STATEWIDE AGENCIES RADIO SYSTEM (STARS)

Annual Report of Anticipated Expenditures for Equipment Replacement

A Report to:

House Appropriations Committee
Senate Finance Committee
Secretary of Public Safety and Homeland Security
Secretary of Finance
Secretary of Technology
Director of the Department of Planning and Budget
STARS Management Group

October 2017

Colonel W. Steven Flaherty
Superintendent

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COMMONWEALTH OF VIRGINIA

DEPARTMENT OF STATE POLICE

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Deputy Superintendent

October 1, 2017

TO: The Honorable S. Chris Jones
Chairman of the House Appropriations Committee

The Honorable Thomas K. Norment, Jr.
Co-Chair of the Senate Finance Committee

The Honorable Emmett W. Hanger, Jr.
Co-Chair of the Senate Finance Committee

The Honorable Brian J. Moran
Secretary of Public Safety and Homeland Security

The Honorable Richard D. Brown
Secretary of Finance

The Honorable Karen R. Jackson
Secretary of Technology

The Honorable Daniel Timberlake
Director of the Department of Planning and Budget

STARS Management Group

Pursuant to House Bill 1500 Item 422.I.2 of the 2017 Virginia Acts of Assembly, I am respectfully submitting herewith a report detailing anticipated expenditures for equipment replacement for the State Agencies Radio System (STARS) over the ensuing six fiscal years.

Respectfully,

W. S. Flaherty

Superintendent

WSF/RAE/tlt

Enclosure

Background:

Colonel W. Steven Flaherty, State Police Superintendent and Mr. Mark Moon, Vice President and General Manager of Motorola signed a $329 million contract between Motorola and the Commonwealth of Virginia for the design, construction, and implementation of the Statewide Agencies Radio System (STARS) on July 13, 2004. Effective July 1, 2011, The Virginia State Police Information and Communications Technology (ICT) Division - Communications Section assumed responsibility for the engineering, installation, maintenance, and operation of the STARS Network. The STARS Network includes the backbone microwave network, the land mobile radio network, the five (5) Tidewater tunnels and two (2) Western tunnels, and all vehicle-based hardware and software for all participating State Agencies. Subsequent to this milestone one locality has joined the network.

The STARS Network provides a multi-channel trunked digital voice and data wireless communications capability specifically designed to meet APCO Project 25 public safety requirements. The core microwave network consists of Synchronous Optical Network (SONET) ring-protected transmission paths providing the highest quality of service and reliability possible with security through controlled system access.

Maintaining technology today is a labor intensive and costly proposition. Hardware and software is typically obsolete by the time it is purchased and installed and the STARS Network is no exception. The annual lifecycle cost to keep the core Motorola portion of the network current is over $1M annually. This does not include the hardware and software upgrades necessary to keep the transport network at top operating efficiency. In addition, much of the support hardware including microwave radios, power subsystems, and multiplexing equipment is at or beyond end-of-life. While all new sites under construction are being equipped with the latest hardware and software there is much work to be accomplished.

This document provides a detailed report of anticipated expenditures for equipment replacement from FY2018 through FY2024. The timing of all upgrades and/or equipment replacements is dependent on availability of funding. This document should provide guidance to the Governor's Office, Secretary of Public Safety and Homeland Security, the Secretary of Finance, the Secretary of Information Technology, the Director of the Department of Planning and Budget, the STARS Management Group, and the Chairmen of the House Appropriations and Senate Finance Committees sufficient detail to enable the joint effort necessary to maintain the highest quality of service, security, and reliability possible for the STARS Network.

The following narrative discusses the major subsystems of the STARS network and identifies the lifecycle cost of individual components. This narrative is followed by a detailed schedule by fiscal year of the annual and one-time expenditures planned.

Transport Backbone:

The backbone of the STARS Network consists of microwave radio and fiber optic cable links configured in unidirectional path-switched SONET rings (UPSR). Should a fiber cable or microwave hop fail, the ring protection maintains the transport services that today consist of T1 circuits. There are spurs to the backbone of varying bandwidths that are not ring protected but are designed for the highest reliability possible.

