Reducing Traffic Challenge Using A Smart Traffic Lighting System

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Author Note

Author is a student and have centered this project around the requirements specified by the Master of Technology Management Capstone Project offered at the School of Continuing Studies at Georgetown University.

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Abstract

As the Crystal City corridor continues to grow and thrive, the demands on the city’s transportation system continue to grow as well. Residents and commuters of Crystal City experience traffic challenges daily. Modern economic structures are shaped by automobile-oriented urban development (Kumar, Singh, Singh, & Baghel, 2018). Deteriorating urban air quality is a caused by the congestion; thus, quality of urban living is directly impacted (Gulia, 2015). To define congestion and mitigation measures, traffic congestions thresholds need to be determined. Measures will need to be implemented to manage these challenges and growth with technology to enhance and optimize the transportation systems throughout the Crystal City corridor. The focus of capstone paper is aimed at understanding the recurring congestion, its measurement and using the scalable urban traffic control systems (SurTrac) as mitigation. Research on this challenge exposes some attention-grabbing insights.

Keywords

Traffic, Congestion; Commonwealth; Scalable Urban Traffic Control; Crystal City; Virginia; Amazon Headquarter, Arlington, Road Users

Research Questions

1) Why is Scalable Urban Traffic Control system being the best choice for the Crystal City Corridor in Arlington, Virginia?

2) What critical factors must the Virginia Department of Transportation and Commonwealth of Virginia needs to ensure for the successful completion of this project?
Reducing Traffic Challenges

List of Acronyms

AC .................. Alternate Current
BYGE.............. Powered by General Electric
CCTV ............. Closed-circuit television
CRI ............... Color Rendering Index
D.C. .............. District of Columbia
DC .................. Direct Current
GAAP ............. Generally Accepted Accounting Principles
GE .................. General Electric
GTX .............. General Electric 14th generation LED bulbs
HOV .............. High Occupancy Vehicles
ITS ............... Intelligent Traffic System
LED .............. Light Emitting Diodes
M .................. Million
N/A .............. Not Applicable
ROI ............... Return on Investment
SDCC ............. Schedule Driven Coordination Control
SDIC ............. Schedule Driven Intersection Control
SurTrac .......... Scalable Urban Traffic Control
SWOT .......... Strengths, Weaknesses, Opportunities, and Threats
VA ............... Virginia
VDOT ............ Virginia Department of Transportation
W .................. Watts
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Introduction

On Tuesday, November 13, Amazon made the announcement of opening their second headquarters in Crystal City and Potomac Yards in Virginia (McCartney & Shaver, 2018). This step promises to bring 25,000 plus jobs over the period of next 12 years. Virginia Tech is also proposing to bring its Innovation Campus to Crystal City in lieu of Amazon opening its headquarters (Fox & Henry, 2018). Additionally, Apple is exploring to open a campus in Crystal City area bringing 20,000 jobs (O'Connell, 2018). The ripple effect of all this will bring additional jobs and small businesses to the neighborhoods. Crystal City already houses the biggest federal employer, The Pentagon, the Fashion City Mall, Costco, Washington Reagan National Airport, private homes, and Skyscrapers apartment complexes (Willis & Roussey, 2018). As the result, the Crystal City corridor is already crowded and bringing additional people to the area will make it worse. This capstone project highlights the problem, analyze the critical factors, and offer solution to improve the situation on hand.

Background and Problem Statement

Crystal City is an urban neighborhood in the southeastern corner of Arlington County, Virginia, and south of downtown Washington, D.C. The commonwealth of Virginia and Arlington County has proposed $800 million for infrastructure projects for Amazon to create jobs. A ceiling of $573 million dollars is set just for Crystal City area over the period of next 12 years (Glambrone, 2018).

Additional revenue will generate by new and existing businesses and will add more traffic challenges to the Crystal City corridor. The ability to move goods and people around the neighborhood at relatively low cost is a substantial benefit for residents and county would like to
maintain this (CambridgeSystems, 2009). The interconnecting 3-lane Route-1 highway, between
Crystal City and Potomac Yards in Arlington Virginia sees the traffic challenge throughout the
day. Image 1 in the appendix section, demonstrates an example of everyday traffic. The
congested roads take elongated time, fuel, and reduce worker productivity. This also results in
impaired roads, vehicle wear-and-tear, increase driver stress and aggression, unhealthy air
quality, and increased carbon emissions from idling vehicles. All these reasons incur more
accidents (Tang, 2018).

