Virginia Department of Transportation
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Newport News Signal System Feasibility Study and ITS Master Plan Volume 2 of 2

ITS Master Plan - Final

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Prepared for:

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Department of Engineering

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Executive Summary

The City of Newport News Intelligent Transportation System (ITS) Master Plan was developed as part of a pre-design for managing the upgrade of the Citywide Traffic Signal System in Newport News. The plan provides a guide for the City through the design and construction phases of the project. Given the rising costs and the limitation of CMAQ funds, it was determined that the City will pursue a multi-year implementation schedule of a Citywide Signal System Upgrade with a focus to prioritize the replacement of the operating equipment and communications. It is essential that this Citywide Signal System Upgrade project move forward now because the existing signal infrastructure has exceeded its 20 year life expectancy and must be replaced with an expandable system to meet future transportation needs. The primary objective of this project is defined in the mission statement as follows:

> *The mission purpose and need of the project is to design and implement an advanced transportation management system for citywide control of highway and local traffic in Newport News utilizing signals, warning devices, and incorporating Intelligent Transportation System (ITS) components. The focus of design will be to develop a system, which safely and efficiently moves people and goods within the City and between surrounding jurisdictions and is responsive to the dynamic demands of coordinated traffic operations. Components of the system will form a flexible architecture that allows for expandability, is easily maintained, is interoperable within the regional vision/architecture, and supports a phased plan of implementation.*

Upgrading the system communications was identified as a priority for phased implementation. The availability of the existing Newport News Public Schools (NNPS) and City's Information Technology (IT) fiber backbone infrastructure provides a high degree of reliability improvements without requiring the City of Newport News Engineering to deploy new cables along several challenging bridge, rail, and interstate crossings. Four (4) alternatives were evaluated during the ITS Master Plan development. The cost for Scenario 3 is slightly higher than Scenario 4. However, the increase in cost provides greater flexibility for device expansion and deploying separate/parallel communication technologies for field distribution. For these reasons, ***Communication Alternative/Scenario 3 is recommended for the Newport News ATMS***.

The Feasibility Study and ITS Master Plan are comprised of two volumes. Volume 1 presents the analysis and findings of the review of signal system upgrades. Volume 2 presents the ITS Master Plan for use in expanding the traffic signal system capabilities.

Technical Summary

The primary objective of developing the Newport News Intelligent Transportation System (ITS) Master Plan is to expand the City's traffic management capabilities through the use of intelligent resources options involving traffic monitoring and information dissemination to motorist. The ITS Master Plan will facilitate establishing policies and strategies for implementation in the City's "Framework for the Future" based upon operational, technological, and economic analysis. The plan outlines ITS applications that will enhance existing operations within the City as well as with surrounding jurisdictions by expanding its traffic management capabilities. The ITS Master Plan focuses on items of regional as well as local significance, potential device locations, and communication trade-off analysis.

Kimley-Horn and Associates, Inc., under subcontract to Wilbur Smith Associates, was retained under the VDOT ITS On-Call contract, to prepare the City of Newport News' ITS Master Plan. When combined with the Signal System Feasibility Study, the ITS Master Plan provides a comprehensive document to serve as the basis for the development of plans and specifications for ITS elements throughout the City. During the early stages of this study, the project team worked with the Steering Committee to establish a mission statement to help guide the decision-making process throughout subsequent activities. The identified mission statement is as follows:

> *The mission purpose and need of the project is to design and implement an advanced transportation management system for citywide control of highway and local traffic in Newport News utilizing signals, warning devices, and incorporating Intelligent Transportation System (ITS) components. The focus of design will be to develop a system, which safely and efficiently moves people and goods within the City and between surrounding jurisdictions and is responsive to the dynamic demands of coordinated traffic operations. Components of the system will form a flexible architecture that allows for expandability, is easily maintained, is interoperable within the regional vision/architecture, and supports a phased plan of implementation.*

The Newport News ITS Master Plan is a compilation of the following three technical documents:

- Regional Systems Analysis
- ITS Local Components
- Communications Alternatives and Recommendations

The regional systems analysis identified integration with others centers, traveler information systems, and considerations for traffic management system and software integration. Policy and priority considerations for these integration efforts are recommended, which include coordination with adjacent arterial traffic signal systems,

integration with VDOT's freeway management system, and supporting regional information sharing initiatives in support of region wide traveler information systems. By reviewing local and regional stakeholder needs, as well as statistics regarding the most useful traveler information, it is recommended that the City of Newport News ITS deployments focus on providing roadway camera images/video, road/lane closures, construction information and other road restrictions, corresponding detours and alternate routing.

> It is recommended that the City of Newport News ITS deployments focus on providing the following information to the public and other regional agencies:
>
> § *Roadway camera images/video*
> § *Road/lane closures, construction information and other road restrictions*
> § *Corresponding detours and alternate routes*

Monitoring roadway traffic and sharing roadway camera video images is the highest priority, since it reaches a broad audience and allows for better regional transportation management decisions with VDOT. The latter two pieces of information, while currently provided to other agencies, are manually distributed by way of fax, phone, and/or email. An integration effort with Newport News Engineering, the Public Safety Computer-Aided-Dispatch (CAD) system, and the VDOT Hampton Roads Smart Traffic Center is the second highest priority, which is envisioned to reduce the amount of manual filtering necessary to supply useful information to 511, the traveling public, and other regional agencies.

Another facet in the development of the ITS Master Plan involves the identification of ITS device types to address the monitoring and refining of potential traffic hazard locations throughout the City of Newport News. In keeping with the initial ITS objective for providing video information about the City's roadways, CCTV cameras is among the first ITS devices explored. Additionally, recommendations for deployment of supplemental portable dynamic message signs, bridge icing warning delineators, over-height vehicle warning systems, flood warning systems, and traffic sensors are identified.

ITS Detection Device System	Recommended Quantity
CCTV	34
Portable DMS	12 locations (6 portables being supplied through other VDOT contracts); 2 portable DMS are proposed
Flood Warning Systems	5
Icy Bridge Warning Systems	8
Over-height Vehicle Warning Systems	2

Subsequent to identifying ITS locations and the regional systems analysis, communication alternatives are provided to determine cost-effective and technologically

sound methods for interconnecting Arterial Traffic Management System (ATMS) and ITS devices throughout the City. An Ethernet-based, fiber-optic network architecture is recommended that leverages the use of existing fiber resource-sharing arrangements with Newport News Public Schools (NNPS) and City's Information Technology communication system. By taking advantage of this existing infrastructure, the Department of Engineering will be able to realize nearly $3 Million in savings during the construction of the ATMS/ITS communication improvements.

Four (4) scenarios are evaluated for the Newport News Department of Engineering's communication between the ATMS central system and the field devices. The existing infrastructure is comprised of several localized closed-loop systems around the City, which are connected to the central system only by way of dial-up phone lines to field master controllers.

1. Scenario 1- Complete Transportation Fiber Backbone is a complete replacement of the existing twisted pair infrastructure with new fiber optic cables along with a completion of crucial links to form a contiguous network. Scenario 1 relies entirely on the Department of Engineering's own infrastructure to communicate with all existing and planned device locations.

The remaining three scenarios rely on the available NNPS/IT fiber infrastructure to various degrees.

2. Scenario 2 - Combination of NNPS / IT Fiber Backbone and Transportation Twisted Pair Distribution relies on the NNPS/IT fiber simply to provide a backbone for connecting both operations centers to the existing field master locations, which in turn use the existing twisted pair distribution to communicate with the remaining signals.
3. Scenario 3 - Combination of NNPS / IT Fiber Backbone and Transportation Fiber Expansion relies on the NNPS/IT backbone in a similar manner to the second scenario, but replaces the existing twisted pair with fiber optic cables instead for the final distribution to traffic signals and ITS devices.
4. Scenario 4 - Combination of NNPS / IT Fiber Backbone and Minimized Transportation Fiber Expansion reduces the amount of overlapping infrastructure between the NNPS/IT backbone and Transportation Division's infrastructure by increasing the number of access points used to connect traffic signals and ITS locations to the NNPS/IT backbone.

The availability of the NNPS/IT fiber backbone infrastructure provides a high degree of reliability improvements without requiring the City of Newport News Engineering to deploy new cables along several challenging bridge, rail, and interstate crossings. The cost for Scenario 3 is slightly higher than Scenario 4. However, the increase in cost provides greater flexibility for device expansion and deploying separate/parallel communication technologies for field distribution. For these reasons, ***Communication Alternative/Scenario 3 is recommended for the Newport News ATMS***.

Finally, system benefits and cost implications are reviewed with respect to decreased system outage, decreased service calls, road condition monitoring, and road condition notification. These benefits result in reduced driver delay and fuel consumption, reduced

system maintenance requirements, and accident reduction savings. These benefits are derived from the proposed system upgrades as well as the enhanced ITS features identified with this ITS Master Plan.

Program planning costs are established for achieving upgrades to the ATMS as well as long-range plans for ITS deployment throughout the City of Newport News. Dynamic message sign deployment by VDOT within the City limits have been reviewed and incorporated into the plan maps, to avoid duplicating the cost of deploying portable DMS in these locations.

Program planning costs are presented for three alternatives as follows:

A. Upgrade central software and install new TS-2 signal controllers in all field cabinet locations, re-using the existing TS-1 cabinets

B. Upgrade central software and install new TS-2 signal controllers in new TS-2 cabinets at all intersections.

C. Upgrade central software and install new TS-2 signal controllers in all locations, re-using 80 existing pole-mounted TS-1 cabinets in the downtown area (south of 39th Street) and installing new TS-2 cabinets at all remaining intersections.

Operations and maintenance staff noted that Program Plan A is not desirable due to the age of the cabinets and the reduced flexibility to take advantage of the proposed features afforded by current signal controller technology. Plan B has the highest overall deployment cost, but not all locations will be conducive to upgrading to TS-2 cabinets. Some intersections within the City operate as two-phase intersections on a fixed time basis with 2-3 different cycle lengths. At these locations, the existing TS-1 cabinet can still accommodate the functional needs of the intersection. Therefore, ***Program Plan C is recommended*** since it provides the flexibility to support both cabinet approaches, allows for a phased implementation if needed for current funding limits, and provides access to advanced controller features for the vast majority of the City's signal system. ***Plan C has a program cost of $15.2 Million*** including components, design, construction administration, and contingencies for both ATMS and ITS improvements throughout the City of Newport News.

1.0 Introduction

The purpose of the Newport News Signal System Advanced Traffic Management System (ATMS) Feasibility Study is to prepare an Intelligent Transportation System (ITS) Master Plan. The plan outlines ITS applications that will enhance existing operations within the City as well as with surrounding jurisdictions by expanding traffic management capabilities.

The primary objective of developing the Newport News Intelligent Transportation System (ITS) Master Plan is to expand the City's traffic management capabilities through the use of intelligent resources options involving traffic monitoring and information dissemination to motorist. The ITS Master Plan will facilitate establishing policies and strategies for implementation in the City's "Framework for the Future" based upon operational, technological, and economic analysis. The ITS Master Plan focuses on items of local as well as regional significance, potential device locations, and communication trade-off analysis.

1.1 Document Organization

This document is divided into 5 sections. Section 1 provides an introductory project overview and document organization. Section 2 analyzes ITS locations for consideration within the City's long-term deployment plans. Section 3 includes an analysis of communication alternatives to support the planned ATMS and ITS devices. Section 4 analyzes integration with others centers, traveler information systems, and other considerations concerning system and software integration. Section 5 discusses benefits versus deployment costs to assist in prioritization of the identified subsystems. .

1.2 Project Overview

The City of Newport News has developed a detailed Signal System Feasibility Study and ITS Master Plan that when combined provides a comprehensive document to serve as the basis for the development of plans and specifications for an ATMS. The implementation of the system upgrades will include remote access for Engineering and Operations staff, interconnectivity with other agencies, will reduce costs, provide detection of hazardous conditions, and will provide redundancy for communications and operations. Kimley-Horn and Associates, Inc., under subcontract to Wilbur Smith Associates, is preparing these documents within the VDOT ITS On-Call contract.

The ITS Master Plan is a compilation of three prior documents, which include:

- Regional Systems Analysis
- ITS Local Components
- Communications Alternatives and Recommendations

1.3 Mission Statement

During the early stages of this project, the project team worked with the steering committee to establish a mission statement to help guide the decision-making throughout subsequent activities. The identified mission statement is as follows:

The mission purpose and need of the project is to design and implement an advanced transportation management system for citywide control of highway and local traffic in Newport News utilizing signals, warning devices, and incorporating Intelligent Transportation System (ITS) components. The focus of design will be to develop a system, which safely and efficiently moves people and goods within the City and between surrounding jurisdictions and is responsive to the dynamic demands of coordinated traffic operations. Components of the system will form a flexible architecture that allows for expandability, is easily maintained, is interoperable within the regional vision/architecture, and supports a phased plan of implementation.

2.0 Local ITS Components

The objective of Section 2.0 is to review the proposed ITS technologies for the City of Newport News which include, but are not limited to, CCTV cameras, dynamic message signs, and some specific weather-related features and over height detection equipment that would provide advance warning and enhance the City's ability to direct motorists to the appropriate roadway facilities.

2.1 Video Surveillance Subsystem

Video surveillance systems allow operators to detect and verify incidents, verify whether field devices are functioning properly, and provide information on traffic conditions to the public and the media. Perhaps their most important feature, however, is their ability to provide information that can be trusted because users can view conditions with their own eyes. With an array of strategically-placed cameras, Newport News Engineering staff, in conjunction with other regional traffic centers can determine appropriate actions needed to respond to incidents and provide valuable information to appropriate emergency service providers, neighboring agencies, the traveling public and the media.

2.1.1 CCTV Technologies

Field equipment for a CCTV installation generally consists of a camera, motorized zoom lens, environmental enclosure, pan/tilt mechanism, local camera controller for field control and troubleshooting, encoder, pole or other mounting structure, lightning and surge suppression devices, and a cabinet to house the ground-mounted equipment. Cameras on the market today include the lens, enclosure, and pan/tilt mechanism in a single unit.

CCTV components housed in the cabinet generally include the following:

- Camera Control Receiver (CCR): A component that decodes command data and controls pan-tilt-zoom, focus, iris, and other functions. Cameras on the market today typically integrate the CCR into the camera itself so it is not a separate mandatory component to purchase. Some agencies have continued to deploy this type of unit for use in local cabinet-level testing by maintenance staff, which reduces the need for carrying a laptop out to the site.
- Communication device: A device is needed to convert the video signal and pan-tilt-zoom control commands for transmission over communications lines. The choice of communications device depends on the communications architecture. This could be a modem for wire type communications, a video optical transceiver for analog communications over fiber, a wireless modem for radio control applications, or an Internet Protocol (IP) video encoder for Ethernet.
- Cabinet grounding system
- Backup power system/Uninterruptible Power Supplies
- Power service interface panels
- Surge and lightning protection for all conductors entering the cabinet including electric service, communications, video and control signals.

- Transformers (if required) may also reside in the cabinet in order to convert to voltages required for the CCTV equipment.

Due to the competitive nature of the marketplace, the main features of the newest products on the market are very comparable. Each of the major vendors of cameras for traffic management offers the capability to communicate via another competitor's proprietary protocol, either by changing the processor's dual in-line package (DIP) switch setting on the camera, or with an optional protocol-translator card for an additional cost. The features described here draw heavily from what is currently on the market. Any camera that meets or exceeds these specifications is acceptable:

- Digital signal processing (DSP) technology
- 22x optical zoom and 10x digital zoom, with automatic or manual focus
- Resolution of 470 Horizontal Television Lines (HTVL)
- Ability to see in low light conditions
- Positioning to 0.1° accuracy
- 360° continuous rotation
- Up to 64 user-defined preset positions, each with a 24-character title
- Eight programmable tours with 32 steps per tour
- Programmable privacy zones (to screen out/restrict viewing potentially sensitive areas)
- NEMA-TS2 temperature and power compliance
- Multi-manufacturer protocol control

Until a few years ago, most cameras were analog, producing good quality images at an affordable price. However, the introduction of Digital Signal Processing (DSP) has increased both the flexibility of using cameras while enhancing the quality of the color images produced. At the heart of DSP lies computer microchips, or "chip sets" which have replaced the conventional integrated circuits in the camera head. This enables DSP camera manufacturers to offer installer-friendly, feature-rich products. DSP cameras generally offer more consistent picture quality than their analog counterparts, operating over a wider range of lighting conditions. They also may include features such as remote set-up and control using a serial data link, a built-in character generator, and on-screen menus.

For transportation applications, enclosures are typically sealed and pressurized with dry nitrogen to keep moisture and contaminants out of the housing and prevent condensation from appearing on the lens and interior of the housing faceplate. Many cameras have built-in pressure sensors that can generate alerts if the pressure falls below a certain threshold. Other optional environmental features of cameras are internal heaters to keep the window clear and free from condensation or ice, sunshields to keep sun glare, rain, and snow off the enclosure face plate, and wipers to clear the lens of moisture.

Cameras can be dome or barrel style as pictured in **Figure 1**. Dome cameras enclose the pan/tilt/zoom mechanism and camera inside a sealed and pressurized dome enclosure. This provides greater protection from the elements and fewer

moving parts but limits the field of vision, i.e., they can not look up. For arterial applications, this is rarely an issue. Cameras at intersections—whether domes or barrels—are typically mounted atop a mast head pole. Domes are often installed at the end of a cantilever structure that makes it look similar to a lighting luminaire, which has the side benefit of drawing less attention. However, the length of the cantilever should be kept to a minimum in order to reduce the amount of potential camera sway.

Figure 1: Dome and Barrel Style Cameras

The pan/tilt mechanism on the barrel style camera, though separate from the camera itself, is typically sold with the camera as a single unit.

2.1.2 Communications

The selection of camera is not dependent on the communications infrastructure. Any camera, whether analog or DSP, interfaces with the communications infrastructure via an interface device in the cabinet. For an Ethernet IP-based communications infrastructure, for example, this would be an IP video encoder.

The marketplace is moving towards producing cameras with embedded encoders. However, most cameras on the market today still leave the encoder as a separate device. Benefits to keeping the encoder separate from the camera are:

- It makes the camera simpler and easier to troubleshoot
- Encoding/decoding technology is changing far more quickly than camera technology.
- Although video compression technologies conform to standards (e.g., MPEG-2, MPEG-4), compatibility problems may arise between different encoder/decoder manufacturers. If this happens, it is easier to swap out an encoder than an entire camera.
- It takes a point of failure out of the camera and puts it on the ground where it is easier to service.

Compatibility with the National Transportation Communications for ITS Protocol (NTCIP) is available as an option with cameras on the market today, though it typically requires additional hardware for the cameras or a custom order with a more powerful chip. Chips that can handle the overhead that accompanies NTCIP will likely be standard with the next generation of cameras set to be introduced in the next year (2007). Until then, cameras on the market today are able to

communicate using competitors' protocols using translators. As a result, the benefits of vendor interchangeability promised by NTCIP are already essentially realized.

2.1.3 Location Strategy

The basic strategy for locating the CCTV cameras was along interstate diversion routes, which include Jefferson Avenue, Warwick Boulevard, and major arterials with direct interstate access. Cameras are placed along Warwick Boulevard and Jefferson Avenue at roughly 1 mile spacing between Bland Boulevard and Harpersville Road. In this rapidly growing area of the City, a secondary benefit these cameras provide is visibility for site specific areas that included large retail developments, the Oyster Point City Center and other large corporate development, and the Newport News/Williamsburg International Airport. **Table 1** describes the recommended locations for 34 CCTV camera sites along with the associated rationale for their use. These locations are depicted on **Figure 2**.

For locations to the north and south of this area, cameras are spaced roughly 2 miles apart. Cameras locations are suggested at signalized intersections as is typical for arterial surveillance systems to minimize the number of connection points required along the communications backbone. Arterial cameras are typically installed atop steel mast arm poles approximately 30' to 35' high. The City's existing fleet of bucket trucks is limited to a maximum height of 35 feet. The majority of the City's signals are currently controlled using mast arm installations. However, a significant portion of these designs only have a 20' mast arm pole without luminaire arms or extensions. Therefore, during the design phase, consideration should be given to either upgrading existing mast arm poles with 35' poles or installing a separate pole at the appropriate height for maximum visibility.

