MEMORANDUM

Introduction

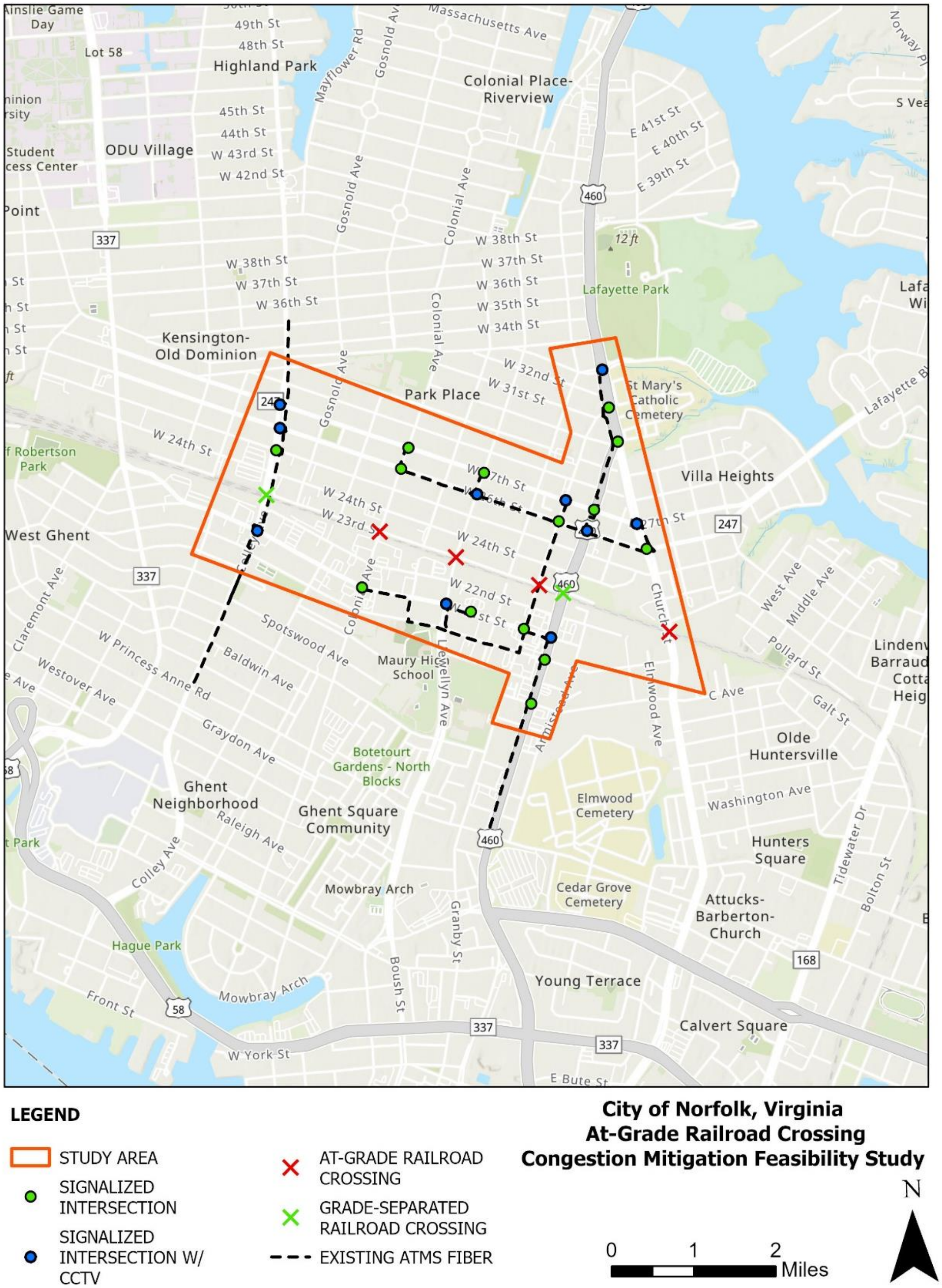
Norfolk Southern Railway has four key, at- grade crossings in the southwest Norfolk study area (Colonial Avenue, Llewellyn Avenue, Granby Street and Church Street) that significantly impact vehicular traffic when trains are present. This line serves the Lambert's Point Yard located approximately one mile to the west. Given the current nature of the railway freight industry, an increase in train length has caused more frequent and longer blocked crossings. In response to the increased congestion within the study area, the City of Norfolk is assessing potential technologies and/or engineering strategies to mitigate traffic congestion during active train crossing events.