Crystal City Metro Rail station, located on the Metrorail blue and yellow lines, is not
accessible for many users in the neighborhood due to limited direct routes, poor signage,
inadequate way-finding instructions, and long-term metro station closings for the maintenance
project (Crystal City Station Access and Second Entrance Study, 2014) City has set a budget of
90.8 million to improve the metro rail for existing and future uses (Funding, 2018) Commuters
are using Uber and Lyft as the primary mode of transportation due to bad metro rail and bus
transit system. It results in additional cars on the road increasing traffic challenges for
commuters (Dvorak, 2017). Negative effects of excessive traffic delay results in significant fuel
waste, higher motorist costs, air pollution, potential diversion of arterial traffic into
neighborhood streets, red-light running violations, and associated crashes (Design-concept-info-
sheets, 2018). As displayed in image 3 and 4 in the appendix, the City has approximately 27
traffic lights (Intersections_Maps, 2010). Complex traffic signal makes the crystal city more
accident prone (Ross, 2015).

**Technical Approach**

As the city takes new traffic challenges, one thing is clear, that sophisticated traffic
control technology is required to abate these problems. Implementing Scalable Urban Traffic
Reducing Traffic Challenges

Control (SurTrac) to existing traffic signals can be one of the solutions to deal with the traffic challenges in Crystal City corridor.

The SurTrac system developed by Rapid Flow Technologies, Inc. from Pittsburg, Pennsylvania is a smart-traffic light control system that optimizes the flow of traffic at already signalized intersections through the integration of its proprietary sensors, lamps, and cameras to route and reroute commercial and noncommercial vehicles, pedestrians, and bicyclists (Smart Traffic Signals, 2012).

SurTrac will not only reduce traffic congestion challenges, but also reduce emissions by 20% (Smith, 2017). The system optimizes signal timings based on amount of automobiles and flow-through data collected by sensors installed at intersections. It will reduce the amount of time vehicles spend idling on roads while enabling an optimal use of roads (Okonkwo & Gong, 2014). This approach is different from methods currently used as it allows for real-time second by second optimization of traffic controls (Okonkwo & Gong, 2014). It also provides responsiveness to changing traffic conditions, while operating in a decentralized manner (Kota, 2015). It is designed to accommodate urban networks and road corridors (Xiao-Feng, Smith, Barlow, & Liang, 2012).

**Technical Components & Process**

The technical components of SurTrac includes the following:

- Computer
- CCTV Camera
- Data Sensor
- Schedule Driven Intersection Control (SDIC) software
- Schedule Driven Coordination Control (SDCC) software
SurTrac control process starts when traffic conditions are extracted from CCTV camera and data sensor installed at each intersection. The computer records this activity. The computer runs a predictive model to generate a signal-timing plan. Schedule to optimize traffic flow at the intersections is generated by the computer. Next, computer received the instructions next time it needs to change the flow. The system then communicates expected schedules to other traffic signals to indicate other automobiles are approaching the intersection. Finally, traffic signals assign vehicular and pedestrian right-of-way and promote the orderly movement of vehicular and pedestrian traffic to prevent excessive delay to traffic (Snow, 2017).

Cost Assessment

Suggestion is to allocate approximately $4.3M towards this project. The cost will include the initial phase of installation of scalable urban control traffic light system, computers, cameras, and data sensors. Keeping the technical challenges in mind, we should also set aside an extra 25% in our budget as contingency amount to cover any unknown costs and problems, which may occur during this project. The overall cost to implement a citywide signal control for our initial calculation of 27 traffic intersections is shown in the table below.
Research

This study was conducted in two different cities, Pittsburgh Pennsylvania, and Atlanta Georgia. These cities were chosen because they both have scalable urban tracking control systems installed and present the same grid pattern of intersections present in Crystal City Virginia. The first step towards this project plan is to obtain the permit required to install the SurTrac system. In every case, Virginia Department of Transportation (VDOT) primary consideration is safety. “The VDOT finds the location where a signal will be needed and help road users and pedestrians more than impede traffic and relieve additional congestion than it will cause (VDOT, 2018).” Federal guidelines are followed under which signal should be considered.
Traffic engineers determine if a signal is needed by carefully evaluating (VDOT, 2018):