The following recommended camera locations are part of proposed roadway widening projects or new signal installations, and warrant further evaluation for pole upgrades or design improvements:

- Warwick Boulevard – Three potential locations between J. Clyde Morris Boulevard and Nettles Lane
- Jefferson Avenue – One potential location between Buchanan Drive and Green Grove Lane
- Thimble Shoals Boulevard
- Jefferson Avenue/Main Street – new signal installation (already under contract – may require a change order)
- Jefferson Avenue/74th Street – new signal installation (already under contract – may require a change order)

Table 1: Proposed Newport News CCTV Camera Locations

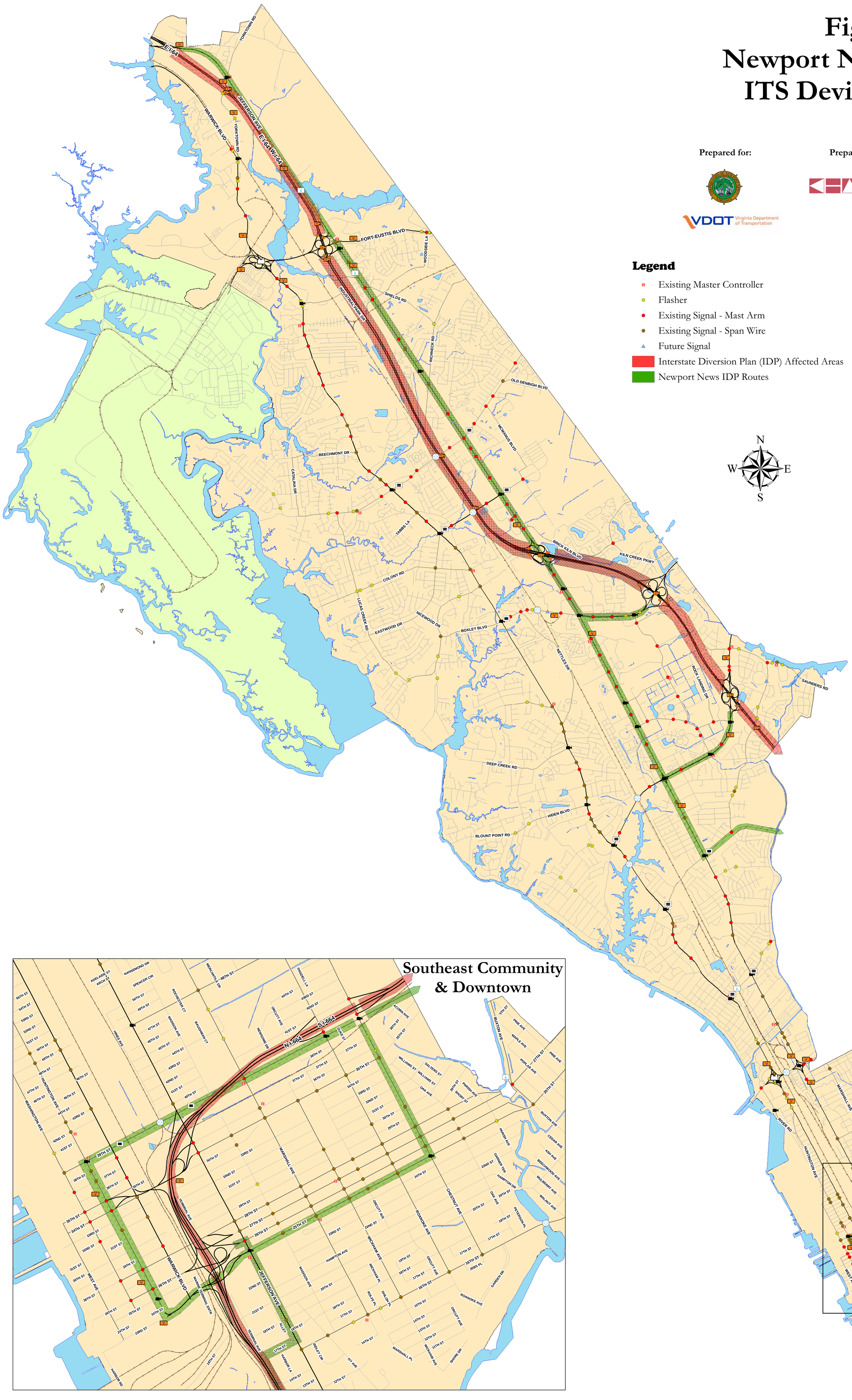
CONTROLLER	CAMERA	LOCATION	RATIONALE
2101	C-1	JEFFERSON-YORKTOWN	To monitor vehicles traveling to/from York County & Interstate Diversion Plan Route
4005	C-2	WARWICK BLVD-YORKTOWN RD.	Ability to detect traffic volumes along Warwick Blvd. and Yorktown Rd.
2201	C-3	JEFFERSON-FT EUSTIS BLVD I-64W OFF-RAMP	Interstate Diversion Plan Route
3507	C-4	WARWICK-INDUSTRIAL PARK DRIVE	Detection of residential, military, school, and cut-through traffic from Jefferson Ave.
3208	C-5	JEFFERSON-MCMORROW	Capture residential and military traffic during peak hours.
2304	C-6	WARWICK-DENBIGH	High retail area.
2901	C-7	JEFFERSON-BLAND	Airport and Siemens traffic monitoring and Interstate Diversion Plan Route
2306	C-8	WARWICK-EASTWOOD DRIVE	Detect traffic traveling to/from Jefferson Ave. and along Warwick Blvd.
2802	C-9	JEFFERSON-OPERATIONS DRIVE	Mall and other retail shops in the area, and IDP Route
2403	C-10	WARWICK-OYSTER POINT	Detection of peak hour traffic volumes.
2804	C-11	JEFFERSON-OYSTER POINT	Extremely busy intersection and the Cities highest accident rate intersection.
2813	C-12	OYSTER POINT-CANON	Detect exiting\entering interstate traffic along Oyster Point and business park traffic..
3103	C-13	WARWICK-DEEP CREEK	Detection of peak hour traffic volumes.
2807	C-14	JEFFERSON-MIDDLE GROUND	Capture business park traffic volumes.
2808	C-15	JEFFERSON-THIMBLE SHOALS	Detect heavy traffic volumes to offer alternate routes.
3107	C-16	WARWICK-HIDEN	Detection of peak hour traffic volumes.
3110	C-17	WARWICK-J CLYDE MORRIS	Detection of peak hour traffic volumes.
2810	C-18	JEFFERSON-J CLYDE MORRIS	Detect heavy traffic volumes to offer alternate routes.
3301	C-19	J CLYDE MORRIS-THIMBLE SHOALS	Detect heavy traffic volumes to offer alternate routes.
3303	C-20	J CLYDE MORRIS-DILIGENCE	Detect traffic exiting\entering the interstate and traffic leaving the business park.
2508	C-21	JEFFERSON-HARPERSVILLE	Detect traffic traveling to\from City of Hampton and volumes along Jefferson Ave.
2701	C-22	WARWICK-HARPERSVILLE	Detection of peak hour traffic volumes.
2502	C-23	JEFFERSON-MAIN	Detect heavy traffic volumes to offer alternate routes.
2601	C-24	WARWICK-MAIN	Detection of peak hour traffic volumes.
3006	C-25	JEFFERSON-MERCURY	Detect heavy traffic volumes to offer alternate routes.
102	C-26	WARWICK-MERCURY	Detect traffic traveling to\from Hampton and the James River Bridge.
106	C-27	RIVER ROAD-73RD ST	reversible-directional road.
903	C-28	JEFFERSON-48TH ST	Detect peak hour traffic.
301	C-29	HUNTINGTON-39TH ST	Interstate Diversion Plan Route
702	C-30	39TH ST-ROANOKE	Interstate Diversion Plan Route
703	C-31	39TH ST-CHESTNUT	Interstate Diversion Plan Route
506	C-32	CHESTNUT-25TH ST	Interstate Diversion Plan Route
1006	C-33	JEFFERSON-25TH ST	Interstate Diversion Plan Route
309	C-34	HUNTINGTON-28TH ST	Interstate Diversion Plan Route

Figure 2
Newport News Proposed ITS Device Locations

Prepared for: VDOT Virginia Department of Transportation

Prepared by: Kimley-Horn and Associates, Inc.

Under SubContract to: Wilbur Smith Associates



Legend

- Existing Master Controller
- Flasher
- Existing Signal - Mast Arm
- Existing Signal - Span Wire
- Future Signal
- Interstate Diversion Plan (IDP) Affected Areas
- Newport News IDP Routes

Proposed Newport News ITS Devices

- Camera
- Overheight Vehicle Detector and Warning Sign
- Portable Dynamic Message Sign
- Flood Monitoring
- Bridge Icing

Existing and Planned VDOT ITS Devices

- Camera
- Arterial Dynamic Message Sign
- System Detector

2.2 DMS Subsystem

Dynamic Message Signs (DMS) are used to inform the motoring public about conditions ahead and give drivers the opportunity to divert to an alternate route or take necessary precautions. DMS are commonly used to advise of congestion ahead, approximate delay times, incident locations, construction areas, special events, and the status of special lanes (e.g., HOV lanes). Sometimes non-traffic related applications are posted on the DMS such as Amber Alerts, parking locations and local festival information. These systems can also direct travelers to other media such as Highway Advisory Radio (HAR) and 511, where more detailed information can be given.

2.2.1 DMS Technologies

DMS come in a variety of sizes and shapes (matrix types), which is determined based on the number and size of each character. Character heights range from 6" to 18", depending on the speed of roadway. Freeway applications use 18" tall characters, while arterial applications can use 6", 8", or 12" characters. The larger characters are easier to read from longer distances; hence, drivers are given more time to make educated decisions. For local perspective, the VDOT-installed dynamic message signs on J. Clyde Morris approaching I-64, as well as at 23rd Street approaching I-664 use 12" characters.

Matrix DMS include character matrix, line matrix and full matrix. In character matrix signs, each character is displayed in its own distinct space in a grid format (e.g., character width and height are fixed). A limitation of character matrix signs is that they only hold a fixed number of characters per line (i.e., text can not be compressed). Line matrix displays have no physical separation between characters on a line, but each line is distinct (i.e., character height is fixed, but width can vary). Full matrix displays are a continuous collection of pixels that can display text with different heights and a variable number of lines depending on the message (i.e., neither character height nor width is fixed). Full matrix signs can also display graphics or icons to help convey a message. **Figure 3** helps to illustrate the differences between character, line and full matrix displays. **Figure 4** shows an example of a full-matrix display.

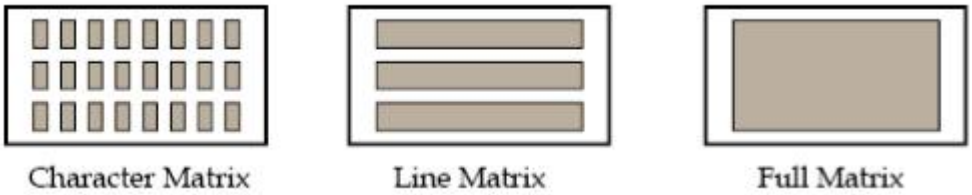


Figure 3: DMS Matrix Display Types
(Source: Wisconsin DOT ITS Design Manual)

Figure 4: Example full-matrix display with graphics

Portable DMS can have anywhere from one to three lines of text with 8-10 characters per line. Typical three-line portable DMS have displays with 4' to 6' heights and 6-12' widths.

In any type of DMS application light-emitting diode (LED) displays have become the industry standard for readability and reliability. White or amber characters are industry standard and provide the best readability.

Example features of portable DMS include:

- 199 pre-programmed messages
- 199 user-defined messages
- 250 message sequences
- Variable update speed
- Multiple font sizes from 6" to 18" (typically fixed at 18" for character or line-matrix displays)
- Animated graphics (certain full-matrix displays only)
- 1-3 lines of text (typically fixed at 3 for character or line-matrix displays)
- Full-size keyboard terminal
- Automatic multi-level dimming (in response to ambient lighting conditions)
- Adjustable height
- Solar powered with adjustable solar assembly
- 60-day autonomy
- Highway Advisory Radio (HAR) transmission
- Radar over speed detection (to display vehicle speeds if over the speed limit)
- Radar data logging and graphing
- ITS-ready options (CCTV, RWIS)

Example communications features for portable DMS include:

- Cellular, wireless RF, landline options
- NTCIP compliance

The cost per portable DMS ranges from $13,000 to $18,000. Different sign models are differentiated on the basis of matrix type, size, whether it can support graphics and/or animation, and whether it can support external ITS devices such as CCTV or RWIS. Permanent sign locations are much more costly due to concrete foundations, sign structures, and maintenance of traffic considerations. For an urban/suburban environment such as in Newport News' case, permanent DMS

installations can range from $80,000 to $160,000 depending upon the size of the structure and the associated foundation.

2.2.2 Communications

The DMS are typically configured/programmed using an embedded or handheld terminal at the sign. As portable DMS are typically wheeled into place for a specific purpose, programming may be done when the sign is deployed. The full benefit of a DMS can not be realized however, unless communications are provided to the City's Smart Traffic Centers (STCs) so that the operations staff can quickly and easily change sign displays remotely. Unlike fixed-in-place DMS that are connected to a wired communications network, portable DMS require wireless communications. Cellular communications provide the greatest flexibility for sign placement since all that is needed to achieve communication to the STC is reception from the nearest cell tower (i.e., not in a dead zone).

Another communication option to communicate with portable DMS is spread spectrum wireless, which is a mature technology that is sometimes used to communicate between adjacent intersections. This technology requires line-of-sight with a transmitter and therefore limits where signs can be located using this application. It would also add an additional cost to install transmitters at all intersections near where a portable DMS sign could potentially be located, which also reduces the overall portability.

A third option is Wi-Fi, or IEEE 802.11, a protocol most commonly used for wireless computer networking. A Wi-Fi transmitter creates a "hot spot" of coverage where a device with a wireless router can connect with the network and communicate with other devices. This is not advised as such wireless networks typically have a shorter coverage distance than conventional spread-spectrum, and can be difficult to secure against unauthorized users.

Currently, DMS include their own proprietary software that allows an operator to dial into a sign and program it remotely. DMS require minimal bandwidth for status monitoring and programming.

However, it is now common for signal system software to provide an interface with DMS via NTCIP, the National Transportation Communications for ITS Protocol. The NTCIP standard for DMS control is mature to the point that it can be required for newly procured portable DMS. This will allow different signs to be provided by various manufacturers and interchangeable from the central system software. **Figure 5** illustrates a standard portable DMS.

Figure 5: Example Portable DMS

2.2.3 Portable DMS Placement and Usage Guidelines

Portable DMS signs are best located at diversion points to allow drivers the opportunity to act on the information provided. These recommendations are based on the assumption that travelers use the freeway for longer trips and the arterial roadways for making shorter trips or accessing local destinations. Furthermore, motorists can get the most benefit from traveler information where there are good alternative routes available. Given the effort associated with placing and getting each portable DMS sign up in operation, it was also determined that these signs would be used for primarily for incidents or events with a longer duration such as detours, roadway repairs, and/or special events. Portable DMS will not be pre-positioned in any of the identified strategic locations. With these assumptions, an initial focus on locating DMS should be on:

- Diverting traffic from Warwick Boulevard to Jefferson Avenue and vice versa to avoid key segments of these major arterials
- Diverting traffic to an alternate railroad crossing

Given the layout of these two major north-south arterials (Warwick Boulevard and Jefferson Avenue), the logical diversion points are along side streets that connect both of these roadways and/or provide diversion around key railroad crossings.

Through various VDOT ITS construction projects in the Hampton Roads region, permanent arterial DMS are already installed or will be installed by the end of 2007 at the following locations listed in **Table 2**.

Table 2: VDOT Existing and Planned Arterial Dynamic Message Sign Locations

VDOT Identifier	Location Description
23rd-N1	23rd Street approaching I-664
Hunt-S1	Huntington Southbound diversion sign
Hunt-S2	Huntington Southbound diversion sign
34th-RP	Associated with Huntington and 34th St ramp with I-664
Jeff-N1	Jefferson Ave. Northbound just south of Mercury Blvd.
Warwk-N1	Warwick Blvd. Northbound just south of Mercury Blvd.
Jeff-S1	Jefferson Ave. Southbound just north of Mercury Blvd.
R17-S4	Route 17/Warwick Southbound just north of Mercury Blvd.
Merc-W	Mercury Blvd. Westbound just east of Jefferson Ave.
Jeff-N2	Jefferson Ave. Northbound just south of J.Clyde Morris Blvd.
Jeff-S2	Jefferson Ave. Southbound just north of J.Clyde Morris Blvd.
R17-N4	J.Clyde Morris (northbound Rt.17) before I-64 interchange
R17-S5	J.Clyde Morris (southbound Rt.17) before I-64 interchange
R17-S6	Route 17 Southbound just north of Victory
Victory	Victory Westbound just east of Rt.17
Jeff-N3	Jefferson Ave. Northbound just south of Oyster Point
Oypoint	Oyster Point Eastbound just west of Jefferson Ave.
Jeff-S3	Jefferson Ave. Southbound just north of I-64 interchange
Jeff-N4	Jefferson Ave. Northbound just south of Ft. Eustis Blvd.
Jeff-S4	Jefferson Ave. Southbound just north of Ft. Eustis Blvd.
FtEus-W1	Ft. Eustis Blvd. Westbound just east of Jefferson Ave.
FtEus-E1	Ft. Eustis Blvd. Eastbound just west of Warwick Blvd.
Warwk-N2	Warwick Blvd. Northbound just south of Ft. Eustis Blvd.
Warwk-S1	Warwick Blvd. Southbound just north of Ft. Eustis Blvd.
Ytown-E1	Yorktown Rd. Eastbound just west of I-64 interchange
Ytown-W1	Yorktown Rd. Westbound just east of I-64 interchange
Jeff-N5	Jefferson Avenue. Northbound just south of I-64 interchange (Exit 247)

Based on these existing and planned VDOT DMS locations, it is recommended that the City of Newport News establish provisions for utilizing portable DMS to augment the permanent VDOT arterial DMS locations. **Table 3** summarizes the proposed portable DMS intersections along Warwick Boulevard and Jefferson Avenue that are associated with local long-term incident diversions and/or special event routes.

Table 3: Proposed Intersections for Portable Dynamic Message Signs

Intersection with:	Warwick	Jefferson
§ 39th Street	ü	ü
§ Main Street	ü	ü
§ Harpersville Road	ü	ü
§ J. Clyde Morris Boulevard	ü	
§ Oyster Point	ü	
§ Eastwood/Bland Boulevard	ü	ü
§ Denbigh Boulevard	ü	ü

It is not anticipated that all 12 locations will require DMS simultaneously. Although, at the DMS locations identified above, multiple signs may be needed—one for each intersection approach. It is anticipated that eight portable DMS would be required to manage a full detour between Jefferson Avenue to Warwick Boulevard and back to Jefferson Avenue (or vice versa). This assumes that two DMS are placed at each of the four intersections (two on each corridor). These potential deployment areas are depicted on **Figure 2** in conjunction with the planned and existing VDOT arterial DMS locations. Six portable DMS are being acquired by the City. Therefore, this ITS program plan accounts for only two additional portable DMS.

The downtown area has a tight grid layout that offers multiple alternate North-South route options to navigate around both Warwick Boulevard and Jefferson Avenue with minimal direction. Therefore, specific DMS locations were not identified in this area of the City.

The use of portable signs affords the City a great deal of flexibility to locate signs for a particular event. In general, the City should adhere to the following guidelines for portable dynamic message signs:

- When two signs are needed to convey multiple messages to the same direction of traffic, they should be at least 1,000 feet apart.
- Signs should be located far enough in advance of a diversion point to allow traffic to change lanes and take the City's recommended alternate route.
- Signs should be placed in advance of recurring queues, if possible
- Portable message signs do not replace MUTCD required signage.

All DMS should accommodate three lines of text. In general, they should convey:

Line 1:	What the event is	(e.g., "Accident," "Road Closed," "Detour")
Line 2:	Where the event is	(e.g., "3 Miles Ahead," "after J Clyde Morris")
Line 3:	Effect or instructions	(e.g., "Dial 511," "Take Alternate Route," "Use Caution")

If more space is needed to convey a message, it can be presented in two alternating parts. This approach should be used with caution, however, as this makes the message more difficult to read and understand. This may result in drivers becoming distracted or slowing down abruptly. If the message is diverting traffic onto alternate routes, it is important that this be done in conjunction with the appropriate signal timing adjustments or that the traffic responsive parameters are set to select an appropriate timing plan.

2.3 Flood Monitoring System

Few motorists thoroughly appreciate the danger of driving through standing water on a road. High water, combined with fast currents, can sweep vehicles away placing their occupants in danger of drowning. Flood monitoring systems are designed to warn motorists of hazardous roadway conditions due to high water.

2.3.1 Flood Monitoring Technologies

These systems can automatically warn motorists of hazardous conditions through the use of dynamic message signs, and can also alert transportation system and emergency response operators of the potential problem. Technologies can include pressure transducers, ultrasonic devices, light beam sensors, in-pavement sensors and/or video camera detectors. These active warning devices can be supplemented with automatic devices that will prohibit roadway access, such as railroad crossing gates, during periods of high water.