This study focuses on reviewing existing train detection technology, their abilities to be integrated into the City's existing Advanced Traffic Management System (ATMS, or specifically KITS), and the impacts to existing traffic signals along the study area corridors. This memo provides a summary of the impacts to traffic flow during extended train stoppages, the characteristics of five (5) existing train crossing technologies, and the potential increase in traffic flow utilizing updated signal timing plans (sometimes referred to as incident management timing plans).

Existing Conditions

The study area limits consist of Colley Avenue to the west and Church Street to the east. The 27th Street corridor is generally the northern limit of the study area with the exception of the signalized intersections along Church Street at Monticello Avenue, Granby Street, and Broadway Street. The southern limit is generally the 21st Street corridor but also includes the signalized intersection at 18th Street and Monticello Avenue. As mentioned, the current at-grade crossings within the study area include Colonial Avenue, Llewellyn Avenue, Granby Street, and Church Street. The two grade-separated crossings, i.e., the primary diversion routes, are at Colley Avenue and Monticello Avenue (see **Figure 1** below)**.**

Figure 1: Project Area



There is frequent congestion within the study area due to the Norfolk Southern train crossings. Given the length of freight trains and the time it takes Norfolk Southern to process/clear the lines, the study area often experiences complete blockage of all four at-grade crossings simultaneously. Norfolk residents and commuters have been reporting longer and more frequent blocked crossings within the study area, often multiple times per day. Although less frequent, trains can sometimes stop on the tracks and block crossings for more than one hour. Blockage of at-grade crossings causes motorists to divert to either the Colley Avenue or Monticello Avenue grade separated crossings. These diversions place additional stress not only on the Colley Avenue and Monticello Avenue corridors but also on the road network running parallel to the railroad, namely 21st Street and the 26th Street/27th Street one-way pair. Additionally, motorists traveling northbound on Church Street utilize 18th Street and 20th Street as diversion routes. These at-grade crossing diversions place immense strain on the roadway network, even more so during the AM and PM peak periods which already experience recurring traffic congestion.

Norfolk uses McCain traffic signal controllers in 2070 type traffic signal cabinets. As shown in Figure 1, all of the signalized intersection controllers adjacent to the at-grade crossings are connected to the traffic signal network via fiber optic cable. This allows these signals to be managed and controlled through the City's KITS ATMS. That said, some signals may not be online at the time this memo was produced, therefore, any communication issues would need to be resolved prior to implementing the solutions discussed below.

Traffic Data and Signal Timing Impacts

Kimley-Horn reviewed available traffic count data within the study area, which was previously collected by the City in 2019 for signal retiming and by VDOT in 2023 for the Project Pipeline study along Monticello Avenue. After comparing the two datasets, the 2019 traffic count data was selected. as it encompassed the entire study area and consisted of generally higher traffic volumes, providing a more conservative analysis. Existing Synchro models and existing signal timing information available from the City were utilized to model existing conditions with a primary focus on the signalized intersections along the following corridors:

- Colley Avenue between 21st Street and 27th Street
- Monticello Avenue between 18th Street and 27th Street
- 21st Street Between Colley Avenue and Monticello Avenue
- 26th Street between Colley Avenue and Church Street
- 27th Street between Colley Avenue and Church Street

Traffic volumes were redistributed across the study area to approximate operations during a complete blockage of all four at-grade railroad crossings within the study area. Diversion routes were assumed based on local knowledge of the study area while maintaining the total inbound and outbound volumes within the network. Synchro 12 was utilized to compare Arterial Level of Service (LOS) results for multiple scenarios during the PM peak hour as shown in Table 1. Table 1 summarizes the arterial LOS and arterial speeds for existing conditions with "no train," diverted traffic volumes with existing signal timing (i.e., without traffic mitigation), diverted traffic volumes with only split and offset adjustments (i.e., existing cycle length), and diverted traffic volumes with cycle length adjustments at the study intersections identified above. Detailed capacity analysis of individual intersections was not performed as part of this study.