- The number of vehicles and pedestrians that use the intersection
- The physical makeup of the intersection
- Roadside development
- Traffic delays during peak hours
- Average vehicle speeds
- Future road construction plans
- The number and types of accidents that have occurred there

**Travel Time Calculations**

(Timeanddate, 2018)

<table>
<thead>
<tr>
<th></th>
<th>Existing Timed Signals using Route 1</th>
<th>SurTrac Timed Signals using Route 1</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny Day (Source)</td>
<td>10 min</td>
<td>8 min</td>
<td>2 minutes</td>
</tr>
<tr>
<td>Snow Day (Source)</td>
<td>20 min</td>
<td>14 min</td>
<td>6 minutes</td>
</tr>
</tbody>
</table>

**LED Traffic Signals**

New traffic lights are made of arrays of light emitting diodes (LEDs). LEDs are energy efficient. LEDs have long life. It generates less heat. Reduction in electricity demands is seen (VDOT, 2018). Lights are brighter. They last for long time, save energy, and reduce operating costs (VDOT, 2018).

**Incandescent Traffic Signals**

The incandescent light produces light by heating a wire filament. This results in the generation of light. The metal wire is surrounded by a translucent glass bulb that is either filled with an inert gas or evacuated (a vacuum). They support a large range of voltages, light outputs, and current,
working well with both AC and DC power (StouchLighting, 2018). They have good ability to extract color. These lights have the worst energy efficiency.

<table>
<thead>
<tr>
<th>Signal Features</th>
<th>LED Traffic Signal</th>
<th>Incandescent Traffic Signal</th>
<th>Winner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlated Color Temperature</td>
<td>Wide range of color temperatures</td>
<td>3 colors temperatures (Soft White, Cool White)</td>
<td></td>
</tr>
<tr>
<td>Color Rendering Index (CRI)</td>
<td>broad spectrum of CRI values 65-95</td>
<td>Outstanding CRI ratings of 100</td>
<td>Incandescent</td>
</tr>
<tr>
<td>Cycling (Turning On/Off)</td>
<td>ideal light - steady light without flicker</td>
<td>steady light generally without flicker</td>
<td></td>
</tr>
<tr>
<td>Dimming</td>
<td>very easy to dim</td>
<td>very easy to dim</td>
<td></td>
</tr>
<tr>
<td>Directionality</td>
<td>180 degrees</td>
<td>360 degrees</td>
<td>LED</td>
</tr>
<tr>
<td>Efficiency</td>
<td>very efficient 50 lumens/watt</td>
<td>Less efficient 10 lumens/watt</td>
<td>LED</td>
</tr>
<tr>
<td>Emissions (In the Visible Spectrum)</td>
<td>very narrow spectrum of visible light energy</td>
<td>Very small percentage of their emissions as visible light.</td>
<td>LED</td>
</tr>
<tr>
<td>Infrared</td>
<td>None</td>
<td>infrared spectrum</td>
<td>LED</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Lifetime Costs</td>
<td>high initial costs and low lifetime costs</td>
<td>Cheapest light to purchase. Short lifespan</td>
<td>LED</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>best on the market</td>
<td>Worst on the market</td>
<td>LED</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signal Features</th>
<th>LED Traffic Signal</th>
<th>Incandescent Traffic Signal</th>
<th>Winner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront Costs</td>
<td>100W-equivalent $10 and $20</td>
<td>$1 - $7 for a 100W bulb</td>
<td>Incandescent</td>
</tr>
<tr>
<td>Warranty</td>
<td>Often 5 to 10 years.</td>
<td>N/A due to the short lifespan</td>
<td>LED</td>
</tr>
</tbody>
</table>
Business Case and Financial Analysis

Based on VDOT intermodal study of 2014, the project team has analyzed the critical information and assessed the target area to develop and guide decisions through an interactive framework to implement the technology solution. Tools, materials to use, and job operators have been researched. Individuals have been identified whose acceptance is essential to success of this project.