More sophisticated flood monitoring systems have the ability to indicate the depth of the water and provide a visual cue to motorists that the roadway is flooded by showing the depth of the water. Such systems can include a solar powered yellow flasher that is activated when the water level reaches a certain depth. The flasher is mounted on a pole that is marked with an incremental depth gauge along with a sign that warns motorists, "Do Not Enter When Flooded." The flasher provides a warning that the water is moving and that it is unsafe to continue on the road. These solar-powered units use new DC operated, yellow light emitting diode (LED), which use only eight watts of electricity each.

2.3.2 Location Strategies

Using historical data and input from the City's Stormwater Division, three key waterways were identified for Flood Monitoring Systems. These areas are identified by the body of water that creates the high water situation as well as the roadway impacted by this event causing temporary detour to be deployed:

- Salters Creek
  - 27th Street at Buxton Avenue
- New Market Creek
  - City line Apartments between 76th Street and 79th
- Jones Run
  - Jefferson Avenue at Woodbridge/Whitewater

In addition to the three water crossings, two other key areas were identified as historical flooding areas.

- Newport News Reservoir along Jefferson Avenue
- Main Street Underpass

During severe storms where flooding occurs, the inability to uses these roadways has a significant impact on the surrounding network. Therefore, the Flood Monitoring system should alert the local commuters in the area of the current conditions as well as have the ability to send an alarm system to contact the Transportation Division of the flooding condition. The Transportation Division will in turn disseminate this information to the necessary 911 respondents. These locations are depicted on **Figure 2**.

2.4 Bridge Icing System

Static warning signs for potential icing on bridges have been in existence for many years. These yellow, diamond shaped signs warn motorists that bridges ice before the roadway, and are often mounted on a hinged sign so that the sign wording is only visible during cold weather months. These signs are passive, and do not actually warn motorists of the presence of ice. In this section, bridge icing notification technologies are reviewed.

2.4.1 Bridge Icing Technologies

There are active systems that use various types of road temperature monitoring technologies to warn motorists of icy conditions via dynamic message signs. Some of the systems also incorporate mechanisms for applying sprays to the roadways that are designed to automatically reduce the accumulation of ice on the roadway.

A newer, simple and effective ice alert system uses white, temperature-sensitive reflectors mounted on standard guideposts that act as delineators until the temperatures approach freezing, at which time the reflectors turn blue in color. These reflectors are accompanied by signs that educate drivers that the presence of blue reflectors indicates freezing conditions. These roadway reflectors are most effective when installed in a series of three to five reflectors based on speed, positioned well in advance of the potential problem area, in order to give motorists ample time to react. These devices are post-mounted, stand-alone devices that do not require batteries, electronic components, or pavement cuts. Such devices are in use in Virginia Beach, Virginia, Staunton, Virginia, Pennsylvania, Ohio, Illinois and Washington, to name just a few.

2.4.2 Location Strategies

These passive ITS elements have been recommended at the following nine locations, which are primarily arterial bridges crossing over the existing railroads, or bodies of water.

- Denbigh Boulevard over I-64/CSX Railroad
- Bland Boulevard over I-64/CSX Railroad
- Oyster Point Road over CSX Railroad
- J. Clyde Morris Boulevard over CSX Railroad
- Mercury Boulevard over Warwick Boulevard/CSX Railroad
- 39th Street over the CSX railroad
- 16th Street Bridge over Salters Creek
- Warwick Boulevard over Lake Maury

These are very passive elements, which do not require any additional action on the part of the Transportation Division. While these systems provide motorists with more accurate information and potential safety concerns, they will be considered a low priority. These locations are depicted on **Figure 2**.

2.5 Over-height Vehicle Sensor Systems

Over-height detection and warning systems alert motorists when the vehicle that they are driving is too tall for the roadway section ahead. These systems are applicable in advance of bridge overpasses, tunnels, and overhead walkways. When a vehicle passes through an over height detector, sign messages alert the driver that the vehicle is too tall and directs them to a nearby exit or detour route so that they do not proceed into the structure ahead.

2.5.1 Over-height Vehicle Sensor Technologies

The over-height detector is usually composed of a transmitter and a receiver that are mounted on posts at the side of the road at approximately the same height as the approaching structure (usually a couple inches lower than the posted clearance, which generally factors in additional tolerances). The transmitter emits a narrow beam to the receiver which is mounted across the roadway. The detector system senses objects that pass through or “break” the beam, thereby indicating an over-height vehicle. The detector can be used in conjunction with lights, signs, and/or flashers to alert drivers to an alternate route, or they can be used to activate a road closing device, such as a barricade or gate.

While enforcement is only a secondary consideration, some agencies have chosen to deploy cameras to monitor the bridge/overpass approaches along with time-lapse recording equipment to assist staff with validating over-height vehicle alerts as well as to potentially identify the vehicle or object triggering the alert.

2.5.2 Location Strategies

Two locations have been identified in the City that would benefit from this ITS applications.

- Warwick Boulevard underpass at Mercury Boulevard
- Fort Eustis Boulevard underpass at Warwick Boulevard

Both of these locations have required significant bridge repairs due to impacts from oversized vehicles. These ITS application will not only minimize maintenance costs associated with repairs, but the costs associated with the detours required to reroute traffic around these highly congested interchanges during such repairs. These locations are depicted on **Figure 2**.

2.6 System Detectors

System detectors can be used for a variety of purposes including indicating the presence of a vehicle at a local intersection, counting raw vehicular volume, characterizing types and speeds of vehicles, or determine occupancy of specific lanes. For the purposes of the ITS features, system detectors were evaluated for queue analysis along the five interstate ramps that provide access onto the City of Newport News local roadways.

As part of the VDOT Smart Traffic Center Phase 3 infrastructure expansion, ITS elements are installed, or in the process of being installed, adjacent to the City's borders along Interstate 64 between J. Clyde Morris and Yorktown Road, and Interstate 664 between Chestnut Ave. and the Monitor-Merrimac Memorial Bridge Tunnel. Consequently, there are system detectors located at the following Interstate interchanges that can provide traffic data pertaining to vehicles entering the local street network.

Yorktown
- I-64 westbound to Yorktown Road

Fort Eustis Boulevard
- I-64 eastbound off ramp to Ft. Eustis Blvd. westbound (to Warwick)
- I-64 eastbound loop to Ft. Eustis Blvd. eastbound (to Jefferson)
- I-64 westbound off ramp to Jefferson Avenue northbound/southbound
- I-64 westbound loop to Ft. Eustis Blvd. westbound (to Warwick)

Jefferson Avenue
- I-64 eastbound off ramp to Jefferson Avenue southbound
- I-64 eastbound loop to Jefferson Avenue northbound
- I-64 westbound off ramp to Jefferson Avenue northbound
- I-64 westbound loop to Jefferson Avenue southbound

Oyster Point Road/Victory Boulevard
- I-64 eastbound off ramp to Oyster Point Road westbound
- I-64 eastbound loop to Victory Boulevard eastbound
- I-64 westbound off ramp to Victory Boulevard eastbound
- I-64 westbound loop to Oyster Point Road westbound

J. Clyde Morris Boulevard
- I-64 eastbound off ramp to J. Clyde Morris Boulevard southbound

- I-64 eastbound loop to J. Clyde Morris Boulevard northbound
- I-64 westbound off ramp to J. Clyde Morris Boulevard northbound
- I-64 westbound loop to J. Clyde Morris Boulevard southbound

This queue information is anticipated to be used primarily for coordination of interstate diversion onto local streets. The VDOT HRSTC produced a report detailing an Interstate Diversion Plan (IDP), which identifies alternate routes to which traffic is directed during Interstate closures at varying locations in the Hampton Roads region. These are detailed routes that have incorporated short distance diversions between successive exits when the freeway is impassable. While traffic voluntarily diverting from the freeway in response to an incident or blockage wouldn't be detoured explicitly on the routes, they are the natural alternatives for most incident scenarios.

The alternate routes that are identified in the IDP include Jefferson Avenue, Warwick Boulevard, J. Clyde Morris Blvd, Oyster Point Road, Fort Eustis Boulevard and several minor arterial in the downtown area adjacent to I-664. When there is a severe incident on I-64 or I-664, traffic heading to the I-664 Monitor Merrimac Memorial Bridge Tunnel into Suffolk may choose to follow Warwick Boulevard or Jefferson Avenue over the length of the city, but this would be rare.

The locations for these VDOT system detectors are shown on the map in **Figure 2** and coincide with the predetermined diversion routes, which are shaded on **Figure 2**.

If there is a severe incident on I-664 in the southbound direction, some traffic may divert to Mercury Blvd to take an alternate bridge crossing. In this case the traffic crossing the main arteries of Warwick Boulevard and Jefferson Avenue may need extra green time. A detector on westbound Mercury Blvd at the border with the City of Hampton could indicate this new traffic pattern. While a late indicator, it is the nearest point within the City for a detector to be located.

In addition to the VDOT freeway off-ramp system detectors, it is also recommended that the City deploy system detectors located within the arterial network to monitor those facilities where the traffic patterns are being diverted to. Depending on the nature and severity of the freeway incident, traffic may take a longer or shorter detour. For example, eastbound traffic exiting the freeway at Jefferson Avenue may return to the freeway at Oyster Point or continue on to J Clyde Morris Boulevard or Hampton Roads Center Parkway. System detectors immediately downstream of Jefferson Avenue and Oyster Point Road, and Jefferson Avenue and J Clyde Morris Boulevard, coupled with the off ramp detectors at I-64 and Jefferson Avenue, would help determine how much traffic is returning to the freeway on these routes. This information is valuable for off-line analysis, and future planning as well. In this scenario, providing motorists with information is a key objective. If motorists are unsure of the downstream conditions on the Interstate, they will have a higher tendency to remain on the City's arterials. Providing motorists with specific information pertaining to the

route diversion will help to avoid excessive/unnecessary diverted volumes along critical City arterials.

2.7 Summary of ITS Locations

ITS technologies including cameras, dynamic message signs, weather monitoring devices, over height detection systems, and system detectors used for queue monitoring are local features that will allow the City of Newport News to better communicate current roadway conditions to the motoring public and emergency management staff. These technologies can provide more effective tools for managing local and regional incidents throughout the boundaries of the City.

While each of these elements provides a benefit, they do not necessarily provide an equal benefit. Some elements have a very specific audience, while other features provide a benefit to a greater audience. Ultimately, the proposed plan will depend on the funding dollars available subsequent to accommodating signal system and communication upgrades. However, based on the current conditions the following actions are recommended. These priorities stem from the level of benefit associated with the type of information that is the most valuable to motorists and other agencies, as presented within the regional systems analysis (Section 4.2).

1. CCTV cameras deployment should be the top ITS priority. The number and location should be evaluated based on complementing the VDOT coverage as well as City of Hampton's camera visibility. Camera locations above and beyond those identified in this Master Plan should be evaluated based on the needs of the adjacent roadways (i.e. monitoring high accident locations, congestion, diversion route, etc.).

2. The City is acquiring six portable DMS signs through current or near term VDOT roadway projects. With eight portable DMS, a full detour route can be displayed and consistent information can be displayed at four key intersections associated with the detour. Therefore, two additional portables are all that is anticipated for the foreseeable future when considered in conjunction with VDOT's planned permanent arterial DMS locations.

3. Following CCTV and DMS, system detector and queue information should be coordinated with the VDOT Hampton Roads STC so that the current traffic sensor information can be automatically/routinely uploaded to the City's proposed signal system central software. This VDOT data should provide a minimum of volume and speed on the critical ramps identified in **Section 2.6** of this document.

4. Condition monitoring and warning systems should be the next set of ITS elements considered for the City of Newport News based on the level of benefit versus the installation cost, and the on-going maintenance cost savings (particularly for over height systems). System deployments would include:

a. Flood monitoring and automated road closure equipment should be deployed in the identified locations to alert and protect motorists from potentially hazardous road conditions.

b. Over-height detection systems placed in advance of key bridges that have a history of over-height vehicle collisions would be monitored to alert the vehicle in advance of the underpass and divert the vehicle prior to impacting the structure.

c. Ice monitoring sensors are a passive ITS feature that provides more accurate information directly to the end user. Since this will not enhance the direct capabilities of the Transportation Division, this feature has the lowest priority for implementation, although it is also one of the least costly ITS features to deploy.

3.0 Communication Plan

The objective of Section 3.0 is to review relevant alternatives for upgrading the Newport News Department of Engineering's communications system in support of the ATMS upgrades as well as the ITS elements identified within this Newport News ITS Master Plan. In this section, network bandwidth needs are established for ATMS and ITS device types, expansion routes are identified to form a contiguous communication infrastructure, network architecture constraints and topologies are reviewed in consideration for fiber allocations, and finally communication alternatives specific to the Newport News system are analyzed.

3.1 Network Bandwidth Needs

Evaluating replacement options for the communication infrastructure begins with an understanding of the bandwidth requirements for the existing and proposed field equipments. Above and beyond communications with the existing traffic signal controllers, there is a need to plan for the communication requirements for Intelligent Transportation System (ITS) devices such as traffic monitoring cameras, dynamic message signs, and sensor systems. The greatest bandwidth demand by far is generated by the cameras.

Low-speed data devices such as traffic signal controllers, flood warning systems, over height vehicle detection systems, and stand-alone system detectors have traditionally managed to get by with a mere 9.6kbps of bandwidth or less. However, similar to the computer industry, the need for increases in bandwidth has been driven by the advancement of ITS technologies, protocols, and new device types. **Table 4** identifies field devices and their required bandwidths. Portable DMS will likely use cellular/PCS technologies for flexible communications throughout the City, but they are included in the bandwidth estimate to account for the potential deployment of permanent signage in the future. The device quantities correspond to the identified locations for ultimate build-out derived from **Figure 2**, which is based on the placement guidelines within Section 2.0.

Table 4: Network Bandwidth Requirements by Device Type

Device	Bandwidth (kbps)	Quantity	Summation (kbps)
CCTV cameras	3,000 (Kbps)	34	102,000
DMS	30 (Kbps)	12	360
Flood Warning Devices	30 (Kbps)	5	150
Over height Vehicle Detection Systems	30 (Kbps)	2	60
Traffic Signal Controllers (via Ethernet)	100 (Kbps)	275	27,500
Other Future ITS elements (additional 15%)	50 (Kbps)	50	2,500
Wide Area Network (center to center)	100,000 (Kbps)	1	100,000
			232,570

Under the City's current leased line communication method, in order to achieve reasonable video quality, the analog video must first be digitally encoded and compressed at the associated camera location before being transmitted over a leased T-1 line, at a minimum. (Note: The bandwidth/quality assumed in **Table 4** above would require an equivalent of two T-1 lines per camera.)

At full build-out, the ITS Master Plan calls for 34 cameras to be distributed across the City. At a cost of $500/month to operate a T-1 line for each camera, the City would spend approximately $6,000/year per camera, which equates to over $204,000 annually upon final build-out for all 34 cameras.

In comparison, over a City-owned fiber optic network, and camera locations that coincide with existing traffic signal locations, the operational cost to add cameras is negligible. However, this comparison is based on two key underlying assumptions. The first is that each traffic signal cabinet has an Ethernet architecture. This feature allows for additional IP-based elements (i.e. video encoders, etc.) to be added at a specific location without consuming additional fiber resources (e.g. strands of fiber). The second is that the overall network is sized sufficiently to handle the additional bandwidth required for those additional devices. Understanding the second assumption along with the requirements listed in **Table 4** suggests that 100 Million bits per second (Mbps) network architecture will NOT suffice for accommodating the long-term bandwidth needs of the City of Newport News' ATMS. Therefore, it is recommended that the City deploy the next higher bandwidth standard that is available on the market, which is 1000Mbps or Gigabit Ethernet (GigE) as it is commonly known in the industry. Hence, the communication alternatives explored within this analysis will be based on the premise of supporting a GigE network architecture.

3.2 Communications Expansion Routes

Today, the City of Newport News Department of Engineering provides communication to 254 signalized intersections with a mixture of 6-pair and 12-pair size 19-AWG twisted pair cables. The majority of the existing twisted pair cables are approximately 20 years old and nearing the end of their useful life expectancy.

As seen on the signal system inventory base map (**Figure 6**), there are gaps within the current communications network between the closed loop systems and the two operations centers, which requires the use of the dial-up public telephone network (i.e. leased lines). In order to eliminate the dependency on leased lines, the existing gaps in the Department of Engineering's cabling infrastructure would have to be filled in to form a contiguous communication path to both operations centers (Operations Center at Jefferson Avenue/Operations Drive as well as City Hall Center at Washington Ave./25th Street).

When faced with the cost of additional infrastructure to fill in the gaps, combined with the need to replace the aging twisted-pair cabling infrastructure, the cost of such an endeavor can be rather daunting. However, so are the anticipated costs to operate high-speed leased telephone lines to adequately serve the CCTV cameras identified as a priority within this ITS Master Plan. The cost to provide telephone

service to these cameras can range up to $204,000 annually if solely reliant on leased T-1 lines.

As discussed previously, fiber optics is the best recommended wireline communication media for ATMS and ITS deployments. In the analysis of communication alternatives, all four scenarios use either new fiber or resource-sharing fiber infrastructure to complete the communication gaps, and provide contiguous paths to both operations centers.

3.3 Ethernet-based Communication Architecture

As industry trends continue to migrate towards industrial Ethernet components, the need for fewer video/data transmission conversions at the field devices is evident with an Ethernet-based (i.e. GigE) alternative. Under the proposed upgrades to the Newport News ATMS, the proposed traffic signal controllers and other ITS devices are planned for supporting Ethernet communication interfaces. However, devices that only support native serial (RS-232) connections can be converted (e.g. with terminal servers) to Ethernet-compatible communications.

Two Ethernet based communication architectures have been evaluated to account for the four alternatives discussed in detail in Section 3.6 of this document. **Figure 7** illustrates the first communication architecture, which is entirely fiber optic Ethernet field communication architecture (Scenarios 1, 3 and 4 fall under this option). The second communication architecture option, as illustrated in **Figure 8,** has a distributed Ethernet field communication architecture along fiber communications to a field hub (i.e. master traffic signal locations) coupled with twisted pair communications to the remaining cabinet locations. The following paragraphs describe the equipment and process involved with establishing an Ethernet-based ATMS architecture.

In **Figure 7** and **Figure 8**, video signals are sent from the CCTV (closed circuit television) camera to the field cabinet, where it is connected to a digital video encoder. The image from the camera is in its native NTSC video composite form and the pan/tilt/zoom control (RS-232 or RS-422) is in its native serial form. These data and video signals are sent to the video encoder, also located inside the field cabinet. The signal is then converted into a compressed digital form (MPEG-2 and/or 4) and connected to an Ethernet switch which places the resulting data stream onto the backbone.

MPEG-4 is one of several broadcast-industry standard compression techniques that provide 30 frames per second with a pixel resolution of 720 x 480 within a digital bandwidth of approximately 2.5Mbps. However, in the Network Bandwidth Requirements section of this report (**Table 4)**, an aggregate bandwidth of 3 Mbps is allocated to each camera.

Figure 6
Newport News Signal System
System Inventory

Prepared for:

VDOT Virginia Department of Transportation

Prepared by:

Kimley-Horn and Associates, Inc.