Arterial Level of Service Comparison – PM Peak Hour				
Arterial and Direction	**Existing Conditions**	**Diversion without Traffic Mitigation**	**Diversion with Split and Offset Adjustments**	**Diversion with Cycle Length Adjustments**
26th St EB	D (13.0 MPH)	D (11.0 MPH)	D (9.7 MPH)	D (10.0 MPH)
27th St WB	C (14.0 MPH)	D (12.7 MPH)	D (12.8 MPH)	C (13.1 MPH)
Monticello Ave NB	E (13.7 MPH)	F (5.4 MPH)	F (8.9 MPH)	E (10.4 MPH)
Monticello Ave SB	D (16.0 MPH)	F (7.0 MPH)	F (6.4 MPH)	F (7.3 MPH)
Colley Ave NB	D (10.0 MPH)	E (8.9 MPH)	D (10.9 MPH)	D (11.1 MPH)
Colley Ave SB	D (9.6 MPH)	F (6.9 MPH)	D (9.9 MPH)	D (10.2 MPH)
21st St EB	E (8.6 MPH)	F (4.2 MPH)	F (5.8 MPH)	F (6.8 MPH)
21st St WB	D (10.8 MPH)	D (9.8 MPH)	D (9.7 MPH)	D (10.4 MPH)

The Highway Capacity Manual (HCM) defines arterial LOS as a function of class and the travel speed along the arterial. The study area consists of arterial class IV's, typically 30 MPH free-flow speeds, except for Monticello Avenue, a class III arterial with a typical free-flow speed of 35 MPH. Comparing the arterial level of service results between existing conditions and those without traffic mitigation reinforces the anecdotal experiences submitted by users of the study corridors. There are significant reductions in speeds in both travel directions along Monticello Avenue and eastbound 21st Street. Although a detailed analysis of splits, offsets, and cycle lengths was not performed for this study, adjustments were made in response to the approximated volume diversions.

Improvements to arterial LOS are anticipated with split and offset adjustments to some of the more congested corridors including 27th Street, northbound Monticello Avenue, Colley Avenue (both directions), and eastbound 21st Street. For the analysis with cycle length adjustments, a 120-second cycle length was assumed (compared to the existing PM peak cycle length of 100 seconds). With these adjustments, further improvements to arterial LOS are anticipated for all corridors. One consideration for future deployment is that a change in cycle length will require a brief transition period for each of the affected signals, and delays will likely increase for minor movements. However, it is anticipated that an increased cycle length will provide the most significant congestion mitigation, particularly during the PM peak period. As future incident management timing plans are developed specifically for train crossing events, the City should consider developing both a higher cycle length incident management plan that can be deployed during train crossings that occur during the PM peak period as well as a lower cycle length plan that can deployed during non-peak times.

Detection Technology Review

As an alternative to more complex, costly, and time-intensive solutions like grade separation, Kimley-Horn evaluated a number of detection technologies that were developed to help mitigate traffic congestion due to blocked train crossings. The following is a brief summary of the technologies reviewed, in alphabetical order. For more information on each technology, refer to the table in **Appendix A**.

Island Radar

Island Radar is a solution that is well-suited for a single rail crossing. They provide a variety of rail crossing equipment, including gates for crossings and flashing signage to warn of incoming train crossings, in addition to radar sensors to detect oncoming trains. Their sensor controller will send a single signal to the local signal cabinet for the intersection. Potential support of communication with external devices can be investigated further if this solution is appealing. Island Radar does not provide direct ATMS software integration; therefore, use of its hardware would require third party integration into KITS.

