIFICATION #5 OPTION B REPLACEMENT

SECTION 2A – MOTOBRIDGE IP SYSTEM OVERVIEW

2.0 OVERVIEW

Motorola MOTOBRIDGE IP is an IP-based radio interoperability system. The system allows dynamic statewide, regional, and local radio interconnections (Trunked and Conventional) for public-safety first responder forces and allows network dispatchers to access and control patches to each and every network connected via MOTOBRIDGE IP gateways.

The MOTOBRIDGE IP Solution consists of the following components:

- Radio Gateway Units (R-GUs) installed at 1st Division Headquarters (1), 5th Division Headquarters (1), each County (14) dispatch centers and the NOC (1)
- Workstation Gateway Units (WS-GUs) installed at 1st Division Headquarters (1), 5th Division Headquarters (1), each County (14) dispatch centers and the NOC (1)
- Operation and Maintenance Center (OMC) Server at the NOC (1)
- Session Initiation Protocol (SIP) Server at the NOC (1)
- Internet Protocol (IP) Routers (1) at each site (2 at NOC)
- Ethernet Switches (1) at each site (2 at NOC)
- Dispatch PCs (1 for each WS-GU)
- Administrative Control Panel (ACP) PCs (1 at NOC and 1 spare)
- Firewall Server (1 at NOC)
- IP Network
- Subscriber Radios/Control Stations

The system is a distributed network architecture, based on peer-to-peer (P2P) IP-based networking and industry standard Session Initiation Protocol (SIP) signaling, which creates a robust and scalable network for mission critical operation. Moreover, the system architecture and design incorporates extensive use of high-availability components throughout the network that results in continued system operation even with the loss of system components (i.e., overall system operation is maintained with no single point of failure).

2.1 MOTOBRIDGE IP Method of Operation

Motorola's MOTOBRIDGE IP System utilizes a customer-supplied IP network, Motorola IP Gateway devices and application software, as well as, standard networking components (commercial-off-the-shelf) to provide a means of networking different radio systems into one virtual network thereby allowing communications and interoperation across radio system boundaries. Native radio system subscribers, (i.e. radios; VHF Low-band, VHF High-band, UHF, 700 MHz, 800 MHz, conventional, or trunked), wireless control stations, or other console operators will interface to MOTOBRIDGE IP Gateway Units (e.g., Radio-GU or WorkStation-GU) that are connected to an IP network via standard routers and other LAN components. The IP network provides the transport mechanism that distributes IP datagrams to multiple target destination locations depending on the specific connections that are dynamically selected by any dispatch operator in the network. It is important to note that access to the STARS IV&D network will require the connection to be initiated with a VSP dispatcher or NOC operator. MOTOBRIDGE IP Gateway Units are soft-switching devices that convert base-band audio of each corresponding radio subscriber or dispatch PC to IP datagrams that are then, dynamically distributed throughout the MOTOBRIDGE IP network.

Each dispatch WS-GU interfaces to a PC with the MOTOBRIDGE IP dispatch software application. Multiple dispatch WS-GUs may be located at a single location or distributed across multiple different locations with an appropriate set of networking components. SIP signalling messages are used between the R-GUs and WS-GUs to establish the connections among them, and while the connection is made, the encrypted (AES) audio is carried together with the related PTT/COR (E&M) signals in the IP datagrams.

Radio connections in MOTOBRIDGE IP network may be established from any dispatcher position; each radio in the system has a unique SIP ID and the dispatcher, at any time and from any place, may browse for the available radios in the system and their status.

MOTOBRIDGE IP provides an Operation and Maintenance Center (OMC) functionality consisting of synchronized servers that may be located at two different geographical locations, which hold the system database of operators/dispatchers, agencies, radio equipment, etc. The Division 1 MOTOBRIDGE IP Interoperability Solution includes a primary OMC server to be located at the NOC. When funding is available, a second OMC (backup) can be added at the Division 6 Communications Center. The OMC provides an overview of the MOTOBRIDGE IP system and holds emergency network configurations to be utilized at a time of crisis.

The following sections provide details on MOTOBRIDGE IP entities.

2.2 MOTOBRIDGE IP Gateway Units (Soft-switches)

For ease of maintenance, MOTOBRIDGE IP Gateway Units (soft-switches) are based on a common hardware platform, which can be configured to serve as either a Radio Gateway Unit (R-GU) or a Dispatch Workstation Unit (WS-GU) through a simple software selection. The hardware and software contained on each gateway device is identical and contains a robust set of features designed for public safety communications, including on-board security (i.e. encryption) features and DSP processors and utilizing a real-time operating system.