Under SubContract to:

Wilbur Smith Associates

Legend

- Existing Master Controller
- Flasher
- Existing Signal - Mast Arm
- Existing Signal - Span Wire
- Future Signal
- Lane Control Signals
- Signal Systems
- System Loops
- Overhead Comm
- Underground Comm
- Intersections with Proposed Emergency Backup Power

0 1,250 2,500 5,000 7,500 10,000 Feet

N S E W

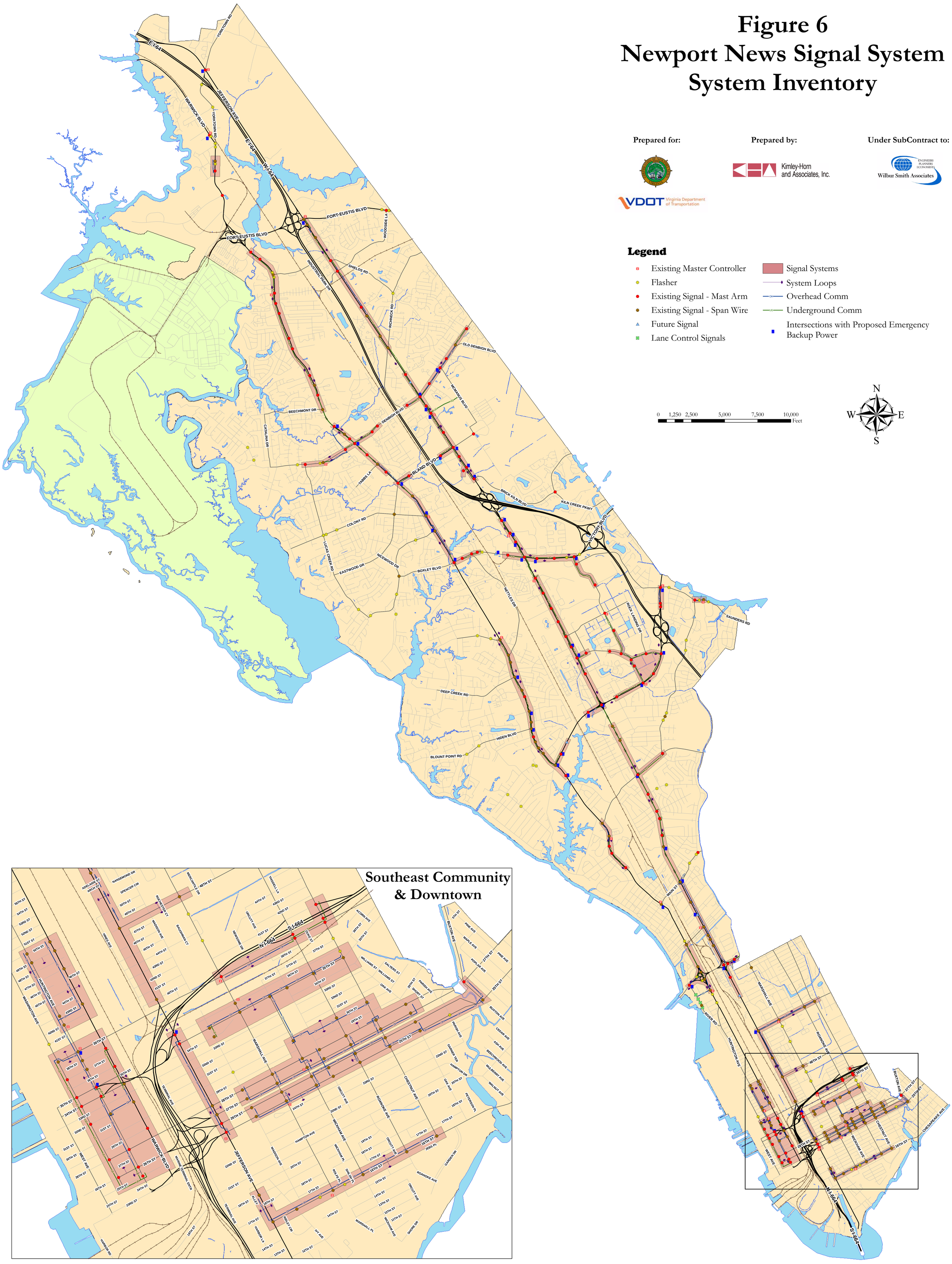
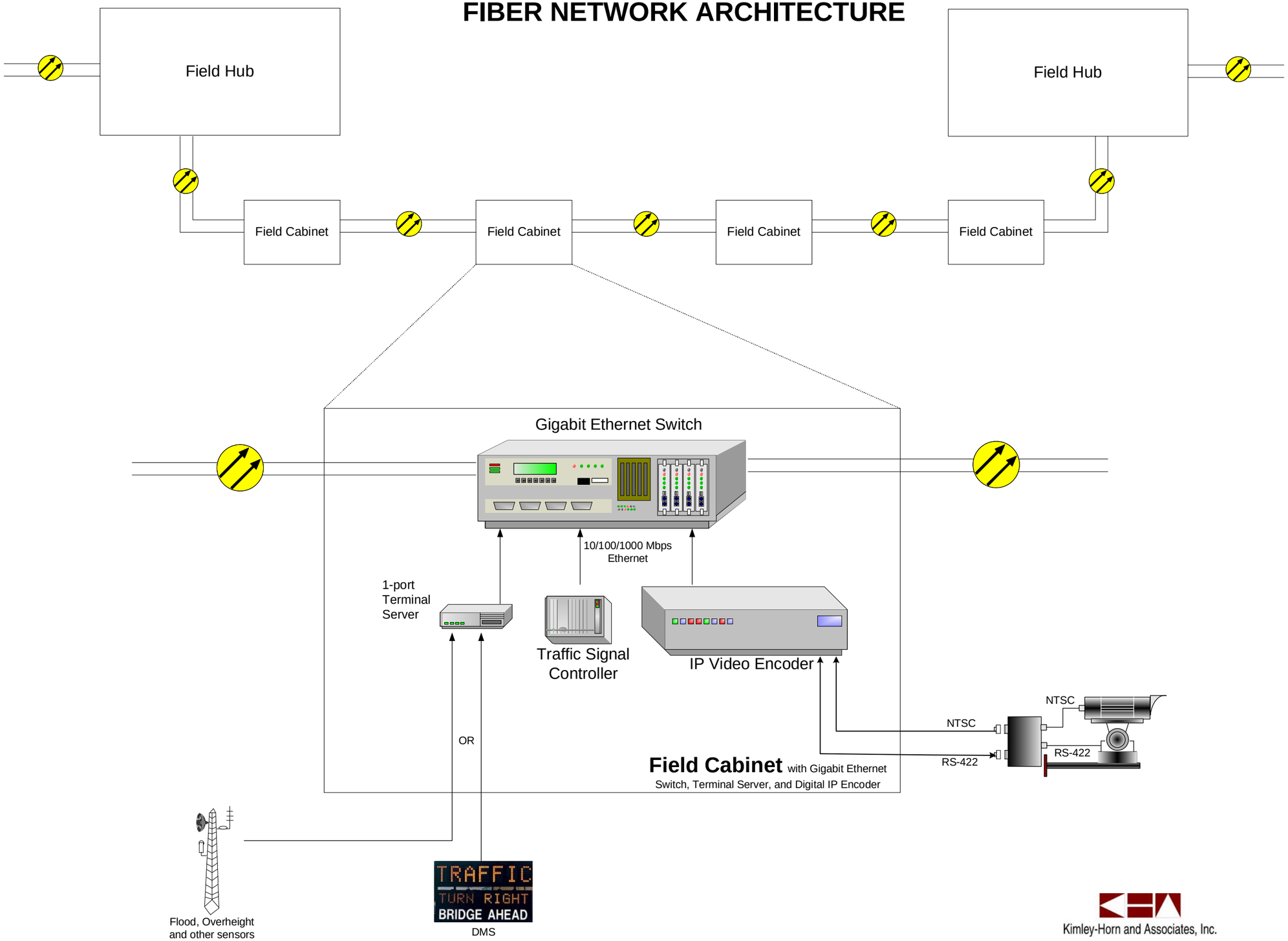
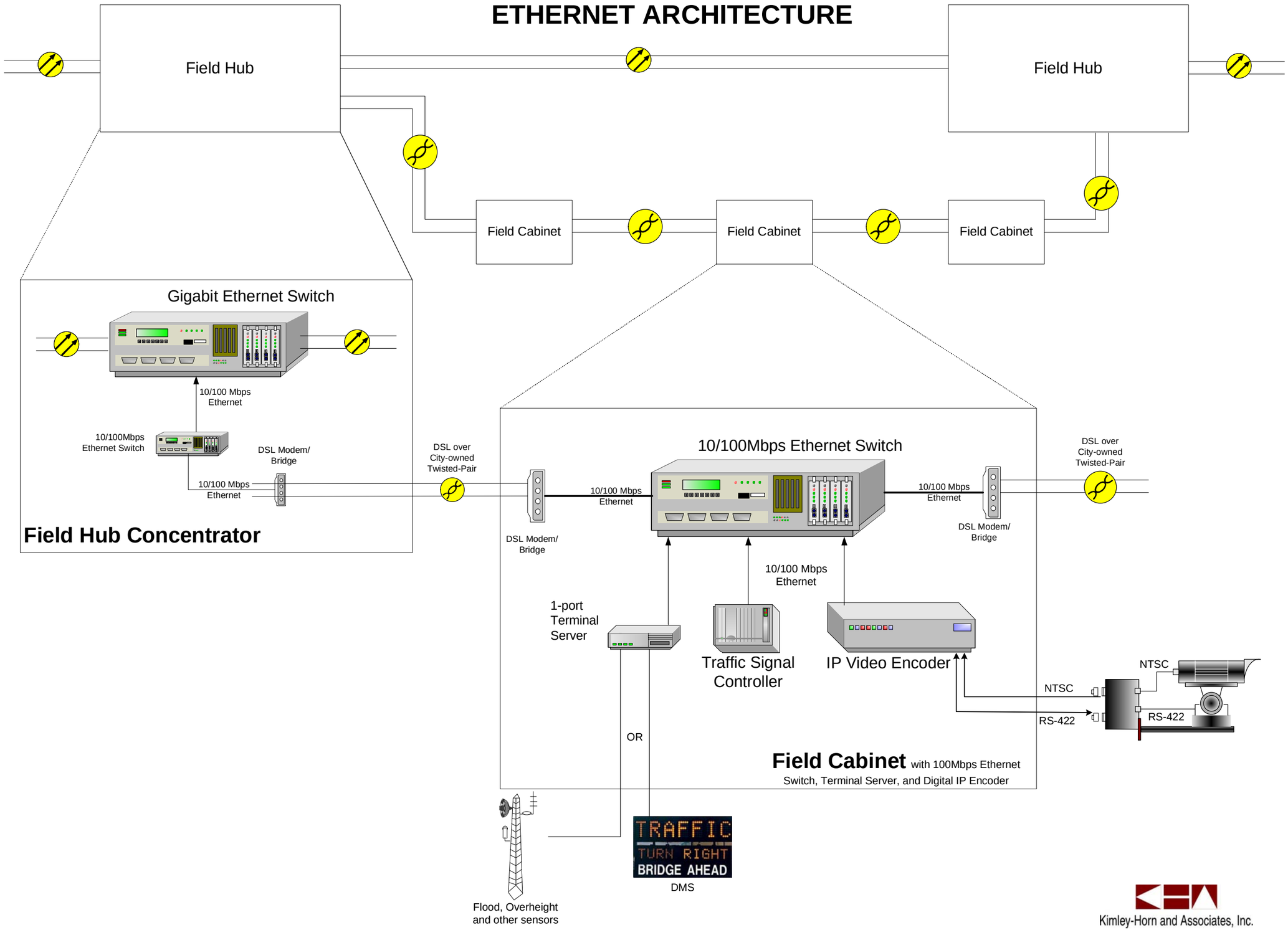


FIGURE 7: ETHERNET TO THE FIELD CABINET – FIBER NETWORK ARCHITECTURE



Kimley-Horn and Associates, Inc.

FIGURE 8: FIBER BACKBONE/TWISTED-PAIR DISTRIBUTION ETHERNET ARCHITECTURE



Kimley-Horn and Associates, Inc.

This bandwidth allocation allows for the use of dual-streaming video encoders; encoders that are capable of transmitting one high-bandwidth stream while simultaneously transmitting a low-bandwidth stream. The key benefit of this technique/technology is that the high-bandwidth image can be earmarked for the traffic operations personnel without sacrificing video quality, whereas the lower bandwidth signal can be placed on a different network channel and allocated for web distribution or inter-agency distribution where bandwidth is more limited.

Serial data transmissions generated from other field devices such as flood warning, over height vehicle detection, etc. are collected and processed in much the same way. The serial data lines are connected to a terminal server, which assigns these devices to an Internet Protocol (IP) address that can be mapped to a virtual computer "COM port" to both of the City's operations centers for applications that rely on native COM port connectivity. The terminal server forwards the data signals on to the GigE switch inside the field cabinet.

Once all of the native field devices have been converted into an Ethernet format, the digitally comprised signals then travel along the distribution network to other field cabinets where additional devices/signals are collected and sent to a field hub network concentrator. In these alternative scenarios there are several field cabinets connected between two field hubs. The field hubs continue the signal along its directed path to the operations centers via two or more alternate paths. In these alternatives, since the conversion to Ethernet is performed at each field cabinet, the function of the field hub is to aggregate/concentrate Ethernet connections from field cabinet chains/rings onto one or more GigE paths to the City's operations centers.

3.4 Network Topology

The topology of a network describes the interconnection of associated devices within the network and also determines the amount of cabling that is required. Network topologies help to establish the means for achieving the criteria for network reliability. The most common network topologies are Star, Ring, and Mesh. These topologies are described below with advantages and disadvantages for consideration within the Newport News communication network.

3.4.1 Star

Star networks, **Figure 9,** make use of point-to-point telecommunications. The star network has a hub at its central point. All telecommunications between the network devices are directed through this hub. Thus, the star configuration is limited in size and performance due to the number of nodes vying for access to the hub.

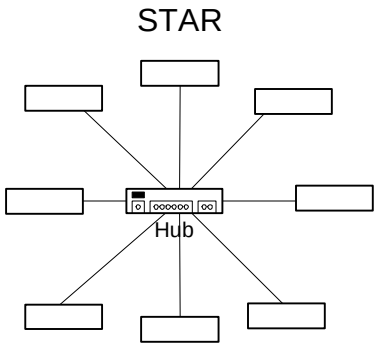


Figure 9: Star Topology

The point-to-point (star) telecommunications link advantages include:

- Quick response times because a dedicated channel is provided between each point.
- Simplicity of design and configuration.

The disadvantages of the star topology include:

- Lack of fault tolerance. In the event of a link failure (for example, a cut fiber), telecommunications would be disrupted since no alternate path is available to maintain the connection.
- Inefficient use of the fiber optic cable, requiring high fiber counts to service the system.
- More equipment to maintain and higher total equipment cost. Each node/device requires a transceiver at each end of every link, as opposed to a single master transceiver for an entire circuit of devices.
- If the hub goes down, all links between devices attached to it also go down.

3.4.2 Ring

Ring topologies can be used for distribution to nodes/devices (e.g. Fiber-Distributed Data Interface (FDDI) to workstations and servers, master rings for Intelligent Transportation Systems (ITS) controllers, etc.) or in the telecommunications backbone (e.g. hub to hub). A ring topology is created by interconnecting each hub to the next, forming a loop or ring. In this configuration, telecommunications are omni-directional, and access to the ring is controlled by software. The limitation of this topology is increased delay time needed to access the ring, but this delay can be very small (micro-seconds) given current technology advancements. Fault tolerance and redundancy of links are provided through advanced software.

The ring topology was created primarily to increase system reliability through fault tolerance for individual equipment failures and cable cut protection. The topology can be used with both fiber optics and microwave/wireless networks. In most fiber optic cable rings, two fibers in the forward and return paths are generally used to create the ring. The self-healing characteristic of the ring is facilitated by

equipment/software that is able to select the best communication path (particularly in the case of a fiber cut or transceiver/switch failure).

A *folded ring,*

Figure 10, also referred to as a "collapsed ring", consists of a single cable routed along a single path that uses several fibers within the cable to create a ring. Generally, two fibers are used for the forward path, and two are used for the return path. Because the forward and return fibers share the same physical cable, a folded ring is not as effective as a physical ring in safeguarding against a cable cut. However, it does protect against a mid-ring device/modem failure by maintaining communication between hubs downstream of the failure.

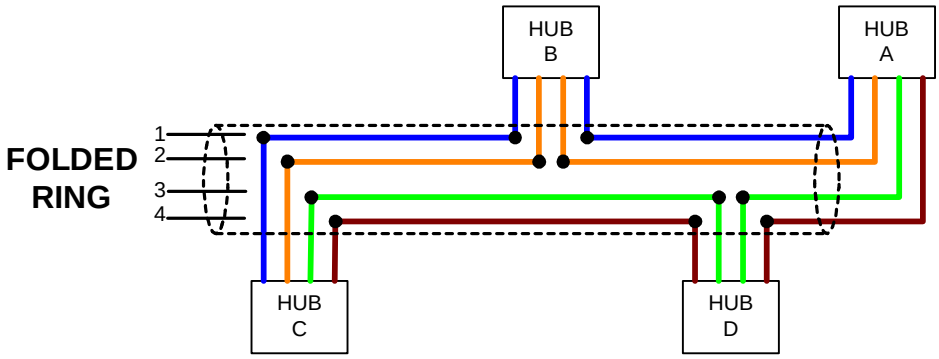


Figure 10: Folded Ring Topology

A *physical ring* (**Figure 11**) is comprised of separate cable paths (also known as path diversity) from end to end. This creates a highly reliable topology by protecting against both equipment and fiber failures. In contrast to a folded ring, two fibers could be routed around the two separate paths rather than four fibers along one path, thereby reducing overall fiber requirements in each cable route.

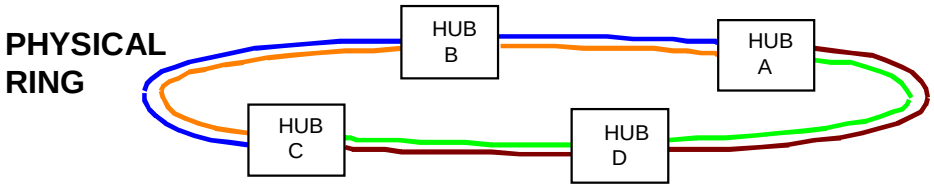


Figure 11: Physical Ring Topology

Thus, advantages of the ring topology include:

§ Fault tolerance. If a telecommunications device were to fail, all other devices would be able to communicate with each other (but not with the failed device). If a link fails in a non-folded portion of the ring, the telecommunications equipment would instantly route data around the fault with no loss of functionality. A cable break on the folded portion of the ring would result in loss of communication to the devices at the end of the folded segment.

§ Minimized fiber usage. Full ring functionality could be provided with only two fibers in some areas (true ring), and four fibers (folded ring) in others.

The disadvantage of the ring topology is:

§ Cost. The equipment needed to create and manage the ring is the most expensive of the three alternatives; however, the cost savings from reducing the number of fibers needed offsets this increase in cost.

3.4.3 Mesh

Mesh topologies, **Figure 12,** are largely limited to telecommunications backbones due to the complexity and high cost associated with them. Mesh topologies provide multiple links between hubs. A basic mesh topology would be used in larger networks in which there are separate groups of node devices in different buildings or areas. A router (e.g. hub component) is typically used to connect these nodes together between buildings and hubs. This topology is used to decrease the amount of traffic (bandwidth) on a network by subdividing, or meshing, the network into several smaller links and rings.

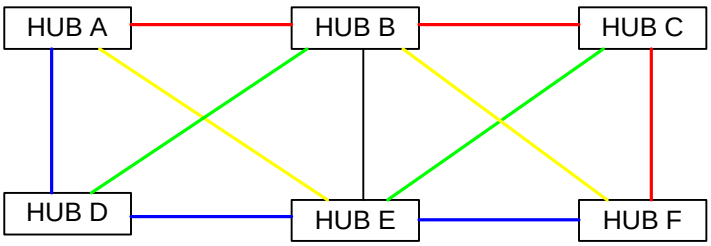


Figure 12: Mesh Topology

The advantage of a mesh topology is:

§ Additional reliability is offered through primary and secondary link assignments.
§ Individual network links can be upgraded rather than an entire ring.

The disadvantages of a mesh topology are:

§ Multiple cable paths add more complexity to complexity and network management.
§ Requires more infrastructure (e.g. fibers/modems, wireless equipment, and leased lines).

Table 5 provides a comparison of several key attributes for star, ring, and mesh topologies. It is recommended that the City of Newport News deploy a ring topology whenever technically and economically feasible. The use of a folded ring may be used on long branch cable runs with multiple devices to reduce the chances of single-point communication equipment failures.

Table 5: Comparison of Topology Attributes

	Star	Ring	Mesh
Reliability	Low	High	High
Infrastructure Optimization	Low	High	Moderate
Time to Deploy Expediency	High	Moderate	Low
Network Response Times	High	Moderate	High
Relative Cost Savings to Deploy	Moderate	Moderate	Low

3.5 Fiber Allocation

In addition to determining the bandwidth requirements, and topology recommendations, fiber allocation is equally important for evaluating communication network alternatives. Based on a ring topology for Ethernet-based communication, the Newport News ATMS/ITS communication system deployments can maximize reliability while minimizing the number of fiber strands needed to complete the network. **Figure 7** depicts this architecture approach for the proposed ATMS in Newport News using fiber optic cables.

Two fibers extend between each field cabinet and ultimately connect to a network concentrator field hub before connecting to one of the City's two operations centers. **Table 6** summarizes the fiber allocation requirements for planning cabling routes throughout the ATMS/ITS network in the City of Newport News. When two physical routes are available to reach an ATMS/ITS device, 2 fibers can be allocated on each route (i.e. Jefferson and Warwick with cross-connects along J. Clyde Morris and Oyster Point would form a physical ring). Branch routes such as Kiln Creek, which are isolated to a single cable route, would require 4 fibers to create a ring topology. However, as discussed previously, folded rings protect a system against a modem/equipment failure from impacting other downstream device locations. When only one or two devices are attached to a given branch route, the impact of such a modem failure is minimal and a daisy-chain topology can be justified.