The microwave radio component of the backbone network consists of radios, waveguide, and antennas. The microwave radios used in STARS are provided by Microwave Networks Incorporated located in Stafford, Texas. The original hardware installed consists of CM6 SONET/SDH Digital Microwave radios that provide a transport bandwidth of 155.52Mbps or Optical Carrier Level 3 (OC3) and 45Mbps or DS3. Manufacture of these radios ended in June of 2006. The last date to purchase parts was December 2006 with the last date for repair support June 2022. Starting in calendar year 2017, all new microwave paths will use the Proteus MX series radio (introduced in 2011) or later model. The remaining CM6 radios in stock will be used for spare parts. MNI will introduce the newest Proteus series in 3rd Quarter of 2017.

Within the next four to eight years the STARS backbone will undergo a major upgrade. This will be driven by Motorola as they migrate from circuit-switched transport to packet-switched Ethernet transport from the land mobile radio RF sites to the Zone Master Sites. Based on our current understanding of this migration, all ring-based microwave radios will require replacement with higher bandwidth radios with Ethernet interfaces. Discussions with MNI indicate their newer radios will accommodate SONET and Ethernet interfaces that will allow the transition from T1 circuit-switched transport to MPLS packet-switched transport. This transition will require the addition of new routers capable of routing MPLS traffic. Once the backbone network is upgraded the RF sites will transition until all T1 transport is eliminated and all of the bandwidth of the backbone will be dedicated to Ethernet/MPLS. The timing of this migration has not yet been determined but it is expected in the fiscal year 2020 -2024 timeframe.

The microwave radio antennas used in most rings are dual polarized and will accept two different microwave radios doubling the capacity of the path when needed. There are a variety of microwave antennas and waveguide components used in STARS. Most microwave antennas are high performance with the cost for an 8 foot dish $14K. The waveguide for a 200 foot tower with four runs of waveguide at 6GHz would cost approximately $13K @ $21 per foot and depends on the required height of the antennas. All microwave radio dishes are encased with canvas covers to keep out wildlife and weather. These covers deteriorate over time and become susceptible to weather and damage from birds seeking places to build nests. We have budgeted to replace 30 antenna covers per year ($52K).

Protection switching for transport services is provided by Fujitsu Network Communications, Inc. multiplexers. All of the Fujitsu FLASHWAVE multiplexer products are manufacturing discontinued: 4100 – January 15, 2014; 4300 – November 12, 2013; and 4500 - June 17, 2012. The FLASHWAVE 4100ES product line is still in manufacture. Components of the end-of-life products are available in secondary markets. A migration to FLASHWAVE 4100ES is planned with procurements annually. Motorola has indicated that their RF site equipment will move from T1 to Ethernet interfaces utilizing Multiprotocol Label Switching (MPLS) packet-switching transport technology by calendar year 2022. This transition will require that all older Fujitsu multiplexers be replaced or eliminated. Microwave Networks MX series radios support Ethernet and MPLS. VSP Engineering is working with Motorola and MNI to determine how and when the transition to packet-switched transport will occur. One item not yet quantified is the routers required for MPLS.

The transition to packet switched transport will eliminate the need for DS1/0 Zhone IMACS multiplexers throughout the network. These products are still in production. The original central processing cards (CPU3) and associated interface cards are manufactured discontinued and must be replaced with CPU7s and their associated Interface Card. This has been an ongoing project as the capabilities of the multiplexers require upgrading in the short term. Our supplier PSI Technologies offers a trade-in allowance for CPU3's when replacing them with CPU7's. The cost of the Zhone multiplexer upgrade is $4.8K each.

The Arcadacs DS1/0 digital cross-connect system is used at the Zone Master Sites and VSP Division offices to groom T1 circuits. This product is well beyond end-of-life with components no longer available. 3rd-party repair shops still attempt to repair defective cards with limited success. This product will require an RFP to select a replacement or elimination through the transition to packet-switched transport.