Project Roadmap & Phases

Project Phases & Milestones

Projection planning is the first phase for the implementation of the new technology. Once the project goals and requirements are identified, the project team will conduct the life cycle evaluation, identify stakeholders and set the project kick off and completion action plan. At this milestone, the gaps will be identified, and research phase will initiate. Systematic improvements and existing infrastructure will be analyzed. Project approval will be requested at this milestone. Funding will be calculated, analyzed, and approved for the project. Virginia Department of
Transportation and Commonwealth of State of Virginia will set the governance and define the standards (Daily_Press, 1989). Adaptive equipment cost proposals will be received which will define the architecture and infrastructure requirements (Kumar A., 2008). Target user experience and adaptation of new technology data will be stored and saved at the data center. Strategies to address maintenance and costs justifications will be defined. Maintenance records will be saved, and performance metrics will be created. At this stage, the Virginia Department of Transportation will track progress and process changes to determine the impact of SurTrac technology for Crystal City corridor. Project will then be closed.

**Crystal City Corridor SWOT Analysis**

**Strengths:**

- Business area capacity will increase
- Already established infrastructure
- Robust job market
- City highway (Route 1) merges into major highway 395 and 66
- Shopping District

**Weaknesses:**

- Ongoing construction
- Poor transit system
- Limited land with growing Population
- Traffic disturbing peace of the neighborhood
- Highway and Airport noise for business and residents
- Restrictive Route 1
Opportunities:

- Increasing Robust Job Market
- Build more apartment community
- Widen main city highway Route 1
- Make the existing small road network wider
- Improve public transit to increase mobility and accessibility among neighborhoods and the city
- Build new greenways and bike lanes
- New greenway and bike lane system along Route 1 to decrease automobile dependence
- Adding an HOV lanes on Route 1

Threats:

- Route 1 is less flexible route as it uses existing highway 395
- Environmental impacts on road facing businesses facing main road
- Multiple service providers can lead to hierarchy disputes
- Increase in cost of living
- Relatively high cost of projects implementation
- High costs of new construction

Mission Model Canvas & Value Propositions

To start implementation of the new Traffic Lights Technology for Crystal City corridor, Virginia Department of Transportation, Commonwealth of State of Virginia, and Scalable Urban Traffic Control (SurTrac) consultants are designated as the key partners for this project shown in image 8 in the appendix. Key beneficiaries of this new technology are road users (commercial
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and noncommercial drivers), Uber and Lyft taxis, freight trucks, delivery trucks, pedestrians, bicyclists, technology suppliers and service providers. By analyzing the problem on hand, the achievements of this mission are determined as reducing commuters travel time by 20%, wait times (idling) at intersections up to 10%, and reduce emission rates up to 20%. Key resources and value propositions have been evaluated as shown in the image 9, 10, and 11 in the appendix, to establish beneficiary’s confidence. Virginia Department of Transportation can evaluate and weigh the pains and gains of key partners and beneficiaries to start installing the new technology and services that will create value for them. For example, the gains for technology service providers will be meeting timelines while implementing the project and or doing installations. Meeting timeliness will keep the project on time with minimal delays. It is gain, because when supplies are needed, SurTrac does not have to rely on a manufacturer who is in another country, which means deliveries are made on time. Service providers will provide extended warranties. VDOT does not have to rely on a private service provider, because SurTrac service providers will go an extra mile to service after all work has been completed.