Table 6: Fiber Allocation Requirements

Ethernet Topology	Fibers Required per Route
Physical ring or daisy-chain – Distribution and/or Backbone	2 fibers
Folded ring – Distribution Ethernet distribution (folded ring)	4 fibers

3.6 Newport News ATMS Communication Alternatives

The Department of Engineering is very fortunate to have an existing array of fiber optic infrastructure that is being made available to them by the Newport News Public Schools (NNPS) along with the IT Department. This resource sharing opportunity provides the Department of Engineering with the use of four fiber strands along three rings that comprise the NNPS cabling network.

The existing communication infrastructure is comprised of several localized closed-loop systems around the City, which are connected to the central system only by way of dial-up phone lines to field master controllers. Four scenarios are evaluated for the proposed the Newport News Department of Engineering's ATMS/ITS communications system.

Scenario 1 is a complete replacement of the existing twisted pair infrastructure with new fiber optic cables along with a completion of crucial links to form a contiguous network. Scenario 1 relies entirely on the Department of Engineering's own infrastructure to communicate with all existing and planned device locations. The remaining three scenarios rely on the available NNPS/IT fiber infrastructure to various degrees.

Scenario 2 relies on the NNPS/IT fiber simply to provide a backbone for connecting both operations centers to the existing field master locations, which in turn use the existing twisted pair distribution to communicate with the remaining signals.

Scenario 3 relies on the NNPS/IT backbone in a similar manner to the second scenario, but replaces the existing twisted pair with fiber optic cables instead for the final distribution to traffic signals and ITS devices.

Finally, Scenario 4 reduces the amount of overlapping infrastructure between the NNPS/IT backbone and Transportation Division's infrastructure by increasing the number of access points used to connect traffic signals and ITS locations to the NNPS/IT backbone. Each scenario is described in further detail in the following sub-sections. A description of the evaluation criteria and their applied meanings is provided in Section 3.6.1.

3.6.1 Prioritized Communications Evaluation Criteria

Table 7 defines the eleven criteria used to evaluate the communication system alternatives for the Newport News ATMS and ITS Master Plan. The rank/priority values range from 11 to 1, where 11 is the highest priority and 1 is the lowest. These priority rankings are based upon the stakeholder inputs/needs as well as previous experience with other comparable systems. These requirements will be used to consistently analyze each communication alternative presented in this report. Priority rankings will be used to assist in summarizing the findings.

Table 7: Communication Network Evaluation Criteria

Requirement	Evaluation Criteria for Network Communications	Rank / Priority
Network Bandwidth	Alternatives will be evaluated for the capability to support identified short-term and long-term traffic signal and ITS bandwidth needs for field devices.	9
Reliability	Alternatives will be evaluated for the ability to offer path diversity and protection from single points of failure.	11
Maintainability	Alternatives will be evaluated for complexity of system maintenance, availability of replacement components/technologies, and the level of staff sophistication required.	4
Open Architecture Support	Alternatives will be evaluated based upon the ability to provide an open platform for different types of communication and video vendors and encoding standards.	1
Flexible Distribution vs. Backbone Uses	Alternatives will be evaluated for the ability to support devices with diverse needs. This will be based upon the ability to support multiple types of interfaces of varying bandwidths. Efficient fiber utilization will also be taken into consideration in evaluating alternatives.	2
Network Security	Field architectures will be evaluated for the ability to provide network security.	6
Scalability/ Expandability	Alternatives will be evaluated for the ability to scale beyond the identified existing and planned ATMS and ITS deployments.	10
Interoperability	Alternatives will be evaluated based upon the ease of which communication equipment can be acquired and deployed from different vendors.	5
Field Equipment Impacts	Alternatives will identify any upgrades (or additional equipment) that may be required to support the given technologies used.	7
City Smart Traffic Center (STC) Implications	Alternatives will be evaluated based upon the demand for physical City STC space for hardware, functionality implications, and central software implications.	3
Cost Implications	Alternatives will be compared against one another for initial capital cost.	8

3.6.2 Scenario #1 –Transportation Fiber Backbone & Distribution

As the majority of the Department of Engineering's twisted pair communication infrastructure is nearly 20 years old, the reliability of the communications provided by these cables has deteriorated to a point where its replacement is strongly recommended. The first communication scenario under evaluation involves the replacement of the Department of Engineering's existing communication infrastructure without any shared resources available from Citywide IT and Newport News Public Schools. Therefore, this scenario has the highest construction cost among the four scenarios analyzed herein.

In this alternative, Gigabit Ethernet capability is present in every field controller cabinet. Translation from serial data (i.e., RS-232) and analog composite video takes place at the specific field cabinet level where the ITS device is located. As described in Section 3.3 and depicted in **Figure 7**, GigE switches are utilized with two or more GigE uplinks to connect with neighboring field cabinets in a ring topology for increased reliability. The GigE switches are also equipped with at

least four copper-based Ethernet ports for connecting to the terminal server, a digital video encoder, the traffic signal controller, and a maintenance laptop. At the field cabinets, video and data signals must be received and processed prior to transmission on the Ethernet network. **Figure 13** shows the Newport News ATMS with an overlay of fiber optic routes utilizing existing Department of Engineering communication routes, both overhead and underground, as well as construction of new routes to provide connectivity with the City's two operations centers. The construction of the communication upgrades in this scenario involves:

Re-use Existing Engineering conduit for fiber optic cables	27.0 miles
Lash new fiber to overhead twisted-pair messenger cables	18.0 miles
Fiber Expansion on new routes	38.0 miles

The infrastructure for this scenario extends nearly 83 miles to provide contiguous fiber communications with all of the City's traffic signals and flashers. Within Engineering's existing conduits, it is proposed to install microtube innerducts to facilitate installing the new fiber optic cables by blowing them through the existing conduit with forced air. This scenario has the greatest cost, as it involves virtually re-constructing the entire traffic signal system communication network. The evaluation criteria summary for this scenario is as follows:

Network Bandwidth: Each segment on a GigE backbone has a theoretical capacity of 1000Mbps. However, due to networking overhead and link management, the typical realized capacity per link is closer to 60-70% of that theoretical maximum, or between 600-700Mbps. By establishing a Gigabit Ethernet network out to every field cabinet, this alternative provides more than enough bandwidth to support the existing and planned ATMS/ITS field devices. Since local concentration of bandwidth can also be an important factor, CCTV location density is also considered. The highest demanding bandwidth route in this scenario includes four cameras (or roughly 12 Mbps). In comparison to the resource-sharing alternatives in Scenarios 2, 3, and 4, an Engineering-owned fiber-optic infrastructure would have far greater bandwidth capacity if you compare a 48 fiber cable to four strands of resource-sharing fibers.

Reliability: A ring-based topology can be deployed provided that some form of Rapid Spanning Tree, Equal Cost Multipath Routing (ECMR), or Virtual Router Redundancy Protocol (VRRP) is used to effectively manage the redundant links. The field cabinet-digitizing architecture reduces the effects of signal loss in the event a field cabinet is lost since two of the field hubs are connected to each field cabinet instead of the traditional method using only one field hub concentrator. Fiber optics is less susceptible to lightning surges and electromagnetic and radio frequency interference (EMI/RFI), which all results in more reliable communications. Since the aging twisted-pair infrastructure would be replaced under this scenario, reliability would also improve compared with existing operations.

Maintainability: Deploying Ethernet to each field cabinet increases the ability of technicians to access network management statistics and other system diagnostics from any cabinet. Technicians can simply connect a laptop to an available Ethernet port and log into authentication systems at the operations center. System technicians will need a higher level of sophistication to troubleshoot networking, IP addressing, routing tables, etc. for all four of the scenarios presented here. Fiber optic Ethernet switches, hardened for ITS field environments have grown in prevalence over the past few years whereby several vendors with common standards are available on the market. This scenario places the largest maintenance burden on the Department of Engineering's staff since the cabling infrastructure would be entirely their responsibility.

Open Architecture Support: IEEE approved the Gigabit Ethernet standard 802.3z in June 1998. 1000-Base-X has a transmission range of 10km over single-mode fibers using standard transceivers. Extended range transceivers are available from most manufacturers upwards of 70km. Multi-vendor support for field-hardened equipment that supports IEEE 802.1Q virtual LAN (VLAN), 802.1w and 802.1D Spanning Tree Protocols, and network management standards (RMON, SNMP) greatly reduces the reliance on a sole-source for networking components.

Flexible Distribution vs. Backbone Uses: This scenario has a complete fiber-optic infrastructure, thus the medium is more than capable of handling distribution and backbone applications above and beyond the proposed Gigabit Ethernet architecture. The use of an Ethernet distribution and backbone in this architecture allows flexibility to extend from the network with other media such as wireless by using Ethernet-compatible standards (i.e. 802.11 and 802.16).

Network Security: Since this scenario relies entirely on a dedicated Engineering fiber optic network, separate from the remainder of the City's IT, it provide the highest network security among the scenarios. However, if Engineering establishes the new network as an extension of the IT network, then network and physical security become a significant issue to manage at each field cabinet. Network security over fiber optics can be managed by segmenting traffic management devices, servers, workstations, and even other agencies onto separate Ethernet virtual LANs (VLANs). When configured in this manner, routing traffic between VLANs can be restricted to certain workgroup LANs, agencies, or even devices.

Scalability/Expandability: An entirely Engineering-owned cabling infrastructure provides significant flexibility. If network segments ever become overburdened, they can be subdivided into more than one GigE segment between field hub concentrators by simply using an additional pair of fibers. Additionally, there is greater flexibility to share fiber resources with neighboring jurisdictions such as the City of Hampton, York County, and James City County for regional traffic management. This provides greater scalability versus the other scenarios.

Interoperability: Several manufacturers have demonstrated interoperability between their respective 802.3z GigE switches. Traditional Ethernet products at the 10/100Mbps copper interconnect-level, which are widely deployed, have experienced an excellent track record with interoperability.

Field Equipment Impacts: Based on the current field device specified to be part ITS master plan, some additional deployment of other hardware will be required to packetize/transform the data into the Ethernet format. These hardware devices include video encoders and decoders, terminal servers, and Ethernet switches/routers. This equipment does impact the spatial constraints in field cabinets. At least three rack units (5.25”H x 19”W max) of space, assuming worst case, would be needed at each field cabinet for this alternative. Less space would be required as ITS components continue to adopt Ethernet interfaces to eliminate the terminal server, and someday perhaps the video encoder.

City Smart Traffic Center Impacts: Unlike traditional signal systems with modem-banks and multiplexers, an Ethernet architecture typically reduces the amount of central equipment needed. In this scenario, a network switch at each operations center along with a digital video management/distribution system is the extent of the communication infrastructure requirements at each of the City’s STCs. However, since Engineering’s fiber optic cables would be directly connected to each center, space for fiber optic patch panels and splice units would also need to be allocated to terminate those cables.

Figure 13
Newport News Signal System Communication Scenario 1

Transportation Fiber Backbone and Distribution

Prepared for:

Prepared by:

Under SubContract to:

VDOT Virginia Department of Transportation

Kimley-Horn and Associates, Inc.

Wilbur Smith Associates

Legend

- Existing Master Controller
- Flasher
- Existing Signal - Mast Arm
- Existing Signal - Span Wire
- Future Signal
- Lane Control Signals
- Signal Systems
- Existing Overhead Comm/New Fiber
- Existing Underground Comm/New Fiber
- Proposed Newport News Transportation Fiber Expansion

0 1,250 2,500 5,000 7,500 10,000 Feet

N S E W

3.6.3 Scenario #2 –NNPS/IT Fiber Backbone & Existing Transportation Twisted-Pair Distribution

Scenario 2 leverages the use of the four fibers within NNPS/IT fiber network simply to provide a backbone for connecting both operations centers to the existing field master locations in order to access the existing Department of Engineering's twisted pair distribution to the remaining signals. Since the NNPS/IT cable routes do not reach all locations some additional fiber routes are included to extend beyond the backbone coverage to reach all of the Department of Engineering's current infrastructure.

Figure 14 shows the Newport News ATMS with an overlay of the twisted-pair routes utilizing existing Department of Engineering communication routes, both overhead and underground, as well as construction of new fiber optic routes to provide connectivity with the City's two operations centers. Additionally, IT access points are shown on the map where the distribution and backbone cabling systems meet. The construction of the communication upgrades in this scenario involves:

Re-use Existing Twisted Pair distribution	44.5 miles
Fiber Expansion on new routes	15.0 miles

The infrastructure for this scenario only extends Engineering's current communication coverage by 15 miles to provide contiguous communications with all of the City's traffic signals and flashers. With the intent to maximize the re-use of the existing twisted-pair distribution, this is the least-cost communication alternative, but with several limitations. The evaluation criteria summation for this scenario is as follows:

Network Bandwidth: Similar to Scenario 1, the backbone portion of Scenario 2 can effectively handle between 600-700Mbps. However, bandwidth is also a measure of the capacity of the physical cabling. Current digital subscriber line (DSL) technologies typically yield no better than 10 Mbps for distances under a mile. Due to the dependence on existing 20+ year old twisted-pair cabling, the bandwidth for this scenario is diminished in comparison to the remaining scenarios. Since some routes have three or four cameras within that span, additional segmentation may be needed to support the required bandwidth using this architecture.

Reliability: A ring-based topology can be deployed provided that some form of Rapid Spanning Tree, Equal Cost Multipath Routing (ECMR), or Virtual Router Redundancy Protocol (VRRP) is used to effectively manage the redundant links. The field cabinet-digitizing architecture reduces the effects of signal loss in the event a field cabinet is lost since two of the field hubs are connected to each field cabinet instead of the traditional method using only one field hub concentrator. Twisted-pair infrastructure in this scenario is more susceptible to lightning surges and electromagnetic and radio frequency interference (EMI/RFI), which yields less reliable communications. Not all of the existing closed-loop twisted-pair

infrastructure would be able to cost-effectively tie back to two different backbone field hubs, thereby reducing the reliability based on susceptibility to any number of upstream communication device failures.

Maintainability: Similar to Scenario 1, deploying Ethernet out at each field cabinet increases the ability of technicians to access network management statistics and other system diagnostics from any cabinet by simply connecting a laptop to an available Ethernet port and logging into authentication systems at the operations center. This scenario, however, with its reduced bandwidth along the final distribution path inherently limits the capability to perform certain functions effectively (i.e. checking a remote digital video stream, downloading large support manuals, etc.) since the distribution path itself can only handle 10 Mbps. Additionally, there are more components and mixed media to maintain under this scenario raising the maintenance complexity for this scenario.

Open Architecture Support: The Ethernet support for open architecture still applies. However, in contrast with Scenario 1 there is an increased reliance on longer distance fiber spans between field concentrators since the backbone does not extend to each field cabinet. With an increased dependence on long-distance optical gear comes an increased dependence in matching components.

Flexible Distribution vs. Backbone Uses: With the use of four fibers along a fiber-optic infrastructure that does not extend to all field cabinets, this scenario is more suitable for backbone delivery than for distribution. The existing aging twisted pair cabling has bandwidth limitations, which reduces the number of devices that can effectively be allocated to each distribution path. Twisted-pair infrastructure, aside from its use for low-speed or DSL applications, is not as flexible as fiber optics for ATMS/ITS deployments.

Network Security: Since this scenario relies on a resource-shared fiber optic backbone, network security is dependent on physical security at the access points as well as fiber interconnect centers. The anticipation with this scenario, and the remaining scenarios (3 and 4) that rely on this resource-shared infrastructure, is that Engineering will establish its own dedicated Ethernet network to the field hubs. By segmenting traffic management devices, servers, workstations, and even other agencies onto separate Ethernet virtual LANs (VLANs), network security over fiber optics can easily be managed. When configured in this manner, routing traffic between VLANs can be restricted to certain workgroup LANs, agencies, or even devices. Interconnection between/with City IT networks should be limited to only a couple of locations (i.e. operations centers) where physical security is more prevalent.

Scalability/Expandability: This scenario has minimal scalability/expandability based upon the bandwidth limitations and lack of flexibility of the existing twisted-pair distribution cables. There is little to no flexibility to share fiber resources with neighboring jurisdictions such as the City of Hampton, York County, and James City County for regional traffic management.

Interoperability: With the reliance on multiple media devices (copper and fiber), interoperability concerns exist. Private-wire DSL modems do adhere to industry

standards, but often times even the telephone service providers install them as matching pairs. This adds an additional layer of interoperability that is needed to ensure that the DSL modems, copper Ethernet switches, and fiber Ethernet switches will effectively work together, not just by physical connectivity but with the associated network layer requirements (i.e. multicasting video, Layer 3 VLAN support, etc.)

Field Equipment Impacts: In contrast to the first scenario and subsequent scenarios 3 and 4, DSL-related hardware increases the spatial demands inside each field cabinet. At least four rack units (7.0”H x 19”W max) of space, assuming worst case, would be needed at each field cabinet for this alternative. Less space would be required as ITS components continue to adopt Ethernet interfaces to eliminate the terminal server, and someday perhaps the video encoder.

City Smart Traffic Center Impacts: As with the first scenario, an Ethernet architecture typically reduces the amount of central equipment needed. In this scenario, a network switch at each operations center along with a digital video management/distribution system is the extent of the communication infrastructure impacts at the City’s STCs. Patch panels for Engineering cabling infrastructure is not required, since it relies on using the four fibers within the NNPS/IT backbone cables.

Figure 14
Newport News Signal System Communication Scenario 2

NNPS/IT Fiber Backbone and Transportation Twisted-Pair Distribution

Prepared for: VDOT Virginia Department of Transportation

Prepared by: Kimley-Horn and Associates, Inc.

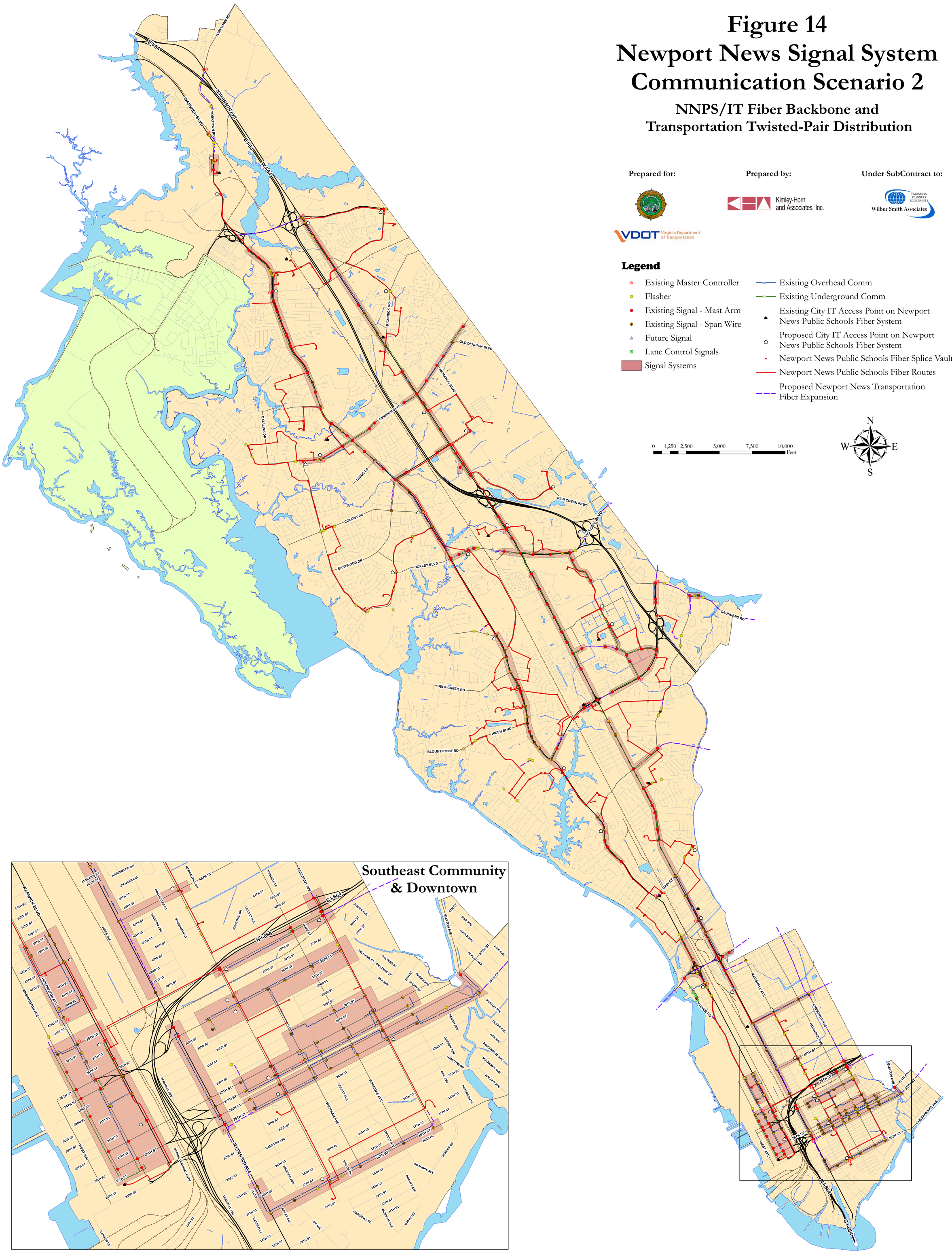
Under SubContract to: Wilbur Smith Associates

Legend

- Existing Master Controller
- Flasher
- Existing Signal - Mast Arm
- Existing Signal - Span Wire
- Future Signal
- Lane Control Signals
- Signal Systems
- Existing Overhead Comm
- Existing Underground Comm
- Existing City IT Access Point on Newport News Public Schools Fiber System
- Proposed City IT Access Point on Newport News Public Schools Fiber System
- Newport News Public Schools Fiber Splice Vaults
- Newport News Public Schools Fiber Routes
- Proposed Newport News Transportation Fiber Expansion

0 1,250 2,500 5,000 7,500 10,000 Feet

N W E S



3.6.4 Scenario #3 –NNPS/IT Fiber Backbone & Proposed Transportation Fiber Distribution

Scenario 3 leverages the use of the four fibers within NNPS/IT fiber cables simply to provide a backbone for connecting both operations centers to the existing field master locations in order to access the existing Department of Engineering's conduits and overhead distribution lines to the remaining signals. Unlike Scenario 2, the twisted-pair distribution is replaced with new Department of Engineering fiber optic distribution cables in Scenario 3. The extent of new fiber cable expansion routes is the same as in Scenario 2.