RF Site Support Hardware

The equipment shelters at STARS RF sites are manufactured by VFP Industries. Sites with ease of access have aggregate buildings of varying sizes. These come from VFP pre-constructed and can be delivered intact. Some remote sites with mountainous access roads have shelters that consist of pre-fabricated panels that must be constructed on-site. These shelters are experiencing leaky roofs and collapsing floors and will require replacement at a projected cost of $80K each.

The towers used by STARS are predominantly free-standing and vary in height from 60 feet to 400 feet. The structural standard that applies to towers continues to become more stringent. The loading on STARS towers is maintained at approximately 85% of the current standard. As additional microwave and LMR antennas are added, the tower loading must be examined and the tower strengthened to maintain compliance with the latest standard. In rare cases such as with the Hampton site the tower must be replaced.

Each STARS shelter is equipped with two BARD HVAC units. These units have been in operation since 2005 and are failing at an increasing rate. The most common failures are the contactor that converts the low voltage thermostat signals to high voltage required to start and run the compressor and fan motors. VSP technicians have been trained to replace these common electrical failures. To change a compressor requires someone with a certification in handling the Freon. The Freon must be vacuumed out of the failed unit and captured. After the new unit is installed it is pressure tested with an inert gas, the unit is recharged with Freon. There are 84 STARS Shelters with two units each. VSP has budgeted to replace twelve (12) units per year. As the system ages this number may need to be increased.

Each STARS RF site is equipped with a propane fueled generator and associated transfer switch. These devices are manufactured by Cummins. The generators and transfer switches are maintained by VSP personnel. Over time some of these units will need to be replaced. Generators are rated by their output under load and cost on average $12K. A transfer switch costs $4K.

STARS LMR sites were initially equipped with uninterruptible power supplies (UPS) manufactured by Emerson to provide backup power for AC powered equipment until the backup generator starts. These UPS units are well beyond end-of-life and will not be replaced. Most transmission equipment such as the microwave radios and Fujitsu multiplexers are powered by -48VDC power. The new GTR8000 site repeaters can be DC powered making it possible to eliminate the UPS. The existing -48VDC power supplies will be resized to power all of the site equipment. Remaining AC powered devices will be powered through inverters. The -48VDC power supplies and GTR8000 repeaters are included in FY2018 funding. The cost for a new -48VDC power plant is $26K and includes inverters and backup batteries.

The incoming commercial power line for each STARS site is equipped with a surge arrestor to protect site equipment from surges from power company equipment failures and lightning strikes. There is an additional surge arrestor installed between the generator and site equipment for the same purpose. VSP has budgeted to replace twelve (12) units per year at a cost of $1.2K each.

Land Mobile Radio Infrastructure Equipment

The land mobile radio (LMR) equipment used in STARS consists of LAN/WAN hardware, site controllers, site repeaters, combiner/multi-couplers that allow multiple frequencies or channels to use the same transmission lines, and antennas. A typical STARS RF site is equipped with a minimum of one receive antenna and one or more transmit antennas. Antennas are susceptible to ice, wind and water damage. We anticipate replacing 5 LMR antennas a year at an average cost of $3.5K each. Transmission line for LMR is $11 per ft. For a 200 foot tower the cost would be approximately $6K.

The Quantar site repeaters are being replaced by GTR8000 repeaters prior to June 2019 to prepare for the 7.16 to 7.18 system upgrade. Quantar repeaters are no longer supported after Motorola Release 7.16. Funding for the Quantar replacement is funded by remaining initial STARS Bond funds and MELP Bond funds in FY2018. The site controllers are now an integral component of the GTR8000 platform.