**Stakeholders and Benefits**

The key stakeholders involved in this project are the Virginia Department of Transportation, Commonwealth of State of Virginia, Road Users, and the SurTrac Rapid Flow Technologies. To ensure that the solution is not overly complex, the only technology supplier of the new technology SurTrac is Rapid Flow Technologies, Inc. The stakeholders will be involved in the acceptance of the new technology.
These stakeholders will serve a function in the migration strategies, and the mission achievements of this project.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Function</th>
<th>Benefit</th>
</tr>
</thead>
</table>
| Virginia Department of Transportation | Responsible for making policies, regulations, mandates, guidelines for standards and making sure that they are enforced in compliance with relevant laws and legislation | • Better traffic flow in the city  
• A more streamlined transport sector  
• Less pollution and control on carbon emissions  
• Lower investments in intersections  
• Reduction of Traffic Accidents  
• Prioritization of emergency vehicles and public transport  
• Potential to create new jobs  
• Less of the budget spent on setting up and maintaining intersection signal control devices  
• Reduction of accidents happening in the intersections |
| Technology Suppliers & Enablers | Provide the SurTrac devices and other needed equipment (sensors, lamps, and cameras) | • Revenue from the sale of new technology equipment |
| Service Providers | Install and maintain the SurTrac devices | • Revenue from the installation and maintenance of devices  
• Revenue for selling value-added services |
| Road Users - Commercial and noncommercial | Commercial and noncommercial drivers inside a vehicle on the road; Bicyclists; and Pedestrians adopting new technology | • Better Traffic Flow with more streamlined operation  
• Less fuel consumption  
• Smaller chance of traffic accidents  
• Potential for cheaper insurance  
• Fewer expenses linked to the accidents  
• Save commuting time  
• Less wear-n-tear to the vehicle engine  
• Save commuting time  
• Faster reaction time for the emergency vehicles |
Assumptions

SurTrac will improve the traffic challenges and signal infrastructure along Crystal city corridor, implement congestion-reducing adaptive signal optimization, and enable future initiatives (Arlington_ITS_Project, 2018). The new system will reduce delay timings and facilitate safe crossing for pedestrians (D’huyvetter, 2015). Overall, the project will reduce congestion and emissions. It will improve safety. It will enable future speed improvements to transit service. SurTrac will implement responsive traffic control systems to help monitor real-time traffic conditions (RapidFlow, 2018).

The system will also adjust the operation of traffic signals during emergencies. It will facilitate the smooth operation of traffic during special events and at intersections, the system will reduce delay timings (RapidFlow, 2018).

Funding Analysis & Resources

As per the Table shown below there is $891 million in the county’s budget for their transportation system. A very small portion from each division can easily cover this initial setup and maintenance cost for the first year. Next year, Annual cost of approximately $1.5M can be added in the budget. If needed, additional funds can be generated by requesting special grants.
The table below displays how each unit of Virginia Transportation System can contribute towards this new traffic light proposal. The percentage of breakdown used for this suggestion is the same as the current breakdown of funds available.

<table>
<thead>
<tr>
<th>Departments</th>
<th>Funds Available</th>
<th>Breakdown of Current Funds Available</th>
<th>Contribution towards SurTrac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligent Transportation System Improvements</td>
<td>$10,000,000.00</td>
<td>1%</td>
<td>$48,268.51</td>
</tr>
<tr>
<td>Pentagon City Multimodal Connections and Transitway Extension</td>
<td>$28,850,000.00</td>
<td>3%</td>
<td>$139,254.64</td>
</tr>
<tr>
<td>Crystal City Metrorail Station - East Entrance and Intermodal Connection</td>
<td>$87,000,000.00</td>
<td>10%</td>
<td>$419,936.02</td>
</tr>
<tr>
<td>Investment from Arlington &amp; Alexandria County</td>
<td>$570,000,000.00</td>
<td>64%</td>
<td>$2,751,304.93</td>
</tr>
<tr>
<td>Non-General Funds from Commonwealth of VA</td>
<td>$195,000,000.00</td>
<td>22%</td>
<td>$941,235.90</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$890,850,000.00</strong></td>
<td><strong>100%</strong></td>
<td><strong>$4,300,000.00</strong></td>
</tr>
</tbody>
</table>

**Financial Analysis**

With 4.3 million cost in mind, the investment will impact more than just the people directly working with the SurTrac technology. We must evaluate how it is going to affect the stakeholders, road users, technology suppliers, and service providers. Will the impact be positive or negative? To analyze the framework, the project cycle is divided in several stages. They are Identification, Preparation, Appraisal, Negotiation/Approval, Implementation, and Evaluation. Project team has analyzed the project by evaluating the economic, technical, institutional environmental, and social aspects of the Crystal City corridor. Two types of costs have been
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designated as fixed and variable which includes investments and operational costs. Initial costs are made up of all events within the project cycle that will not incur after the project is initiated. Fixed costs such as maintenance, rentals, and research, value will remain constant throughout the project. Replacements cost will start once the system is installed. The project team has assumed that all parameters of the project for financial evaluation are known for certainty. If the project face uncertainty in the middle of the project, then the actual value may vary. Cost overruns caused by project delays or inaccuracies in estimation will not significantly change project costs. Just by replacing all traffic signal bulbs to LED bulbs will impact positively financially. Although the unit savings shown in the table below are only the rough estimates, but the express the order of magnitude of available power reduction ratios (CooperIndustries, 2018).