Figure 15 shows the Newport News ATMS with an overlay of fiber optic routes utilizing existing Department of Engineering communication routes, both overhead and underground, as well as construction of new routes to provide connectivity with the City's two operations centers. Additionally, IT access points are shown on the map where the distribution and backbone cabling systems meet. The construction of the communication upgrades in this scenario involves:

Re-use Existing Engineering conduit for fiber optic cables	27.0 miles
Lash new fiber to overhead twisted-pair messenger cables	17.5 miles
Fiber Expansion on new routes	15.0 miles

The infrastructure for this scenario extends nearly 60 miles to provide contiguous fiber communications with all of the City's traffic signals and flashers. Within Engineering's underground conduits, it is proposed to install microtube innerducts to facilitate installing the new fiber optic cables by blowing them through the existing conduits with forced air.

A Gigabit Ethernet (GigE) switch is required at the City STCs to communicate with the field concentrator cabinets/locations and to distribute video and data to/from the remaining traffic signal cabinets. School flashers are anticipated to be connected to the nearest school in order to gain access to the NNPS/IT backbone. Depending upon each school's location, the amount of fiber strands available may be designated solely for NNPS use.

Under those circumstances, it may be necessary to use a fiber optic splitter technology, such as Passive Optical Network (PON), to gain access from a NNPS branch/spur route to the primary NNPS backbone. Such a method would allow both entities to share a pair of fiber strands on the branch cable, and then split them apart at the nearest splice vault along the primary backbone route.

The evaluation criteria summation for this scenario is as follows:

Network Bandwidth: As with Scenario 1, the available network bandwidth easily exceeds the identified and planned needs for the City's ATMS. Bandwidth is also a measure of the capacity of the physical cabling. The available theoretical

bandwidth along the distribution routes is greatly improved over Scenario 2's twisted-pair infrastructure.

Reliability: Similar to Scenario 1, since the aging twisted-pair infrastructure would be replaced under this scenario, reliability would improve compared with existing operations and Scenario 2. Department of Engineering fiber optic distribution paths could also be shared/exchanged for additional fibers on the NNPS/IT cable routes to improve the reliability of both networks.

Maintainability: Largely the same as Scenario 1 with a positive maintainability situation. However, in contrast to Scenario 1, this scenario reduces the amount of physical cabling that would need to be maintained by Department of Engineering staff.

Open Architecture Support: Identical backbone and distribution architecture to that of Scenario 1 with a high degree of open architecture and equipment that supports standards.

Flexible Distribution vs. Backbone Uses: As with Scenario 1, a fiber-optic infrastructure entirely in use with this scenario is easily capable of handling distribution and backbone applications above and beyond the proposed Gigabit Ethernet architecture. The low demand on fiber resources makes this alternative attractive for distribution and backbone purposes, particularly since resource-sharing fibers are limited.

Network Security: As with Scenario 2, this scenario relies on a resource-shared fiber optic backbone, where network security is dependent on physical security at the access points as well as fiber interconnect centers. Interconnection between/with City IT networks should be limited to only a couple of locations (i.e. operations centers) where physical security is more prevalent.

Scalability/Expandability: The size of the network (GigE) and the use of new Engineering fiber cables for distribution greatly increases the scalability and expandability of this scenario in contrast to Scenario 2. However, due to the reliance on only four NNPS/IT fibers, there is a potential limitation along certain routes. This also has the potential to limit flexibility to share fiber resources with neighboring jurisdictions such as the City of Hampton, York County, and James City County unless passive optical network (PON) splitters are used to increase the capacity of the individual fiber strands.

Interoperability: Same as Scenario 1 with a good track record for demonstrated vendor interoperability.

Field Equipment Impacts: This scenario has the same equipment requirements as Scenario 1. At least three rack units (5.25"H x 19"W max) of space, assuming worst case, would be needed at each field cabinet for this alternative.

City Smart Traffic Center Impacts: Similar to Scenario 2, patch panels for Engineering cabling infrastructure are not required under this scenario, since it relies on using the four fibers within the NNPS/IT backbone cables.

Figure 15
Newport News Signal System Communication Scenario 3

NNPS/IT Fiber Backbone and Transportation Fiber Distribution

Prepared for: VDOT Virginia Department of Transportation

Prepared by: Kimley-Horn and Associates, Inc.

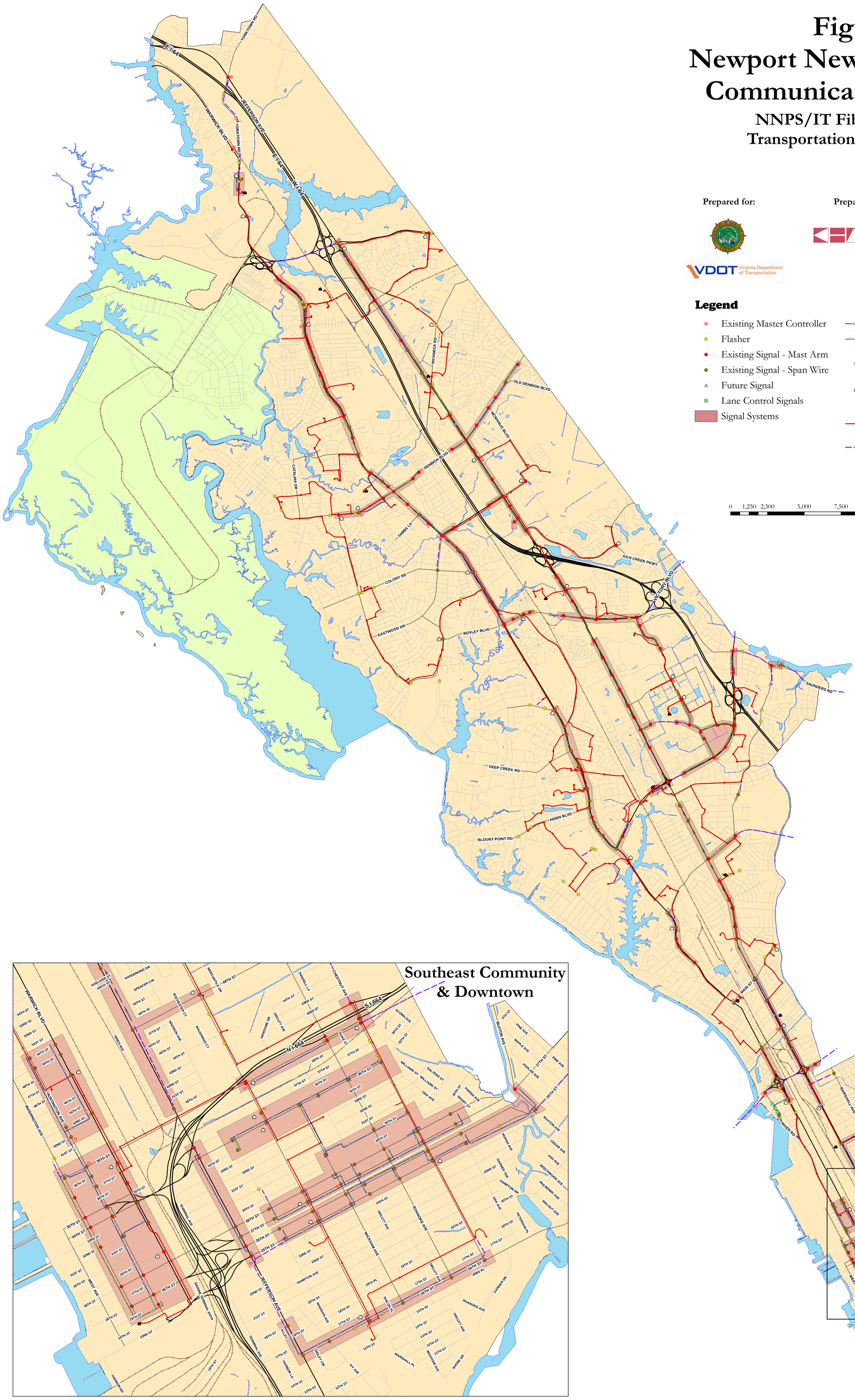
Under SubContract to: Wilbur Smith Associates

Legend

- Existing Master Controller
- Flasher
- Existing Signal - Mast Arm
- Existing Signal - Span Wire
- Future Signal
- Lane Control Signals
- Signal Systems
- Existing Overhead Comm/New Fiber
- Existing Underground Comm/New Fiber
- Existing City IT Access Point on Newport News Public Schools Fiber System
- Proposed City IT Access Point on Newport News Public Schools Fiber System
- Newport News Public Schools Fiber Splice Vaults
- Newport News Public Schools Fiber Routes
- Proposed Newport News Transportation Fiber Expansion

0 1,250 2,500 5,000 7,500 10,000 Feet

N W E S



3.6.5 Scenario #4 –NNPS/IT Fiber Backbone & Minimized Transportation Fiber Distribution

Scenario 4 also leverages the use of the four fibers within NNPS/IT fiber network, simply to provide a backbone for connecting both operations centers. However, to minimize the amount of cabling overlap between NNPS/IT cables and Department of Engineering cables, this scenario involves more access points along the NNPS/IT routes. Scenario 4 results in 110 new access points, which is in contrast to 37 access points in Scenario 3. This increase in access points maximizes direct connections to as many traffic signal locations as possible while minimizing the amount of new Engineering cables deployed. The extent of new fiber cable expansion routes is the same as in Scenarios 2 and 3, but the amount of Engineering's infrastructure routes that are re-used is reduced.

Figure 16 shows the Newport News ATMS with an overlay of fiber optic routes utilizing existing Department of Engineering communication routes, both overhead and underground, as well as construction of new routes to provide connectivity with the City's two operations centers. Additionally, IT access points are shown on the map where the distribution and backbone cabling systems meet. The construction of the communication upgrades in this scenario involves:

Re-use Existing Engineering conduit for fiber optic cables	16.0 miles
Lash new fiber to overhead twisted-pair messenger cables	11.5 miles
Fiber Expansion on new routes	15.0 miles

The infrastructure for this scenario extends nearly 43 miles to provide contiguous fiber communications with all of the City's traffic signals and flashers. Overall, this is a reduction of approximately 17 route miles of Engineering's proposed fiber infrastructure.

Network Bandwidth: As with Scenarios 1 and 3, the available network bandwidth easily exceeds the identified and planned needs for the City's ATMS. The available Department of Engineering fiber cable bandwidth is less than for Scenario 3 since there are fewer route miles and increased reliance on the four NNPS/IT strands.

Reliability: Similar to Scenarios 1 and 3, since the aging twisted-pair infrastructure would be replaced under this scenario, reliability would improve compared with existing operations in Scenario 2. Department of Engineering fiber optic distribution paths could also be shared/exchanged for additional fibers on the NNPS/IT cable routes to improve the reliability of both networks.

Maintainability: Largely the same as Scenarios 1 and 3 with a positive maintainability situation. However, in contrast to Scenarios 1 and 3, this scenario has the least amount of physical cabling that would need to be maintained by Department of Engineering staff.

Open Architecture Support: Identical backbone and distribution architecture to that of Scenario 1 with a high degree of open architecture and equipment that supports standards.

Flexible Distribution vs. Backbone Uses: Splice vaults for accessing the NNPS/IT backbone cables are not always adjacent to Engineering's traffic signal locations. The increased reliance on the NNPS/IT backbone limits this scenarios use for some branch distribution situations. Furthermore, since the NNPS/IT backbone cables are at least 6 feet below grade in most cases, the close spacing of many of the proposed IT access points at traffic signals may be difficult to construct thereby increasing the mileage of Engineering's re-used cable routes.

Network Security: As with Scenarios 2 and 3, this scenario relies on a resource-shared fiber optic backbone, where network security is dependent on physical security at the access points as well as fiber interconnect centers. Interconnection between/with City IT networks should be limited to only a couple of locations (i.e. operations centers) where physical security is more prevalent.

Scalability/Expandability: Similar to Scenario 3, the reliance on only four NNPS/IT fibers is a potential limitation along certain routes. This also has the potential to limit flexibility to share fiber resources with neighboring jurisdictions such as the City of Hampton, York County, and James City County unless passive optical network (PON) splitters are used to increase the capacity of the individual fiber strands.

Interoperability: Same as Scenario 1 with a good track record for demonstrated vendor interoperability.

Field Equipment Impacts: This scenario has the same equipment requirements as Scenario 1. At least three rack units (5.25"H x 19"W max) of space, assuming worst case, would be needed at each field cabinet for this alternative.

City Smart Traffic Center Impacts: Similar to Scenarios 2 and 3, patch panels for Engineering cabling infrastructure are not a factor and relies on using the four fibers within the NNPS/IT backbone cables.

Figure 16
Newport News Signal System Communication Scenario 4

NNPS/IT Fiber Backbone and Minimized Transportation Fiber Distribution

Prepared for:

Prepared by:

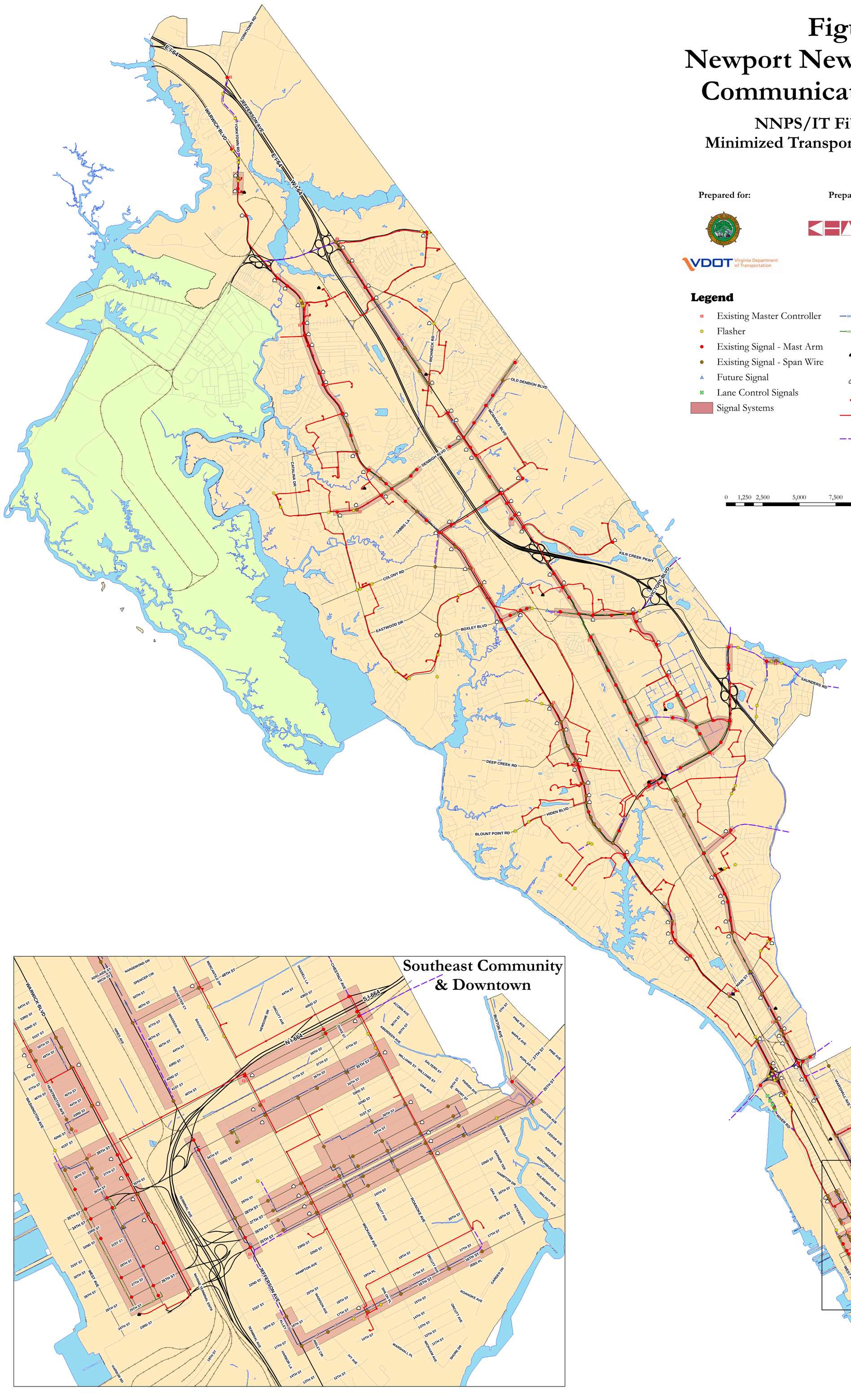
Under SubContract to:

Legend

- Existing Master Controller
- Flasher
- Existing Signal - Mast Arm
- Existing Signal - Span Wire
- Future Signal
- Lane Control Signals
- Signal Systems
- Existing Overhead Comm/New Fiber
- Existing Underground Comm/New Fiber
- Existing City IT Access Point on Newport News Public Schools Fiber System
- Proposed City IT Access Point on Newport News Public Schools Fiber System
- Newport News Public Schools Fiber Splice Vaults
- Newport News Public Schools Fiber Routes
- Proposed Newport News Transportation Fiber Expansion

0 1,250 2,500 5,000 7,500 10,000 Feet

N W E S



3.7 Summary of Communication Alternatives Recommendations

Table 8 ranks the communication alternative scenarios quantitatively by assigning a number score to each attribute based on implications and quality, with 1 representing the worst/lowest and 5 representing the best/highest. As mentioned earlier in this section, the rank/priority values range from 11 to 1, where 11 is the highest priority and 1 is the lowest. The scores for each evaluation criteria are multiplied by the priority, and are summed to give each scenario an overall weighted technical score. The technical score is multiplied by the cost ranking to establish the overall score. The alternative with the highest overall score is deemed the best alternative for the City of Newport News to adopt. For reference purposes, the ranking/priority initially presented in Section 3.6.1 is re-iterated here. Scenario 1 has the highest weighted technical score. However, Scenario 3 has the highest overall score when cost is considered.