Oculus Rail

Oculus is a new solution that involves sensors and cameras capable of detecting incoming trains at crossings. This is a product being created specifically for use cases as described in this study, and prototypes should be ready for operation. ATMS integration is part of the solution package, and Oculus Rail is still deciding what the optimal method of data delivery is for said integration. They have specifically stated that their initial product will provide data from an API provided through an internet portal. Oculus uses a subscription model where they own and deploy the hardware (sensors, cameras and other devices) and supplies the client with data from the crossings.

Ouster Lidar

Ouster provides Lidar for rail crossings as well as other ATMS and ITS applications. The use of this technology would require physically wired sensors at the crossings and would be capable of integrating into a larger system. Ouster provides a software called “Blue City” that is made specifically for using lidar for traffic management purposes. However, pricing for the system may not be worth the limited use case described in this study. Price and scope of tailored solutions can be provided upon further coordination with Ouster.

Rail State

Rail state is a technology that does not directly address the use case for this study. Rail State keeps track of trains, and the conditions of the rail cars on different segments of rail by monitoring them with sensors they have stationed alongside railroad ROW. This may give information on what trains are coming throughout the day, but not the exact time of crossing.

Trainfo

Trainfo is a solution that provides train detection, communication with road signs, communication with Emergency Dispatch Systems, and is capable of being integrated into ATMS software such as KITS. Trainfo does not just have the possibility of ITS integration but offers it as a primary service and goal of their advertised solution. Furthermore, Trainfo offers the service of using data from their sensors to provide predictive delays of traffic in response to rail crossings. It directly addresses the use case of this project. Trainfo places its sensors outside of railroad right-of-way (ROW). Both the sensor communications as well as DMS sign communications can be achieved wirelessly. Trainfo requires an annual service fee as well as equipment costs. The annual license is per county, and cost can be shared with any city adjacent to Norfolk using Trainfo services. Equipment purchased from Trainfo would be owned by the City and have a 5-year warranty.

Kimley-Horn reached out to each manufacturer and/or vendor to get information on the cost of each technology. As noted, some solutions are based on an all-inclusive subscription model, whereas some require installation by the owner. Where pricing did not include infrastructure equipment like poles, we added estimated quantities and pricing based on available, recent bid data. To best compare each solution, total pricing is based on a 10-year useful life. For a breakdown of the estimated costs, refer to **Appendix B.**

In comparing these solutions, Island Radar is a small spot solution that can be implemented per crossing and incorporated into the City's current ATMS. Oculus is developing solutions specifically for this study's use case. Trainfo provides a solution that meets the needs of this study and provides additional functionality and benefits. Ouster Lidar provides a solution that is more extensive and costly than the other options; a more tailored solution would be required to trim down costs for the use case of this study.

Recommendations

Short Term

Based on our review of the City's existing infrastructure, the signal timing impacts, and research of various technologies, the following improvements are recommended as lower cost, short-term solutions to help mitigate traffic congestion associated with traffic diversion during train crossings:

1. **Queue Monitoring** – Queue monitoring of traffic backups due to stoppages at rail crossings can be used to either trigger signal timing changes or trigger alerts at message signs (e.g., blank-out signs, dynamic message signs). This can be accomplished relatively quickly and at a low cost by deploying additional vehicle detectors at strategic locations. The Congestion Manager module of the KITS ATMS can be utilized to deploy signal timing changes at any signal or group of signals based on inputs from any detector(s).

2. **Deploy Train Detector Technology** – Similar to vehicular queue monitoring, installing unobtrusive train detectors at each crossing could be used to trigger signal timing changes or alerts at message signs. Train detection technologies offer additional benefits to queue monitoring because they focus on the cause of the delay, not the effect. I.e., you will know when queues are caused by the presence of trains and have an idea of how long they might last.

   Recommended technologies include sensors from Island Radar, Oculus Rail, or Trainfo. The train detectors used to support the recommended solutions can and should be integrated into KITS to enable similar use as triggering inputs through the Congestion Manager module. In addition, this integration will provide a real-time indication of the status of each detector within KITS. This status can then be incorporated into reports used to analyze the outcomes of the adjacent signals during train stoppage events.

It should be noted that there may be some challenges if a physical connection of the detection equipment to an adjacent traffic signal controller is required to make use of the detector data. As illustrated in **Appendix C**, these devices will be two blocks away, and there are many existing underground and overhead utilities that will need to be avoided.