**Risks and Mitigation Strategy**

The biggest risks are the pedestrians at the signalized crossings when waiting to cross the roads while the traffic is rerouted to accommodate the congestion. It is a give and take scenario. Safety of the vulnerable road users (pedestrians and bicyclists) in traffic is an important goal. Pedestrians are endangered at the intersections. Large number of conflicts can be resolved by installing count down timers displays for both red light and green light for pedestrians by placing a signage of showing how much time the light will give for pedestrians to cross the street. These countdown timers need to be voice enabled for blind pedestrians. Keeping the pedestrian crossing times to 40 - 60 seconds will give ample time to pedestrians to cross longer intersections. This will prevent pedestrian congestion at the intersections and reduce number
of accidents. Another way to mitigate this issue is by installing the crosswalk in-pavement flashing lights to alert motorists that pedestrians are using the crosswalk are the cause of traffic challenges in urban road and freeway networks lead to a strong degradation of the network infrastructure reducing throughput, which can be countered via suitable control measures and strategies.

Another risk that needed to be evaluated is the LED traffic lights versus incandescent traffic lights. LEDs are more energy efficient, cost less to operate, easy to maintain, can use battery backup solution, last longer, brighter and easier to see in bright sunlight, but sometimes the ice freezes on them, which in turn cause accidents and congestion.

Traffic congestion results in excess delays, reduced safety, and increased environmental pollution. To mitigate this issue, an altered visor with a scoop on top, so it can deflect the snow from falling on the traffic light, or better yet, use GTX Flax LED Heated Shell Signal Modules, however, it only snows for few months or so (CurrentBYGE, 2018).

Another risk of having traffic signal in every intersection is the major cause of the rear-ended collisions. Unjustified traffic signals can also cause congestion and traffic delays and congestion (CityofIrvine, 2018).

More risk is felt when it is not indicative that new technology will be adapted by the users or not. This is called the risks of adoption. The gains will come from the combination of several factors such as cost reduction, product enhancement, and competitiveness. This is the type of Return on Investment (ROI) which focuses frequently of financial factors. Accepting a risk is not same as adopting a risk.
Transportation has always been a crucial aspect of human civilization, but it is only in the second half of the last century that the phenomenon of traffic congestion has become predominant due to the rapid increase in the number of vehicles and in the transportation demand in virtually all transportation modes. The stream speed models and free flow models were developed by incorporating the prevailing traffic conditions of the chosen arterial road (Akcelik, 2003). The traffic management option emerges as the better one in terms of increased travel speeds, reduction in travel times and delays at congested locations (He, 2016).

**Ethical Consideration**

Ethics play an integral part whenever we deal with money. Virginia Department of Transportation is funded by primary state tax transportation revenue and their main sources for funding are motor fuel tax, motor vehicle sales and use tax, motor license fee, and state sales and use tax. They also receive funds through Federal Highway Administration and local tolls (VDOT, 2018).

There is an established code of ethics contract between commonwealth of Virginia and Department of Transportation (VDOT-CodeofEthics, 2018). However, in order to eliminate error and fraud, it is important to establish safeguards to this added project plan and take precautionary measures to maintain the transparency and accuracy in the accounting books (Council, 2018). In the absence of effective internal controls, there is no assurance of accuracy in the accounting/financial reports. Strong internal controls help by identifying and fixing the error or potentially fraudulent activity prior to becoming a larger issue (AICPA, 2014).