Table 8: Comparison of Communication Scenarios

Requirements/Criteria	Scenario 1 – NNDE Fiber		Scenario 2 – NNPS Fiber + NNDE Twisted-Pair		Scenario 3 – NNPS Fiber + NNDE Fiber		Scenario 4 – NNPS Fiber + NNDE Fiber (minimized overlap)		Rank/Priority
	Base Criteria Score	Weighted Score	Base Criteria Score	Weighted Score	Base Criteria Score	Weighted Score	Base Criteria Score	Weighted Score	
Network Bandwidth	5	45	2	18	4	36	3	27	9
Reliability	5	55	2	22	5	55	5	55	11
Maintainability	4	16	3	12	5	20	5	20	4
Open Architecture Support	5	5	3	3	5	5	5	5	1
Flexible Distribution vs. Backbone Uses	5	10	2	4	4	8	3	6	2
Network Security	5	30	4	24	4	24	4	24	6
Scalability/ Expandability	5	50	2	20	4	40	3	30	10
Interoperability	5	25	3	15	5	25	5	25	5
Field Equipment Impacts	5	35	3	21	5	35	5	35	7
City Smart Traffic Center (STC) Implications	3	9	5	15	5	15	5	15	3
Cost Implications	1	8	4	32	2	16	3	24	8
Technical Summation		**288**		**186**		**279**		**266**	
Cost Summary	**$8.7M**	2	**$3.2M**	5	**$5.7M**	4	**$5.2M**	4	
Scoring Sum including Cost	***576***		***930***		***1116***		***1064***		

Table 9 shows the detailed cost comparison for the four communication scenarios, which includes miles of fiber cables and additional communication components, which vary by type and quantity for each scenario. In Scenarios 1, 3, and 4 includes a GigE switch at each traffic signal and flasher location throughout the City. In Scenario 2, GigE switches are located at existing field master locations and key access points for connecting with new branch cables. Additionally, in Scenario 2, two DSL modems and one copper-based Ethernet switch are allocated for field cabinets that remain on the twisted-pair infrastructure in Scenario 2. Network access connection fees are based on input from NNPS/IT for the cost associated with making a new termination point on the resource-sharing backbone. Based on the cost associated with each component, the overall cost for each scenario is as follows:

Table 9: Communication Scenarios Cost Comparison Tabulation

			Scenario 1 - Transportation Fiber		Scenario 2 - NNPS/IT Fiber Backbone/ TransportationTwisted Pair Distr.		Scenario 3 - NNPS/IT Fiber Backbone/ Transportation Fiber Distr.		Scenario 4 - NNPS/IT Fiber Backbone / Minimized Transportation Fiber Distr.	
Item / Description	**Unit Price**	**Unit**	**Fiber Distribution**		**Twisted-Pair/Fiber Distr.**		**Fiber Distribution**		**Fiber Distribution**	
			Quantity	**Subtotal**	**Quantity**	**Subtotal**	**Quantity**	**Subtotal**	**Quantity**	**Subtotal**
Re-use Existing NNTE conduit for fiber	$50,000	Mile	27.0	$1,350,000		$0	27.0	$1,350,000	16.0	$800,000
Lash new fiber to overhead TWP routes	$50,000	Mile	18.0	$900,000		$0	18.0	$900,000	12.0	$600,000
Re-use Existing Twisted Pair distribution	$0	Mile			45.0				-	
Fiber Expansion	$140,000	Mile	38.0	$5,320,000	16.0	$2,240,000	16.0	$2,240,000	16.0	$2,240,000
GigE Switch	$3,500	Each	321	$1,123,500	161	$563,500	321	$1,123,500	321	$1,123,500
DSL Modem	$800	Each	-	$0	256	$204,800	-	$0	-	$0
100Base-T Copper Ethernet Switch	$1,000	Each	-	$0	101	$101,000	-	$0	-	$0
New Network Access Connection Fee	$5,000	Each	-	$0	37	$185,000	37	$185,000	110	$550,000
Total Cost				***$8,693,500***		***$3,294,300***		***$5,798,500***		***$5,313,500***

Communication scenarios have been compared in direct application to the communication needs of the Newport News ATMS and ITS components based upon the existing and planned expansion. Ethernet communication standards are prevalent over fiber optic, wireless, and leased-line media by many vendors providing a great degree of flexibility for the Department of Engineering to use multiple communication media for distribution to ATMS/ITS field devices. While the Engineering-owned fiber scenario (Scenario 1) is equal to Scenario 3 for the highest/best overall score, the cost of such a deployment cannot be overlooked.

Reliability, maintainability, open architecture support, interoperability, field equipment impacts, and City Smart Traffic Center (STC) implications are excellent for Scenario 3. Network bandwidth, flexible distribution/backbone uses, scalability, and network security are not the highest for Scenario 3. However, they are still attractive, and when offset by nearly $3 Million in cost savings compared to Scenario 1, becomes an acceptable trade-off.

The availability of the NNPS/IT fiber backbone infrastructure provides a high degree of reliability improvements without requiring Engineering to deploy new cables along several challenging bridge, rail, and interstate crossings. The cost for Scenario 3 is slightly higher than Scenario 4. However, the increase in cost provides greater flexibility for device expansion and deploying separate/parallel communication technologies for field distribution. For these reasons, ***Scenario 3 is recommended for the Newport News ATMS and ITS communications network.***

4.0 Regional System Analysis

In Newport News, as with all localities in the region, much of the traffic within its borders is determined by the regional transportation network and regional trip-demand patterns. Therefore, Newport News cannot effectively manage traffic on its roads without considering its place in the regional context. This section outlines the agencies Newport News needs to share information with, the type and nature of the data (particularly for traveler information purposes), and how ATMS fits into the larger regional context to achieve interconnectivity and develop a cooperative system. Some sections of text are italicized to emphasize key points or conclusions.

4.1 Integration with Other Centers

According to the 2004 Hampton Roads ITS Strategic Plan, one of the region's top priorities is to become "one interconnected region," which in part means a transportation system that seamlessly operates across jurisdictional boundaries. This involves a measure of transparency when it comes to sharing critical transportation-related information with multiple agencies and jurisdictions.

While each municipality in the Hampton Roads area manages traffic along the local street network, the VDOT Hampton Roads Smart Traffic Center (HRSTC) is the nerve center for transportation operations in the region. However, the HRSTC cannot effectively manage traffic on regional roadways without the aid of the local agencies that make up the region.

4.1.1 Arterial Traffic Signal Coordination

The Newport News arterial street system adjoins the City of Hampton, which recently upgraded their ATMS in 2004, York County, whose signal system is managed by VDOT, and James City County. The most important need of neighboring signal systems is to provide adequate traffic signal coordination across their boundary lines to improve traffic flow and reduce unnecessary delays. This of course, is a common issue and different agencies have developed solutions to this problem. In a national survey of cross-jurisdictional signal coordination agreements[1], success in this task requires:

- common cycle times
- timing plans with proper offsets references
- common time base (clocks must be synchronized to each other or a common reference)

These criteria are typically met through inter-agency agreements and not through the integration of software. Interagency agreements can be written to standardize a cycle time and produce timing plans with offsets that provide coordination over jurisdictional boundaries. They can take the form of a memorandum of understanding or a more formal agreement developed by legal staff. Most agencies control their own signals and timing plans and do not share control due to liability concerns, the difficulties integrating across different software and hardware systems and communications platforms, and the challenge of developing agreeable terms for allowing other agencies to change signal timings. *The independence of*

jurisdictions to use advanced technologies such as traffic-responsive plan selection can cause one agency's timing plans to change and be out of synchronization with the other, particular if the other system is running a time of day plan. In such a case, care must be taken to minimize cross-boundary incompatibilities through the selection of switching thresholds.

Coordination requires synchronized clocks to ensure offsets do not drift over time. Older signal systems required different jurisdictions to provide coordination across boundaries through a hardwired interconnect cable with a lead agency providing a timing synchronization pulse over the cable. Modern traffic signal systems, however, have WWV clocks or can dial into WWV clocks. WWV is the radio call sign for the National Institute of Standards and Technology (NIST) shortwave station in Fort Collins, Colorado. The primary mission of station WWV is to distribute official time signals derived from atomic clocks. NIST radio station WWV broadcasts report time and frequency information 24 hours per day, 7 days per week to millions of listeners worldwide. *This common time base eliminates the need for any physical interconnection between systems or controllers for time coordination across jurisdictional boundaries*. However, each jurisdiction must manually coordinate and implement timing plan changes using the same parameters, when an incident, event, or new traffic patterns warrant the changes.

4.1.2 Interstate/Freeway Management Coordination

In addition to cross-jurisdictional arterial networks, two important regional freeways managed by VDOT (Interstate I-64 and I-664) pass through Newport News. When incidents occur on either facility on the Peninsula, it is common for drivers to use Newport News' arterials as alternate routes. Based on the Regional ITS Architecture, the HRSTC is the designated information clearinghouse for regional incident data. In order for VDOT's HRSTC to satisfy this responsibility for the region, as Newport News expands its ATMS capabilities, VDOT will need access to the following capabilities/ information:

- The ability to select and view Newport News' cameras. This feature will help confirm and track arterial incidents at or near interstate interchanges, as well as to evaluate alternate route (interstate diversion routes) conditions for use in incident management strategies for freeway incidents.
- The ability to operationally control (i.e. pan-tilt-zoom) Newport News' cameras at any time, including evenings and weekends.
- Notification of local construction, lane closures, and planned special event schedules to supplement 511 and other traveler information services.
- Notification of local detours (traffic or weather/flood related) and work zones impacting standard traffic patterns.

At present, based upon the current 511 system architecture, it is envisioned that the HRSTC will filter the information provided by the City and process it for inclusion into the 511 database. Under an incident scenario involving either the City's arterials or VDOT freeways, the 511 system could be enhanced to provide motorists with roadway conditions on alternate routes based upon the available

information/video obtained from the City. Should the City expand into longer hours of operation, it may be necessary and/or desirable to have the ability for City staff to directly enter local incident information into VDOT's 511 system.

Similarly, in accordance with the Concept of Operations developed with the ATMS Feasibility Study phase of this project, the Newport News Department of Engineering will act as the City's gateway for disseminating regional transportation information to other City departments. In order to satisfy this role for the City, the Newport News Department of Engineering needs the following capabilities/information from the VDOT HRSTC:

- The ability to select and view VDOT's freeway cameras
- The ability to select and view adjacent jurisdictions' cameras, which are shared with VDOT
- Notification of freeway incidents on interstate sections in and adjacent to the City
- Notification of arterial incidents within other regional jurisdictions (particularly on the Peninsula)
- Notification of freeway and other regional jurisdictional construction schedules, maintenance schedules, special event schedules, bridge openings, and bridge and tunnel repairs (particularly on the Peninsula)

With the provided information from VDOT, the Newport News Department of Engineering would distribute incident/event/construction data to other City departments including the Police, Fire and Rescue, Office of Emergency Management, Public Schools Transportation, and Public Works and the Engineering Department Mapping/GIS Division. This is in accordance with the VDOT Hampton Roads Regional ITS Architecture, which was last updated during the development of the 2004 Hampton Roads ITS Strategic Plan[2]. Under an incident scenario involving either the City's arterials or VDOT freeways, the 511 system could be enhanced to provide motorists with roadway conditions on alternate routes based upon the available information and video obtained from the City.

4.2 Traveler Information Systems

With Newport News' ATMS, the City will have the capability to begin providing traveler information services for construction area, special City events and traffic related incidents on its major arterial streets. This expansion of its traditional traffic management functions represents a shift toward a more active traffic management center, receiving and disseminating traffic-related information on a daily and sometimes real-time basis.

Nationally, it is common for arterial traffic management systems to provide traveler information via various media. According to the ITS deployment tracking database,[3] the most prevalent media employed by arterial traffic management centers are shown in **Table 10** below.

Table 10: Traveler Information – Type of Media Usage by Agencies

Traveler Information Medium	Number of Agencies Using this Medium (106 agencies reporting)	
Internet Web Sites	92	87%
Email	70	66%
Facsimile	66	62%
Dedicated Cable TV	62	58%
511 or Other Automated Telephone System	59	56%
Pagers or PDAs	34	32%
Kiosks	29	27%
Interactive TV	14	13%
In-vehicle Navigation Systems	3	3%

While it is recognized Newport News utilizes traditional means such as e-mail facsimiles to respond to citizen requests, it is not recommended at this time that Newport News target for priority of email, dedicated Cable TV or pagers to disseminate traveler information. It would be more advantageous for the City to feed information to the VDOT statewide Virginia Operational Information System (VOIS)/511 system. The existing 511 system is a phone system as well as an Internet site for traveler information. The www.511virginia.org website provides travelers with information regarding construction and incidents on state roads. *As part of the Newport News signal system upgrade, it is recommended that protocols and/or training be put in place so that incidents identified by City of Newport News staff can be reported/transmitted to the VDOT Hampton Roads STC staff for upload into the VOIS and 511 databases.*

It is most important, however, that Newport News make its camera views and other traveler information available to the media as the vast majority of travelers use mainstream broadcast radio and television for their traveler information. Based on a survey of travelers in the Seattle metropolitan area, four out of five travelers have used radio traffic reports and three out of five travelers have used television traffic reports.[4] The survey found that less than half of all travelers were even aware of web-based traveler information, let alone use it, even though the traffic congestion in Seattle is as bad as any in the country and the web-based traveler information as good as any in the country.

In summary, Newport News should disseminate traveler information via the following media:

- Virginia 511 telephone system
- Portable variable message signs

According to the same ITS deployment tracking source, the most prevalent types of information disseminated by arterial traffic management centers are identified in **Table 11** below.

Table 11: Traveler Information – Type of Information Delivered by Agencies

Type of Traveler Information	Number of Agencies Distributing this Type of Information (106 agencies reporting)	
Road Closures	92	87%
Work Zone / Construction Events	91	86%
Detours	85	80%
Special Events	77	73%
Road Restrictions	64	60%
Alternate Routes	62	58%
Incident Information	59	56%
CCTV Images	47	44%
Road Surface Conditions	47	44%
Real-time Construction Information	36	34%
Weather	33	31%
Congestion	32	30%
Travel and Tourist Information	27	25%
Parking	21	20%
Arterial Travel Times	13	12%
Arterial Travel Speeds	12	11%

It should be noted that this data represents agencies of all sizes and some may have more resources than Newport News Department of Engineering to deploy more advanced services. Nonetheless, there is a definite tendency toward more static, non-real-time information as most arterial traffic management systems do not have staffing or resources to track and disseminate accurate and timely real-time information. This is true for Newport News as well. Therefore, based on the size and characteristics of Newport News, it is recommended that the City focus on disseminating:

- Road/lane closures, construction information and other road restrictions
- Corresponding detours and alternate routes
- CCTV images

4.3 Integration Priorities, Policies, and Considerations

In the previous subsections, various aspects pertaining to the type of information to be shared with neighboring agencies and other City Departments have been presented. Additionally, statistical data has been cited that provides the basis for establishing priorities and policies for implementing regional integration and data sharing initiatives. This section provides integration priorities, 511 system considerations, and CCTV camera initiatives recommended for implementation in the development of an updated ATMS for the Newport News Department of Engineering.

4.3.1 Integration Priorities

The highest integration priority for the City of Newport News is to *make camera images available* for broadcast to as large an audience as possible. Camera images are the most versatile form of traffic information, and are useful for traveler information, incident detection and verification, evacuations, flood monitoring and verification, and security. Camera images would be shared through integration with the VDOT HRSTC and potentially the VDOT's Statewide Video Distribution System (SVDS). The SVDS is an on-call contract administered by VDOT, and Trafficland is their current contractor. The public and the mass broadcast media would be able to access the camera images from these sources. *Given that Trafficland is a private company, distributing free information to a profit making entity will require a policy decision from the City of Newport News prior to implementation.*

The next highest priority is to establish procedures to *regularly update VOIS/511 with planned construction and road closure information*. This provides advance warning to travelers so they can better plan their trips. This information is recommended to be limited to planned events, which is kept current with all major events, and where outdated information is removed promptly will provide a valuable service to the public. Methods for automating and/or streamlining the data entry process are discussed further in Section 4.3.2.

The third highest priority is to *integrate the Newport News computer aided dispatch (CAD) system with the HRSTC*. This would help the HRSTC to better monitor incidents on Newport News' roadways and make the VOIS and 511 incident logs more comprehensive. It would also better alert Newport News traffic engineering staff of incidents that may warrant timing plan changes along major City arterials. In addition, it could also be used as a performance tool to evaluate the ability/sensitivity of proposed traffic responsive timing plan selections.

4.3.2 VDOT's 511 System

The existing incident information in the VOIS and 511 databases could be augmented by an integration effort with the local Newport News Departments of Police, Fire and Emergency Management computer-aided-dispatch (CAD) system. Currently, incidents from the Virginia State Police (VSP) CAD are automatically fed to each STC in the state. In addition, the design is in place for the Northern Virginia STC to integrate with the Fairfax County CAD system when its software

platform is upgraded within the next few years. It is envisioned that, similar to the current manual filtering process by STC staff for VSP incidents, the Newport News CAD data would be filtered by HRSTC staff prior to populating the VOIS database for subsequent inclusion into the 511 database. VDOT currently performs automated filtering based upon VSP "10 codes," which are used to quickly distinguish for example between freeway incidents versus robberies, domestic incidents, and other issues that typically do not affect transportation networks. A similar integration is envisioned to reduce the amount of manual filtering necessary to supply useful information to 511 and the traveling public. Integrating the Newport News CAD with the HRSTC will require a design that is dependent upon the capabilities of the two respective (CAD and VOIS/511) software systems and will also require a management policy subject to final review by the affected departments.

As the VOIS system is accessible to VDOT agencies only, the City of Newport News also needs to be able to feed traffic-related information to the HRSTC to enter into the VOIS/511 systems. Within the prescribed data entry guidelines, the City should determine what events on its arterial roads should be made available to the public via this medium. An interface that allows Newport News to send VDOT database entries for HRSTC operators to enter into the VOIS system with minimal modification would be desirable for both agencies. This interface with VOIS need not be integrated with the traffic signal system software, but it must not require a stand-alone workstation.

As stated previously, it is envisioned that the Engineering Department's Transportation Division will be the distributor of incident/event/construction information to other City departments. It is important to note, however, that signal system software packages do not feature incident tracking, incident logging and construction schedule tracking capabilities. As a result, Newport News could require vendors to add this feature as part of its procurement or the City could seek other solutions to meet this need. As the HRSTC will be the manager of real-time information, *this could take the form of a viewer application. Planned construction events could be tracked on browser-based calendaring application hosted by a third party developer/provider.*

The most significant issue with Newport News contributing additional local traffic data into the VOIS and 511 systems—both from the CAD and planned construction events provided by Newport News Engineering staff—is institutional in nature. While the HRSTC is best equipped to manage real-time incidents given its mission, staffing and hours of operation, the addition of information on Newport News' local roads could be taxing to operators. After the VSP CAD was integrated into the Richmond STC, the number of incidents being managed by STC operators doubled. While such a jump is unlikely in this case, clear expectations need to be set with respect to which roads are given priority to ensure HRSTC operators adequately track incidents Newport News' local roads. The fact that 511 does not span beyond certain major routes mitigates this issue somewhat, but the additional workload on HRSTC staff could still be significant.

4.3.3 CCTV

Similar to incident and construction data, the public would be best served by a central repository for CCTV images. Currently, the SVDS provider handles statewide video distribution for VDOT. The interface with the SVDS currently goes through the HRSTC. There are currently VDOT policies in place regarding when images are not appropriate for public viewing (e.g., graphic images from severe accidents), which should not need to be replicated for every local agency providing camera images. At the same time, this would enable the public to get all its camera views from one source. While this is a regional understanding of VDOT's operating policy for video distribution, local agency participation is by no means mandatory. An additional avenue for video distribution is via local cable television channels. The City's Video Production presently uses Cable Channel 48. City staff have discussed the potential of using a second channel for local traffic condition reports as well as displaying live traffic camera feeds.

The Newport News traffic management center at City Hall can currently view VDOT's camera images in real-time on an HRSTC workstation and a wall monitor that can access four (4) of VDOT's camera images simultaneously via the two VDOT-provided encoder/decoder pairs and a video quad-plexer. The workstation is literally a remote extension of VDOT's HRSTC Ethernet network that provides access to VDOT's graphical interface software, which allows video selection and camera control (when VDOT does not need the camera for incident management). The addition of the City's own camera images on its own network presents some integration challenges for merging the two sets of images together for display at the City, as well as sending images to VDOT.

There is an existing microwave connection to VDOT's network between Newport News City Hall and the HRSTC via a VDOT tower site in Newport News, which is connected to the VDOT fiber backbone. This is recommended to be upgraded to a fiber connection, but it is currently a one-way connection with information/video images being sent from VDOT to the City. Through the remote workstation the City has the ability to identify what cameras they wish to display on their video wall monitors at City Hall. The microwave link and fiber optic extension is currently configured for 100Mbps capacity, but only two video encoder/decoder pairs are assigned to the City for simultaneous access to two video streams from VDOT.

In order for Newport News to send its camera images for viewing in real-time to the HRSTC, a segmented two-way connection is needed. The existing network link between the two agencies has the capacity to handle approximately 20 video streams simultaneously. The biggest design issue, however, is in routing data between two closed IT networks without violating each other's network security policies. Segmenting the network connection between VDOT and the City into two pieces maintains the separation of the two closed IT networks, while still allowing both sending and receiving information between each other and applying agency-appropriate IT security policies. This would allow VDOT to have access to select and view the City's traffic cameras in a similar manner to that currently being administered by the City to access VDOT's cameras from their network.