To add capacity to an LMR site requires a pair of frequencies for each channel added. The VHF frequency spectrum that STARS operates in is all but occupied. To overcome congestion in the various wireless frequency bands, new digital technologies have been introduced that allow more information to be carried in smaller bandwidths. TDMA splits the current 12.5 KHz channel bandwidth into two 6.25 KHz channels doubling the per channel capacity. To implement TDMA requires new hardware and software: MCC7500 consoles, new mobile and portable radios, a second receive antenna in some instances, and new RF site and master site software. All dispatch consoles have been upgraded to MCC7500, the orders for the GTR8000 site repeaters will include the necessary hardware for TDMA, the mobile and portable radios required for TDMA are scheduled for upgrade, and the software required will be updated when the conversion process is implemented.

TDMA implementation guidelines specify that at some sites a second receive antenna is required. An additional antenna at the top of the tower requires transmission line, additions to the combiner/multi-coupler network, and possibly a new tower structural analysis. Manpower to implement TDMA will also be impacted. This modification to an RF site is expensive ($12.7K):

- Average cost of LMR antenna - $3.5 K
- $3-5K for additions to the combiner/multi-couple networks
- Transmission line @ $11 per foot with towers ranging from 60-400 feet ($2.2K for a 200 foot tower)
- New structural analysis for the tower - $1.5-3K each.

The Motorola 2500 site routers will no longer be supported after Release 7.16. The LMR site routers are being replaced as part of the GTR8000 upgrade. 17 microwave-only sites will require upgrade prior to the Release 7.18 upgrade scheduled for June 2019. The Motorola 2500 LMR site routers were equipped with serial interfaces that use an HSU card in the Zhone multiplexers to convert the serial bandwidth to multiple DS0 bandwidths for transport across a T1 circuit. The GGM8000 replacement routers currently use T1 wide area network interfaces. In order to combine the LMR site bandwidth (11DS0s) with other site circuits such as remote consolettes and telephone circuits, the redundant Zhone CPU3 processor cards must be replaced with redundant CPU7 processor cards, associated interfaces cards, and new firmware. The HSU card is replaced by DS1 cards. These

changes are being performed along with the Quantar to GTR8000 upgrades. The cost for a Motorola GGM8000 router is $3.4K. The cost of the Zhone upgrade is $4.8K each.

Motorola has indicated that the next generation of transport will evolve to Ethernet interfaces. This will change the paradigm from circuit switched to packet switched transport. At that time none of the currently existing transport hardware is capable of an Ethernet interface. This will require significant network redesign. The cost of a basic Fujitsu 4100ES is $45K each. Some of the larger sites may require more than a single multiplexer.

Repair parts for site repeaters, antennas, transmission lines, and combiner/multi-coupler components are required from time-to-time due to damage by wind, water, or lightning.

Network Management Platform

The STARS Network is managed, monitored, and programmed by the Network Operations Center (NOC) through a number of redundant network management platforms. The RF site environment is monitored by the Motorola MOSCAD System. This system was upgraded prior to the Motorola Release 7.14 upgrade in 2015. This system also monitors the microwave radios, the Zhone multiplexers, and the site repeaters for faults. The Motorola Unified Event Manager (UEM) also monitors the system and is partially redundant with the MOSCAD. These systems will be integrated into a single client computer with the Release 7.16 upgrade scheduled for January 2018.

The ZoneWatch application monitors all radio call activity by pulling trunking information from the Air Traffic Router (ATR). ZoneWatch also receives fault information relating to repeater sites and the zone controller from the Unified Event Manager (UEM). Through the ZoneWatch display NOC personnel can view the health of each LMR site and all channels operating at a site with a quick glance.

STARS LMR configuration management is provided by the Provisioning Manager and the Unified Network Configurator. The Provisioning Manager enables centralized provisioning of ASTRO® 25 systems with various system-level, user-level, and device-level configuration required for proper system operation: specifically the ability to configure subscriber radios, consoles, system infrastructure, and radio traffic applications. The Unified Network Configurator application is used to discover network devices, manage configurations, and manage credentials.

The microwave radio network is monitored by the Telscan application. The company that provided this system is out of business and this system is scheduled to be replaced in FY2018. The Fujitsu multiplexers are monitored and programmed through the Fujitsu NETSMART application. Both of these systems are scheduled to be replaced in FY2018 through an RFP with funding provided by existing STARS bond funds.