2.2.1 Radio Gateway Unit

Each Radio Gateway Unit (R-GU) is capable of interfacing to a maximum of eight (8) different radio / communication devices (up to four are being provided) connecting any combination of VHF (Low and High band), UHF, 700 MHz, 800 MHz conventional or trunked radio equipment to MOTOBRIDGE IP network. Additional radio devices can be added at a single location or distributed across multiple locations by simply adding the appropriate number of R-GUs and associated networking components that does not exceed the capacity of IP network link provided. This provides virtual unlimited means of system expansion and scalability. The R-GU implements a "radio-service" function for every radio/station connected to each of the eight (8) ports (up to four are being provided). The radio-service function allows multiple remote dispatchers and radios (radio patches) to share the radio for bi-directional RF communication. Sharing is achieved by a priority mechanism that allows the highest priority user to take the Push-To-Talk (PTT) control on transmission, and by a packet-distribution mechanism that allows all remote users to get a replica of the received (or Tx-monitoring) audio from the radio.

The R-GU uses Motorola Remote PTT Dedicated Framing Layer (RPDFL) to implement the radio-service function, and Session Initiation Protocol (SIP) to initiate the RPDFL connections.

2.2.2 Workstation Gateway Unit (WS-GU)

The WS-GU provides the dispatcher with the following communication capabilities:

- Remote radio connections.
- Radio System dispatch console interface.
- Intercom connections.
- Telephony.

- Conferences and radio-patching capabilities.

To use these, the WS-GU would use SIP for session initiation of all types, RPDFL for remote radio connections, intercom and conferences, and RTP for telephony. All audio sources are summed by the WS-GU for the dispatcher left/right ears with full volume control over each audio source. The dispatcher WS-GU position will be equipped with two (2) desktop speakers to allow monitoring of the dispatch position audio when the headset is disconnected.

The dispatcher users operate their WS-GU through a GUI application running on a PC connected to the WS-GU.

2.3 OMC

The OMC is the main server in the MOTOBRIDGE IP system, which allows the manager in the STARS NOC to centrally configure all users at the time of incident and in normal day-to-day routine. The OMC is a central location where all the system users (administrators, dispatchers, radios) are registered, and where system wide information (interoperability "drawer" plans, active patches, remote alarms, conferences, and security parameters, etc.) is stored and manipulated.

When funding is available, the OMC may be built using synchronized servers located in two separate geographical locations (i.e. STARS NOC and Division 6 Communications Center) to assure high-availability of the OMC service. However the OMC is not considered as a single-point of failure in MOTOBRIDGE IP system because:

All MOTOBRIDGE IP active connections are peer-to-peer (P2P) IP connections and would continue to operate even when both OMC sites are "down." (However, no automatic failover will take place at the absence of the OMC.)

All MOTOBRIDGE IP connections are initiated through SIP servers, thus new connections may be established even in the absence of the OMC. (However, any system-wide information that is updated while the OMC Server is down is not provided to the dispatchers, who must rely on the existing system-wide information stored in their dispatch consoles.)

Security Management (i.e. log-in and authentication) is lost in the absence of the OMC. All crypto-keys remain active but cannot be managed.

2.4 SIP infrastructure

MOTOBRIDGE IP has adopted standard SIP protocol as its resource identification and registration scheme (SIP URI and SIP Registrar), and Session Initiation Protocol.

The use of SIP allows MOTOBRIDGE IP to utilize off-the-shelf standard equipment to create a scalable county/region/state-wide network that may be extended easily to a worldwide network with minimum effect on the OMC. The SIP Servers offload from the OMC the need to manage the resources' IP addresses, or to be involved in every session-initiation across the network, thus allowing the OMC application to be "lighter" and the whole MOTOBRIDGE IP network to be much more survivable and scalable.

For the purpose of utilizing the standard, SIP protocol, each resource (radio, R-GU, WS-GU, OMC) in the MOTOBRIDGE IP system is assigned by a unique SIP registration identity (e.g., SIP URI) and is represented by a SIP User Agent (SIP-UA) process in front of the regional SIP Proxy server. SIP protocol messages are extended in standard fashion to support RPDFL session's initiations.

2.5 Firewalls

Motorola will provide Firewalls in the MOTOBRIDGE IP network to protect the OMC and SIP servers from malicious attacks.

The operation of the Firewall is transparent to the OMC or SIP equipment. The WS-GU/R-GU supports IP-Sec tunnels to gain access to the OMC and SIP servers through the firewall(s).

2.6 IP Backbone

The IP backbone consists of the following:

2.6.1 IP Backbone – Wide-Area Network (WAN)

A set of IP Routers, whose traffic is carried by a public or private telecom carrier to the STARS NOC and then to the remote sites participating on a cross-state IP network.

2.6.2 Access Networks

MOTOBRIDGE IP deployment involves the formation of local area networks (LAN). Those include LAN switches and access routers, and are deployed at the city and county sites to allow intra-site communication and access to the wide-area IP backbone.