In addition, VDOT also needs to be able to control cameras to verify, monitor and track incidents when the Newport News Traffic Operation STC is not staffed, which is currently between 5 p.m. and 8 a.m. during the week and all the time on weekends. Newport News' Engineering staff needs the capability to take over control of its cameras at any time, however. The technical and institutional details of this arrangement will have to be worked out and clearly listed in a written document (i.e. memorandum of understanding).

Newport News also needs viewing access to the City of Hampton's video and vice versa to maximize operation during normal and incident conditions along critical corridors, though these will likely be routed through the HRSTC, in the long term, in accordance with the regional architecture.

4.4 Summary of Regional Systems Analysis

Within this report, regional systems are analyzed for integration with others centers, traveler information systems, and considerations for traffic management system and software integration. Recommendations are made for these three areas along with policy/priority considerations for integration efforts. The following is a summary of the recommendations for each of the three areas listed in order of priority of the recommended implementation.

4.4.1 Integration with Other Centers

Coordination with Adjacent Arterial Traffic Signal Systems

Continue to deploy traffic signals with a common time based on WWV clocks. This common time base eliminates the need for any interconnection between systems or controllers for time coordination across jurisdictional boundaries. However, each jurisdiction must manually coordinate and implement timing plan changes using the same parameters, when an incident, event, or new traffic patterns warrant the changes. If both agencies have a mutual desire to allow one another the ability to change timing plans based upon pre-determined conditions, interconnection will be necessary along with an appropriate memorandum of understanding.

Coordination with Freeway Management and Regional Information Sharing

Based on the Regional ITS Architecture, the HRSTC is the designated information clearinghouse for regional incident data. In order to satisfy this role for the region, as Newport News expands its ATMS capabilities, *VDOT will need* access to the following capabilities/information:

- The ability to select and view Newport News' cameras. This feature will help confirm and track arterial incidents, as well as to evaluate alternate route (interstate diversion routes) conditions for use in incident management strategies for freeway incidents.
- The ability to fully control (i.e. pan-tilt-zoom) Newport News' cameras on evenings and weekends when the City can release control.
- Notification of local construction, lane closures, and planned special event schedules to supplement 511 and other traveler information services.

- Notification of local detours (traffic or weather/flood related).

The Newport News Transportation Division will act as the City's gateway for disseminating information to other departments. In order to satisfy this role for the City, *Newport News Department of Engineering needs* the following capabilities/ information from the VDOT HRSTC:

- The ability to select and view VDOT's freeway cameras
- The ability to select and view adjacent jurisdictions' cameras, which are shared with VDOT
- Notification of freeway incidents on interstate sections adjacent to the City
- Notification of arterial incidents within other regional jurisdictions (particularly on the Peninsula)
- Notification of freeway and other regional jurisdictional construction schedules, maintenance schedules, special event schedules, bridge openings, and bridge and tunnel repairs (particularly on the Peninsula)

With the regionally significant information provided from VDOT, the Newport News Department of Engineering would distribute incident/event/construction data to other City departments including the Mapping Division, Police, Fire and Rescue, Office of Emergency Management, Public Schools Transportation, and Public Works.

Likewise, the VDOT VOIS/511 system would be able to provide motorists with additional roadway conditions on alternate routes based upon the available information and video obtained from the City.

4.4.2 Traveler Information

Traveler Information Systems- Media

It is not recommended at this time that Newport News pursue email, dedicated cable TV or pagers to disseminate traveler information. Newport News should disseminate traveler information via Internet web sites, VDOT's VOIS/511 system, and variable message signs. The City of Newport News should make the integration with the VDOT VOIS/511 system a top priority, as part of a broader region wide traveler information system. As part of the Newport News signal system upgrade, it is recommended that protocols and/or training be put in place so that incidents identified by City of Newport News staff can be more easily reported/transmitted to the VDOT Hampton Roads STC staff for upload into the VOIS and 511 databases.

Traveler Information Systems- "Information"

It is recommended that the City of Newport News focus on disseminating the following traveler information:

- CCTV images
- Road/lane closures, construction information and other road restrictions
- Corresponding detours and alternate routes

4.4.3 Integration Priorities

The highest integration priority is to make camera images available to as broad an audience as possible, including external agencies and the traveling public. It is recommended that this be established through integration with the HRSTC to allow distribution through the VDOT Statewide Video Distribution System (SVDS) contract (i.e. Trafficland is the current contractor). The public and the mass broadcast media would be able to access the camera images from these sources. The second priority is to establish procedures to regularly update VOIS/511 with planned construction and road closure information.

Finally, the City should integrate the Newport News computer aided dispatch (CAD) system with the HRSTC. This would help the HRSTC to better monitor incidents on Newport News' roadways and make the VOIS and 511 incident logs more comprehensive. An integration effort similar to that used for accessing Virginia State Police CAD information is envisioned to reduce the amount of manual filtering necessary to supply useful information to 511 and the traveling public. Integrating the Newport News CAD with the HRSTC will require a design that is dependent upon the capabilities of the two respective (CAD and VOIS/511) software systems.

The Newport News Department of Engineering will be the distributor of incident/ event/construction information to other City departments. As the HRSTC will be the manager of real-time information, this could take the form of a viewer. Planned construction events could be tracked on browser-based calendaring application hosted by a third party developer/provider.

CCTV Video Integration

Once the City begins deploying its own traffic surveillance cameras it is recommended that the existing network connection with VDOT be upgraded. The existing microwave connection to VDOT's HRSTC is currently configured as an extension of the HRSTC local area network with a remote workstation. Since the plan for ATMS communications involve an IP-based Ethernet infrastructure, a segmented network concept will need to be established in order to keep both agencies' networks separated from one another, while still achieving the desired information and video sharing. It is recommended that a transition to a fiber optic interconnect be pursued within the design of the signal system upgrades at either the south end of the City to the VDOT I-664/23rd Street hub building, or to the north via access to resource sharing fibers at the J.Clyde Morris VDOT variable message sign, which connects to the Ft. Eustis VDOT hub building. Both agencies will need to continue to have the ability to select and view each other's cameras along with from surrounding municipalities connected to the VDOT Hampton Roads Smart Traffic Center. This resource sharing will provide VDOT with the ability to control cameras to verify, monitor and track incidents when the Newport News traffic management center is not staffed, which is currently between 5 p.m. and 8 a.m. during the week and all the time on weekends.

[1] Timbrook, P., Trombly, J., and A. Gupta, Cross-Jurisdictional Signal Coordination Case Studies – Final Report, ITS Joint Program Office, U.S. Department of Transportation, Washington, D.C., February 2002. http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE/13613.html

[2] PB Farradyne, Inc., Hampton Roads Intelligent Transportation Systems Strategic Plan 2004. http://www.hrpdc.org/transport/reports/HR%20Strategic%20Plan%202004.pdf, prepared for VDOT and the Hampton Roads PDC

[3] ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/, ITS Joint Program Office, U.S. Department of Transportation, Washington, D.C., 2004.

[4] Peirce, S. and J. Lappin, "Why don't more people use advanced traveler information? Evidence from the Seattle area," Presented at the 83rd Annual Meeting of the Transportation Research Board, National Research Council, Washington, D.C., January 2005.

5.0 User Benefits and System Costs

It is understood that a coordinated signal system provides a benefit to the traffic network. Some of the benefits are recognized by the individual drivers and others by the personnel in charge of maintaining the transportation system. Some benefits are more easily quantifiable than others. The purpose of this section is to estimate several of the anticipated benefits that are quantifiable and have monetary value to either drivers or traffic managers. Benefits from system features identified by the steering committee are also included in this discussion.

To perform the benefits analysis, a matrix of potential system benefits related to the upgrade of the existing communications system was first developed. Review of signal system technologies and discussions with City of Newport News Engineering staff revealed three categories of benefits, which would be realized, with the upgrade of a copper-based signal system to fiber optic cable. These benefits categories include:

- Increased communications system reliability;
- Increased system coverage benefits; and
- System feature enhancements.

Table 12 shows the system benefits matrix used in this analysis. The specific benefits are quantified in terms of time savings for trips, savings for reducing fuel consumption, and savings for reducing emissions.

Table 12: Benefits Model Matrix

Category	Result	Benefit
Increased Reliability	Decreased System Outage Time	Decreased Driver Delay
		Decreased Vehicle Emissions
		Decreased Fuel Consumption
		Decreased Accident Occurrence
	Decreased Service Calls	Decreased Maintenance Costs
Increased Coverage	Increased Corridor Lengths, New Corridors, and Dynamic Corridor Assignment based on time-of-day	Decreased Driver Delay
		Decreased Vehicle Emissions
		Decreased Fuel Consumption
		Decreased Accident Occurrence
Enhanced Features	High-speed Remote Access to Signal Controllers	Decreased Labor Costs
	Visual Condition Monitoring	Decreased Labor Cost
		Increased Incident Response Effectiveness
		Decreased Driver Delay
	Road Condition Notification Systems (Congestion, Flood Warning, Overheight Vehicle, Icy Bridge, etc.)	Decreased Accident Occurrence
		Decreased Vehicle Emissions
		Decreased Fuel Consumption
		Decreased Driver Delay

5.1 Benefits Due to Increased System Reliability and Increased Coverage

The current copper-based traffic signal system regularly experiences communications failures due to modem and controller failures, electromagnetic interference, and interconnect failures. To determine the magnitude of system reliability benefits that could be achieved through replacement of the current system with a fiber-optic communications network, the frequency of communications failures was analyzed based on data provided by Newport News Engineering staff. The resulting benefits are categorized into time savings and maintenance savings.

5.1.1 Operational Efficiency and Time Savings

During normal operation, a corridor that is part of a coordinated signal system typically experiences a 15% increase in operational efficiency or a 15% decrease in average travel time experienced by vehicles passing along the corridor. Therefore, during the time that a signal is not operating as part of the signal system, vehicles passing along the corridor typically experience 15% increase in travel time which translates into greater delay, increased fuel consumption, increased vehicle emissions, and increased accident occurrence due to more vehicle stops.

5.1.2 System Maintenance Savings Analysis

In addition to reductions in travel times due to decreased system failures, a corresponding reduction in service calls will be experienced with a new system. Based on data supplied by Newport News Engineering, the average field service call for communications failures takes four hours, at an assumed cost of $65 per hour for technician time and service vehicle operation costs. Over the past three years, there has been an average of 40 service calls for communication malfunctions per year. This equates to an annual cost of **$10,400** for communication failure service calls.

Additionally, the availability of spare parts has become problematic due to lack of vendor support and diminishing suppliers for the types of communication modems currently in use. Newport News technicians have been forced to troubleshoot and repair controllers and modems in-house rather than obtaining spares or outsourcing repairs through vendor contracts. Over the past three years, there has been an average of 25 devices (10%) requiring in-house repairs annually, each averaging 8 hours including system board diagnostics, acquiring replacement resistors/chips /components, and testing. This equates to an annual cost of $**13,000** for equipment repairs.

With the implementation of a fiber optic communication network, it is assumed that the failure rate is negligible. Based on manufacturer specification and field experience, the occurrence of failures in fiber optic communications systems due to component failure or due to component damage due to lightning strikes is quite low. The expected life of fiber optic communications cable is between 30 and 50 years and some believe, beyond. Since the medium has been in widespread use for less than two decades, a more precise service life is not available. The stated mean time between failures for fiber optic transceivers is greater than 100,000 hours (11.4 years). Taking this mean and computing an expected failure rate of fiber optic transceivers/switches in the first year using a Poisson distribution yields an expected number of failed devices in the first year of 0.06, effectively zero. Because the fiber optic cable is a dielectric medium, environmental events such as lightning storms are not expected to bring electric transients and power surges, which may ordinarily damage copper/twisted-pair communications equipment in the cabinet.

5.2 Benefits from Enhanced Systems Features

The last source of benefits from the construction of a new signal system would be realized through the inclusion of system feature enhancements such as the increased system monitoring, visual condition monitoring, and road condition notification systems.

System Monitoring enhancements come as a result of the features that are widely available on current controllers and system software packages. These enhancements include advanced reporting (i.e. loop/detector failures, max recall, loss of communications, etc.). Under the current system, when detectors for actuated signal control fail, many times the failure goes un-noticed until reported by motorists, public safety or others typically in off-hours. System reporting enhancements allow maintenance staff to develop pro-active repair strategies. For example, an intersection with 20,000 vehicles per day (vpd) on both corridors, not repairing a detector in a timely manner can result in motorist travel delay, increase fuel consumption/emissions. Aggregate delay for this situation can be nearly 300 hours per week (or roughly 1% of the traffic volume), which equates to nearly $4,200 per week per intersection with a failed detector. With 20 detectors on average having failed, and not repaired within a week, the travel time savings that can result from proactive maintenance capabilities would be approximately **$84,000** annually.

Additionally, communication speed with signal controllers is a gauge of the system's and staff's ability to update timing information and perform queries of controllers. The current system is limited by 300 bps communication channels and dial-up connections to on-street field masters. High-speed remote access would reduce the amount of field labor costs in a manner similar to the reduction in service calls due to increases in communications reliability. For the most part, these benefits would not be recognized solely with the upgrade of the copper communication cable to fiber optic.

It is not until the new signal system is operational with new equipment and technologies that fully utilize the fiber optic communication network that these benefits can be quantified. As such, they are excluded from this benefits analysis. However, the qualitative aspect of this upgrade cannot be denied. Without system upgrades, reliability and operational efficiency will continue to decrease, while time to repair components and restore normal operations will continue to increase.

ITS benefits are associated with two key aspects: gathering useful data (i.e. traffic congestion, incident verification, equipment malfunction), and efficient dissemination of that data.

Condition monitoring systems such as CCTV and system detectors, provide a measurable benefit to the motoring public, operations staff, as well as public safety workers. The ability to monitor VDOT system detectors (at key Interstate interchanges), as well as those that are deployed by Newport News, allows City staff to more quickly respond to changing traffic patterns with alternate timing plans downloaded to field controllers using high-speed communications, noted

previously. Based on an average 30 minute corridor delay, affecting 2,000 motorists in the peak period approximately 20 times per year, implementing traffic-responsive operations would yield annual time savings of 20,000 hours. Travel time has a value of approximately $14 per person-hour, which results in an annual time savings value of approximately **$280,000** to the motoring public. With typical arterial camera costs approximating $60,000 per location, this results in a benefit/cost ratio of approximately 4.66:1.

Similarly, the quicker an incident can be responded to and cleared, the less delay that is experienced by motorists. CCTV and DMS play key roles in establishing this benefit for the public and for public safety. CCTV can be used to visually verify incidents that are reported through 911 or other means. CCTV in the vicinity of the corridor can assist public safety dispatchers to make educated/informed decisions about what resources (i.e. fire, ambulance, tow-trucks) to send to the scene. DMS allow City Engineering staff and VDOT staff to disseminate this information to motorists in advance of the scene.

Condition notification systems: The ability to alert motorists to divert before entering a congested/incident area, or Interstate section. Plans for deploying several VDOT arterial DMS signs in the City of Newport News will support the initiative of notifying motorists of Interstate conditions/incidents along alternate routes such as Jefferson Avenue. For example, currently many motorists heading to I-64 from Jefferson Avenue via J.Clyde Morris or Oyster Point Rd. are not notified of congestion/incidents on the Interstate until they have reached I-64. DMS planned along Jefferson Avenue will notify motorists prior to committing to these routes and further reduce motorist travel time delays. Based on similar statistics, an average 45 minute delay affecting 2500 motorists in the peak period approximately 12 times per year (once a month), an annual time savings value of **$315,000** can be attributed to advanced motorist notification and condition monitoring. This savings is not indicative of system-wide savings, but overall savings can be expected to be higher when applied across the entire City of Newport News.

Other condition notification systems have been identified for viable use in the City of Newport News. These systems include, but are not limited to, Icy Bridge Warning Delineators, Flood Warning systems, and Over-height Vehicle Warning systems. The primary goals for these three systems are accident prevention, motorist safety, and infrastructure protection.

Conventional “Icy Bridge” condition static signs are commonly taken for granted by many motorists. By the time they realize the conditions actually exist, it is too late. When these situations occur, it usually results in a multi-vehicle incident as one or more vehicles lose control and fold others into the incident. Even with a two-vehicle incident involving property damage only (PDO), the cost of repairs to the vehicles can range from $15,000 to $25,000. With the average cost to place advanced warning delineators on both approaches to a bridge costing no more than $2,000 per bridge, merely preventing one accident per year can result in approximately a 10:1 benefit/cost ratio.

Similarly, over-height vehicle operators may overlook static warning signs and either graze, or potentially ram into, low-clearance bridges in the City. Active warning systems that monitor actual vehicle heights and alert the vehicle in question have been found to be far more effective at reducing bridge collisions. The damage severity can vary dramatically, and increases with each subsequent impact until it ultimately results in a bridge replacement. However, using a conservative estimate for the initial impact, approximately $150,000 per incident can be anticipated with only one occurrence. The cost to instrument a minimum of three approaches for each bridge is approximately $180,000. This results in a benefit/cost ratio of approximately 1:1.2.

Flood warning systems are comprised of elements used to monitor for flooding conditions, notify staff, and provide a means for closing a road with gates. There are three locations that have been identified within the City that can benefit from these systems. Flooding conditions do not occur frequently, but when they do the impact on operations staff to mobilize and manually close the road during inclement conditions can be challenging and in some cases unsafe. Therefore, the benefit of these systems is not limited to accident or stranded-motorist avoidance savings, but also to staff safety and labor savings. A typical flood warning system is approximately $45,000 per location. Annual labor cost for a single flood event at one location would be approximately 16 hours including setup and tear-down of the closure and the detour signage, based on two staff members to implement. Providing automated/remotely-controlled warning systems would result in a labor savings of approximately $1,000 annually. When coupled with property damage avoidance, again limiting to a single multi-vehicle incident of approximately $15,000 to $25,000, the resulting benefit/cost ratio for flood warning systems would be nearly 1:2.1.

5.3 Program Planning Costs

Program planning costs are established for achieving upgrades to the ATMS as well as long-range plans for ITS deployment throughout the City of Newport News. Dynamic message sign deployment by VDOT within the City limits have been reviewed and incorporated into the plan maps, without duplicating the cost of deploying portable DMS in these locations.

Program planning costs are presented in three alternative forms as follows:

A. Upgrade central software and install new TS-2 signal controllers in all field cabinet locations, re-using the existing TS-1 cabinets

B. Upgrade central software and install new TS-2 signal controllers in new TS-2 cabinets at all intersections.

C. Upgrade central software and install new TS-2 signal controllers in all locations, re-using 80 existing pole-mounted TS-1 cabinets in the downtown area (south of 39th Street) and installing new TS-2 cabinets at all remaining intersections.

The itemized program planning costs are included in **Appendix A**. Key aspects to the program planning cost assumptions include:

- Approximately 20 signal controller locations are included in the estimate for system growth even though those locations would likely be paid for in the future when constructing new signal locations.
- The system detector cost is conservatively high and factors in the potential for non-intrusive technologies as well as traditional loop detectors.
- Per signal cost for network access and incidental site improvements may include conduit, communications and wiring, foundations, etc.
- The over-height vehicle sensor system cost is $60,000 per approach. Four approaches were assumed for the Warwick/Mercury interchange, and three approaches were assumed at the Warwick/Ft. Eustis interchange.
- VDOT's ITS efforts were considered in the City's proposed ITS master plan maps, and are not included in program costs. The VDOT plan includes 27 permanent DMS within Newport News.
- Eight portable DMS units are proposed; but six are already funded by CMAQ, so only two additional signs are included in the program plan.
- Central system ATMS software costs are above and beyond the field controller software that is included with the controller hardware. The central system package allows for data sharing, providing traveler information, and a number of other features, some of which may include ITS.
- Central system ITS software costs address software needs associated with elements that are not currently available through ATMS software vendors.
- The program plan is based on a phased implementation, whereby the entire design could be completed initially, but the construction could be bid in phases so that the main bid will build as much functionality as possible and smaller plans can be bid if funding becomes available.

Operations and maintenance staff have noted that Program Plan A is not desirable due to the age of the cabinets and the reduced flexibility to take advantage of the proposed features afforded by current signal controller technology. Plan B has the highest overall deployment cost, but not all locations will be conducive to upgrading to TS-2 cabinets. Therefore, **Plan C is recommended** since it provides the flexibility to support both cabinet approaches, allows for a phased implementation if needed for current funding limits, and provides access to advanced controller features for the vast majority of the City's signal system. ***Plan C has a program cost of $15.2 Million*** *including components, design, construction administration, and contingencies for both ATMS and ITS improvements throughout the City of Newport News.*