Subscriber Equipment

Each STARS vehicle is equipped with over $30K in electronic hardware consisting of mobile and portable radios, laptops, cameras, sirens, light bars, digital vehicular repeaters, and speed enforcement devices. Most subscriber equipment has been in service for twelve years and is nearing or beyond end-of-life. The mobile radio, portable radio, and digital vehicular repeaters work as a combined system and have to be replaced at the same time. Not all replacement hardware is compatible.

As of this writing VSP plans to replace the primary subscriber hardware: SIRS radios, mobile radios, DVRSs, and portable radios in fiscal years 2019-2021. Base station radios will be replaced during the same timeframe.

The cost for a single subscriber equipment unit is:

- Mobile radio - $7.4K each
- Portable radio - $8.0K each
- Digital vehicle repeater - $8.5K each
- SIRS mobile radio - $.9K each

In addition to in-vehicle equipment STARS uses three models of base station radios that allow stationary office users to communicate with mobile users. The XTL5000 consolettes are used in dispatch centers to backup dispatch consoles. The cost of these radios is $9.5K each.

XTL5000 and XTL2500 control station radios allow office personnel to communicate with mobile users. The cost to replace both of these units with a single unit is $6.8K each.

Another desired feature to be implemented is radio authentication. This feature blocks any cloned radio from connecting to the STARS network. This feature requires new mobile, portable, and DVRS radios and will be implemented after the radio replacement effort described above. If all new radios are ordered with the feature included the infrastructure cost will be between $50K and $100K.

Software and Tools

To engineer, operate and maintain a complex network like STARS requires engineers and technicians and a host of software applications, tools, and test equipment. LMR and microware radio design today is performed using a number of software applications. Specialty tools abound from automotive analyzers to speedometer calibration devices. Test equipment is required to tune radios, calibrate other test sets, and identify sources of radio frequency interference. The cost of a single spectrum analyzer is over $30K each.

Additional Information

In addition to the specific items identified above, there are annual hardware and software maintenance requirements. The current projected annual cost of hardware and software maintenance is $901K. The detailed list of procurements below includes all of the major items requiring replacement.

Equipment Replacement Timeline by Fiscal Year

Please find below a listing of the current one-time expenses for the next six fiscal years. There will be expenses in FY2022 through FY2024 but none have been identified to date.

Fiscal Year	Total
2019	$46,283,303.59
2020	$51,130,243.13
2021	$39,483,243.13
Total	$136,896,789.85