3. **Public Communication** – Regardless of the technology solution selected, the City strongly desires the ability to integrate it with widely used mobile applications like Waze using their "Waze for Cities" program. Notifying the public of this integration would help travelers know what they can expect when using these popular apps. Alternatively, the City of Norfolk could attempt to implement a similar solution that is available at the Terminal Boulevard crossing, where they have an agreement with the Port of Virginia that allows them to send text alerts 20 minutes prior to train crossings. It is recommended that the City initiate conversations with Norfolk Southern and Lamberts Point Railyards to see if a similar agreement is feasible.

Intermediate Term

As a next step, intermediate solution, it is recommended to add unobtrusive rail crossing sensors tied to new dynamic message signs (DMS) ahead of key decision points along Church Street, which carries the highest volume of daily traffic across an existing at-grade crossing. These DMS would provide advanced warning to travelers of an active crossing so they can decide whether to take an alternative route. In particular, it is recommended to install a DMS on southbound Church Street, which has an S-curve south of 27th Street that blocks the view of the rail crossing. Currently, this results in travelers turning onto 25th Street to get to the underpass on Monticello Avenue. However, since left-turn movements from 25th Street onto Monticello Avenue are prohibited for most of the day, this can lead to illegal movements by diverted vehicles and has resulted in an increase in crashes at that location. It is recommended to install a DMS north of 27th Street to allow southbound drivers an opportunity to more safely divert to 27th Street to access Monticello Avenue.

We recognize that the City has a future project planned and funded to implement a DMS solution at a number of locations in the Wards Corner area, but those will not be installed for several more years following the funding agreement, design, and construction. Due to the anticipated expense of this type of project, a similar solution for this area would require additional time and funding of its own.

Long Term

Finally, the recommended long-term solution is to grade separate the highest volume crossing at Church Street. This will significantly alleviate congestion on Monticello Avenue during active train crossing events by eliminating the traffic diversion from Church Street to Monticello Avenue, which in turn will provide additional capacity for diverted traffic from the lower-volume at-grade crossings at Colonial Avenue, Llewellyn Avenue, and Granby Street. However, grade separation is a complex endeavor, and utility relocation and right-of-way acquisition needs can add significant time and expense to the project. Therefore, it is recommended that the City begin exploring potential funding programs such as the Federal Railroad Administration's Railroad Crossing Elimination Grant Program.

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APPENDIX A – Technology Review Matrix