2.6.3 IP Network Requirements

Symmetrical connectivity technology
Static IP Address Scheme

Packet Jitter	< 50 msec (recommended)
	<100 msec (supported)
Packet Delay	< 300 msec (recommended)
	< 400 msec (supported)

Packet Loss < 2%
No Network Address Translation/Network Address Protocol Translation (NAT/NAPT)

Reliable system operation and delivered voice quality cannot be guaranteed if the network performance does not always meet these requirements.

2.6.4 MOTOBRIDGE IP System Performance

- Audio delay between two end units on the same LAN < 50 msec
- PTT delay between two end units on the same LAN < 20 msec
- Talkpath set-up time < 2 seconds

2.6.5 IP Network WAN Bandwidth Utilization

Maximum rating for MOTOBRIDGE IP WAN bandwidth utilization and IP packet loading are specified below per radio/intercom participant pair and at full voice utilization.

Vocoder Type	Frame Length	AES Encryption	Packet loading	BW Utilization
G.729	40 msec	Yes	25 per second	18.4 kbps
G.729	40 msec	No	25 per second	16.8 kbps
G.729	30 msec	Yes	33.3 per second	20.3 kbps
G.729	30 msec	No	33.3 per second	19.8 kbps
G.729	20 msec	Yes	50 per second	30.4 kbps
G.729	20 msec	No	50 per second	25.6 kbps
G.729	10 msec	Yes	100 per second	48 kbps
G.729	10 msec	No	100 per second	43.2 kbps
G.711	40 msec	Yes	25 per second	72.8 kbps
G.711	40 msec	No	25 per second	72.8 kbps
G.711	30 msec	Yes	33.3 per second	75.8 kbps
G.711	30 msec	No	33.3 per second	75.8 kbps
G.711	20 msec	Yes	50 per second	81.6 kbps
G.711	20 msec	No	50 per second	81.6 kbps
G.711	10 msec	Yes	100 per second	99.2 kbps
G.711	10 msec	No	100 per second	99.2 kbps

Radio, intercom Telephony and conference audio can be vocoded using either G.711 or G.729. **Note**: Care will be taken to ensure that a low vocoder rate (G.729) is not used with audio that has already been de-vocoded from a low rate vocoder (IMBE). The G.711 vocoder provides higher quality voice audio but requires higher bandwidth.

Network bandwidth for each of the remote sites participating has been mutually agreed to be 512 kbps based upon the following assumptions:

The Division 1 MOTOBRIDGE implementation with 14 localities requires support for one conference with up to four (4) simultaneous remote dispatch conference attendees and one radio patch with up to four (4) remote radio participants at each site location at any given time.

- AES encryption will be enabled on all gateway to gateway communications within the IP backbones network.

- A frame length of 30 msec is the system default for initial settings which can be updated dynamically by the system administrator.

- This configuration initially set with a G.711 vocoder at 30 msec requires at least 303.2kbps of network bandwidth to support up to four (4) dispatch conference attendees simultaneously.

  303.2kpbs = 75.8 kbps x 4 remote conference attendees

- The configuration initially set with a G.729 vocoder at 30 msec requires at least an additional 81.2 kbps to support up to 4 non-conference type of communications.

  81.2kpbs = 20.3 kbps x 4 remote radio participants

- An uncommitted allocation of 127.6kbps is reserved to anticipate unusual or high demand activity needed during a crisis situation beyond the configuration initially set.

2.7 Subscriber Radios

The MOTOBRIDGE IP supports the following subscriber radios:

- MCS 2000
- Spectra
- ASTRO Spectra
- ASTRO Spectra Plus
- XTL 5000
- Non-Motorola radios/stations are limited to 4-Wire/6-Wire/Tone Remote Control only

Please note that advanced features such as "virtual control head," are only supported on Motorola radios supporting the SB9600 interface bus.

2.8 MOTOBRIDGE IP Implementation

This Contract Modification covers the MOTOBRIDGE IP-specific infrastructure equipment and software and is prepared with the understanding that the Commonwealth of Virginia provides the data line connectivity between all sites.

2.8.1 Included Items for the Division 1 MOTOBRIDGE IP Implementation

The following is a high-level list of what is included in this Contract Modification:

- MOTOBRIDGE IP Gateways – including the R-GU and WS-GU.
- Network switches and routers needed to interface the MOTOBRIDGE IP equipment to the Commonwealth's IP network.
- MOTOBRIDGE IP Dispatch positions and peripherals (headsets, and desktop speakers).
- Firewall hardware and software to protect the OMC and SIP servers.
- Control Stations (quantity of three [3]).

2.8.2 Items Not Included for the Division 1 MOTOBRIDGE IP Implementation

The following is a high-level list of what is **not** included in this Contract Modification:

- IP network (access LANs) between MOTOBRIDGE IP components listed above.
- Localities Subscriber radios and RF infrastructure.
- Transport backhaul.

- IP planning.
- Bandwidth planning.
- PSTN Interface.