FY	Category	Cost Period	Description	Qty	Unit Cost	Extended Cost
2019	Hardware	One-time	DVR Replacement	1031	$8,476.71	$8,739,488.01
2019	Hardware	One-time	Replacement of T1 Transport Links	150	$55,000.00	$8,250,000.00
2019	Hardware	One-time	Service Monitor Replacement	10	$42,952.50	$429,525.00
2019	Hardware	One-time	2500 Site Router Replacement	17	$3,360.00	$57,120.00
2019	Hardware	One-time	Tunnel DVR + Mobile Replacement	18	$15,661.97	$281,915.46
2019	Hardware	One-time	XTL5000 Consolettes	157	$9,500.00	$1,491,500.00
2019	Hardware	One-time	XTL5000/XTL2500 Control Stations Replacement	186	$6,843.95	$1,272,974.70
2019	Hardware	One-time	SIRS Mobile Radio Replacement	782	$926.41	$724,452.62
2019	Hardware	One-time	XTL5000 Mobile Radio Replacement	1892	$7,445.15	$14,086,223.80
2019	Hardware	One-time	XTS5000 Portable Radio Replacement	1350	$7,963.04	$10,750,104.00
2019	Software	One-time	STARS Radio Authentication	1	$200,000.00	$200,000.00
			2019 Total			**$46,283,303.59**
2020	Software	One-time	Over-the-Ethernet Rekeying	1	$208,000.00	$208,000.00
2020	Hardware	One-time	STARS Master Site Disaster Recovery	1	$3,357,000.00	$3,357,000.00
2020	Hardware	One-time	XTL5000/XTL2500 Control Stations Replacement	186	$6,843.95	$1,272,974.70
2020	Hardware	One-time	XTL5000 Mobile Radio Replacement	1892	$7,445.15	$14,086,223.80
2020	Hardware	One-time	XTS5000 Portable Radio Replacement	1350	$7,963.04	$10,750,104.00
2020	Hardware	One-time	DVR Replacement	1031	$8,476.71	$8,739,488.01
2020	Hardware	One-time	Replacement of T1 Transport Links	125	$55,000.00	$6,875,000.00
2020	Software	One-time	Over-the-Air-Programming (OTAP)	1	$1,092,000.00	$1,092,000.00
2020	Hardware	One-time	SIRS Mobile Radio Replacement	782	$926.41	$724,452.62
2020	Software	One-time	RF Site Software Additions for TDMA	175	$23,000.00	$4,025,000.00
			2020 Total			**$51,130,243.13**
2021	Hardware	One-time	XTL5000 Mobile Radio Replacement	1892	$7,445.15	$14,086,223.80
2021	Hardware	One-time	DVR Replacement	1031	$8,476.71	$8,739,488.01
2021	Hardware	One-time	XTL5000/XTL2500 Control Stations Replacement	186	$6,843.95	$1,272,974.70
2021	Hardware	One-time	SIRS Mobile Radio Replacement	782	$926.41	$724,452.62
2021	Software	One-time	RF Site Software Additions for TDMA	170	$23,000.00	$3,910,000.00
2021	Hardware	One-time	XTS5000 Portable Radio Replacement	1350	$7,963.04	$10,750,104.00
			2021 Total			**$39,483,24**
			Grand Total			$136,896,789.85

Financing Options for STARS:

As directed in CHAPTER 836 (2017 VIRGINIA ACTS OF ASSEMBLY), ITEM 422, the Department coordinated with the Department of the Treasury to determine potential financing mechanisms for equipment replacement. The Department of Treasury provided the following financing possibilities:

If financing over cash funding is the preferred option for funding the STARS program, two options exist, Virginia Public Building Authority (VPBA) and the Master Equipment Leasing Program (MELP). Both options have been used by VSP in the past for the STARS program.

The issuance of VPBA bonds must be authorized by the General Assembly and the Governor through the Appropriations Act. Any such authorization of bonds for this project could then be structured and issued on a shorter term basis of 10-years (or another term based on the life of the equipment) as a standalone issuance or combined with an issuance of longer-term VPBA bonds. When the STARS program was initiated, VPBA bonds were authorized. The STARS projects were allocated to bonds paying off in 10-years that were a portion of an overall issuance of 20 year bonds that funded all types of VPBA authorized projects. Debt service on VPBA bonds, including the STARS portion, comes from general fund appropriations to the Treasury Board.

MELP is another option which provides Commonwealth Agencies and Institutions financing for equipment and energy efficiency projects. The available terms offered through the program are 3, 5, 7 and 10 years. The term may not exceed the useful life of the equipment. If MELP financing is used, VSP would request financing through the Department of Treasury. VSP would make lease payments and would be required to seek sufficient funding through the Appropriations Act to cover such payments. The equipment would serve as collateral. Due to the collateral requirement, if an agency defaults, the Lessor can repossess all of the equipment/projects financed under the Agreement. Eligible projects to be financed under MELP are stand-alone equipment and software financed in conjunction with hardware. Soft costs are typically not included in equipment financing.

Virginia State Police Recommendation:

The Virginia Department of the Treasury has provided two recommendations for the financing of the STARS program, VPBA and MELP. Of these two options the Department of State Police recommends VPBA financing. This option has no negative impact on the Department's general fund budget, in that all agency expenditures would be paid with VPBA funds (against a special fund appropriation) and the debt service would be a general fund appropriation to the Treasury Board.