	Island Radar	Oculus Rail	Ouster Lidar	Rail State	Trainfo
Brief Overview	Island Radar uses radar sensors at rail crossings to detect oncoming trains, as well as traffic on the rails. Upon train crossings, their controller can send a signal to a traffic signal cabinet to trigger signal timing changes. Their solution is for singular rail crossings and doesn't come out of box with integration software for larger systems. Island Radar also sells stop arms and light up signs to complement the detection system.	Cameras and sensors used to detect trains. Data stored in cloud and available through API. System will be capable of learning from traffic backups to provide predictive information on impact of train crossings.	Lidar has been used for roadway intersections as well as for monitoring of train tracks and rail crossings. It is a technologically heavy option that provides many possibilities.	Rail State is a service that keeps track of rails, trains, and carts. It runs a real-time database of trains and their locations and is 3rd party from the railway companies. Its intended use cases do not include railroad crossings. It can be used to determine when and how many trains may be crossing on any given day, but not accurately enough to reroute traffic in a timely manner.	Trainfo places sensors outside the ROW at rail crossings. It can detect trains farther out than traditional technologies and can communicate with ATMS, emergency dispatch systems, and DMS. Besides the sensors, Trainfo also provides analytics on the traffic impacts of rail crossings as Bluetooth sensor for queue monitoring, and wireless DMS signs to alert drivers of upcoming rail crossings.
Hardware	• Radar sensor • "Do Not Stop on the Tracks" light up signs • Stop arms	• Cameras • Train sensors • Solar panels to power both	• Lidar sensor • Edge computing hardware to pre-process Lidar output before delivery to a software system	• Scanners • Thermal • Various others	• Cameras and acoustic sensors are used to detect the train and traffic at crossing • Optional Bluetooth sensors and Yellow Beacons are available
Software	Island Radar does not provide any software as a part of its solutions.	Oculus data is accessed via an online portal, but they are not developing standalone software to interact with its devices. However, they do allow data to be accessed through an API available through an online portal.	Ouster provides various software solutions for accessing and organizing Lidar data. Blue City is their full package ITS solution and their *SDK* software allows more tailored and customizable applications of their devices.	Rail State provides a software platform for viewing and analyzing data from its sensor network. However, this software cannot be integrated with any ATMS, nor is it geared for traffic management functions.	Trainfo provides an online data portal that can be accessed to retrieve information from their sensors and analytics. No standalone software is provided.
Basic Setup	Two wired radar sensors, a junction box, and a controller are installed at each location. The radar controller connects back to the traffic signal cabinet of the nearby signalized intersection.	Solar powered sensors/cameras with wireless communication. Installed in public right-of-way adjacent to rail crossing. The sensors detect oncoming train and send the data to the cloud where it is accessible by the client.	Lidar is placed on a pole at the crossing and would be wired to an edge computing device, which would in turn be connected to a modem. The Lidar would detect oncoming trains as well as send notifications of foreign objects along the tracks and send the information back to the software system.	Rail State owns its own network of sensors and provides data to the customer based off their existing sensors.	Camera, acoustic sensor, and equipment box all reside on a pole. All control elements for the sensors reside within the box. Equipment box includes step up/down transformers as needed. Data is transmitted wirelessly to be made available on an internet portal, or transmitted through an Ethernet cable to local equipment, if requested.
KITS Integration	Island Radar is capable of sending out a signal that KITS can use as an input to detect train crossings. This feature is required for KITS to determine when to make signal timing adjustments.	KITS is capable of interfacing with the API and retrieving data from Oculus.	A tailored solution is possible for KITS to interface with either Blue City or SDK software.	Not available.	Integration with KITS or any other software is offered as part of the annual license.
Third Party App Integration	No third-party app integration advertised; therefore, would rely on KITS.	API will be available for access.	Blue City and SDK both have options that support integration with third party software.	No third-party app integration advertised.	Yes, it integrates with X (Twitter) as well as Waze. Trainfo is currently working on integration with other apps (such as Google Maps).
Recurring Cost	No.	Yes, subscription basis.	Software solutions have recurring cost. Lidar sensors themselves do not.	Yes, subscription basis.	Yes, subscription basis.

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APPENDIX B – Estimate of Deployment Costs

Total Installation Cost Per Crossing, With 10 Year Total Cost Estimate

Description	Quantity	Unit	Unit Cost	Total	Notes
ISLAND RADAR					
Radar Mast Extension	2	EA	$ 600.00	$ 1,200	*
Junction Boxes	2	EA	$ 400.00	$ 800	*
Radar Electronics	1	EA	$ 12,000.00	$ 12,000	*Used for train detection. Rail State VDR24, Two Radars
Pole & Foundation	1	EA	$ 3,000.00	$ 3,000	*Pole to affix sensor. Example: PF-2 VDOT pole & foundation.
Mast Cable	2	EA	$ 400.00	$ 800	*Cable connecting Radar sensor to VDR24
Cabling	600	FT	$ 4.00	$ 2,400	*Cabling connecting computation element to a traffic communications cabinet
Vehicle Radar Sensor	0	EA	$ 8,000.00	$ -	*Wavetronix device. Used for vehicle count. (optional)
Maintenance of Traffic	1	DAY	$ 5,000.00	$ 5,000.00	
			Total Installation Cost	*$ 25,200.00*	
			Total Maintenance Cost	*$ -*	*To by covered by city forces.*
			Total Annual Recurring Cost	*$ -*	*No licenses or other annual fees*
			Total Radar Cost	**$ 25,200.00**	Estimated 10-year life cycle
OCULUS					
Initial Implementation Fee	1	EA	$ 350.00	$ 350.00	Subscription contract will be yearly. Cost will only be locked in per year. Includes installation of all equipment necessary to track train activity at one crossing.
			Total Installation Cost	*$ 350.00*	
			Total Maintenance Cost	*$ -*	*To by covered by Oculus*
Annual Subscription	1	EA/YR	$ 2,500.00	$ 2,500.00	
			Total Annual Recurring Cost	*$ 2,500.00*	
			Total Oculus Cost	**$ 25,350.00**	Cost for 10-years

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APPENDIX B – Estimate of Deployment Costs

OUSTER LIDAR					
LiDAR Sensor OS2 Kit	1	EA	$ 32,000.00	$ 32,000.00	128 Channel LiDAR,600ft radius detection range. Includes LiDAR, edge box, mount, cables
TSNT Edge Box	1	EA	$ 2,624.00	$ 2,624.00	*1 edge box per site, unless TSNT service is placed at TMC.
TSNT Server for TMC	0	EA	$ 8,750.00	$ -	*Central Server as opposed to edge boxes. Collects data from Lidar and sends appropriate messages to ATMS (optional)
336 Cabinet, 2 doors, Pole Mount	1	EA	$ 5,750.00	$ 5,750.00	*
Pole & Foundation	1	EA	$ 3,000.00	$ 3,000.00	*Pole to affix sensor. Example: PF-2 VDOT pole & foundation.
TSNT Software	1	LS	$ 3,000.00	$ 3,000.00	Software to allow LiDAR to communicate to VMS or City's system.
Onsite Support: System Integration	1	LS	$ 500.00	$ 500.00	System integration. Once per site.
Maintenance of Traffic	1	DAY	$ 5,000.00	$ 5,000.00	
			Total Installation Cost	*$ 51,874.00*	
			Total Maintenance Cost	*$ -*	*To by covered by city forces*
			Total Annual Recurring Cost	*$ -*	*No licenses or other annual fees*
			Total LiDAR Cost	**$ 51,874.00**	Estimated 10-year life cycle
TRAINFO					
Crossing Sensor Kit	1	EA	$ 7,000.00	$ 7,000.00	Sensors are owned by city with a 5 year warranty from Trainfo. Trainfo takes care of installing sensor to pole.
Optional Beacons (Yellow Light & Sign)	0	EA	$ 7,500.00	$ -	Further solution offered by Trainfo. No necessary for current scope of project.
Pole and Foundation	1	EA	$ 3,000.00	$ 3,000.00	*Pole to affix sensor. Example: PF-2 VDOT pole & foundation.
Maintenance of Traffic	1	DAY	$ 5,000.00	$ 5,000.00	
			Total Installation Cost	*$ 15,000.00*	
			Total Maintenance Cost	*$ -*	*To by covered by Trainfo.*
Annual License (6-10 crossings)	0	EA/YR	$ 26,000.00	$ -	Annual license cost. Per county.
1/10 Share of License Cost	1	EA/YR	$ 2,600.00	$ 2,600.00	According to Trainfo Norfolk can share the cost with other cities in the county (Suffolk)
Annual Sensor Data Charge	1	YR	$ 600.00	$ 600.00	Annual charge for cost of using wireless data on sensors.
			Total Annual Recurring Costs	*$ 3,200.00*	
			Total Trainfo Cost	**$ 47,000.00**	Cost for 10-years

*Note: Unit cost of materials increased to reflect installation costs.

APPENDIX C – Example Train Sensor Schematic

(See Attached)

○ TRAIN SENSOR ON EXISTING LIGHT/UTILITY POLE

[T] EXISTING TRAFFIC CABINET

[C] SENSOR CONTROLLER ON EXISTING POLE

— — — WIRELESS/WIRED CONNECTION

——— WIRED CONNECTION

NORTH

GRAPHIC SCALE IN FEET
0 100 200 400

CITY OF NORFOLK

EXAMPLE TRAIN SENSOR SCHEMATIC

COLONIAL AVENUE
NORFOLK, VIRGINIA

Kimley»Horn

DATE 10-30-2024	
DRAWN BY SJF	CHECKED BY JRG

SKETCH
APPENDIX C