In the past also, VDOT was in trouble for not spending taxpayer dollars wisely (Jenks, 2010). Constantly review the internal processes and look for any loopholes and this can only be achieved by proper documentations, verification, supervision, delegation, and authorization.
Conclusion

Traffic congestion presents more than a headache for commuters; it has a negative impact on the delivery of goods and services and the general well-being of citizens. The Washington, D.C., metropolitan area has the nation's highest rate of congestion. The Crystal City corridor also experiences high levels of congestion, as it is the first exit out of Washington DC 14 street bridge and a way to get to Reagan National Airport.

This capstone paper has demonstrated the need for smart traffic lighting system in Crystal City Corridor of Arlington Virginia, which will be used to streamline the traffic congestion and intersection management due to sudden population and business growth. A thorough interaction between the stakeholders together with benefits and how each stakeholder will experience from the deployment of Rapid Flow SurTrac system in 27 intersections with traffic signals in Crystal City corridor. Information about the current state of the intersections and the traffic challenges, and the needed technology have been collected and presented. Issues regarding the migration have been explained. The mission model has been proposed using the Osterwalder canvas. SurTrac is a technology with a lot of potential to improve the traffic congestion challenges for the roads and traffic signal intersections in Crystal City. Facilitating this technology must be implemented to ensure interoperability and ubiquitous deployment.
Appendix

Figures and Images

Image 1 Congested Routes in Red - Map Crystal City Corridor (Source)

Image 2 Causes of Congestion (Source)

Image 3 Crystal City Traffic Lights Count Map 1 (Source)

Image 4 Crystal City Traffic Lights Count Map 2 (Source)

Image 5 SurTrac Traffic Control System Process (Source)

Image 6 Annual Hours of Delay in Washington DC Region (Source)

Image 7 Average Commute Length Virginias (Source)

Image 8 Reducing Traffic Challenges - Mission Model Canvas (Created by Author)

Image 9 Value Propositions of Technology Suppliers (Created by Author)

Image 10 Value Propositions of Road Users (Created by Author)

Image 11 Value Propositions of Service Provider (Created by Author)

Image 12 Communication between Key Partners & Beneficiaries to Achieve the Mission (Created by Author)
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Figures and Images

Image 1 Congested Routes in Red - Map Crystal City Corridor (Source)

Causes of Congestions

- Special Events: 5%
- Poor Signal Timing: 5%
- Bad Weather: 15%
- Work Zones: 25%
- Bottlenecks: 40%
- Traffic Incidents: 10%

Image 2 Causes of Congestion (Source)
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Image 3 Crystal City Traffic Lights Count Map 1 (Source)

Image 4 Crystal City Traffic Lights Count Map 2 (Source)
Reducing Traffic Challenges

Image 5 SurTrac Traffic Control System Process (Source)

Image 6 Annual Hours of Delay in Washington DC Region (Source)
Reducing Traffic Challenges

**Image 7 Average Commute Length Virginia (Source)**

**Mission Model Canvas – Reducing Traffic Challenges**

**Key Partners**
- Scalable Scalable Urban Traffic Control (SURTRAC) Consultants
- Virginia Department of Transportation
- Commonwealth State of Virginia

**Key Activities**
- Planning
- Executing
- Maintaining
- Customer Service
- Complying with Rules & Regulations
- Code of Ethics
- Record Keeping
- Risk Mitigation

**Value Propositions**
- Road Users:
  - Reduce travel time
  - Reduce wait times at intersections
  - Reduce emissions rates
- Technology Suppliers:
  - Ownership of Product/Service
  - Competitive Advantage
  - Meet Timelines
- Service Provider/Enabler:
  - Smooth transition to new technology
  - Strong Customer Service

**Buy-in Support**
- Market Study
- Explain Benefits
- Solicit Feedback
- Address Concerns
- Engage Emotions

**Key Resources**
- Human Resources
- Finances
- Lamps
- Human Resources
- Engineers
- Marketing
- Business Partners
- Intellectual Resources
- Databases
- Software & Hardware
- Financial Resources
- Funding Sources

**Beneficiaries**
- Road Users
  - Drivers
  - Non-Commercial
  - Commercial
    - Uber/Lyft
    - Freight
    - Deliveries
  - Pedestrians & Bicyclists
  - Technology Suppliers
  - Service Provider/Enabler

**Cost Structure**
- Value Driven
  - Fixed Cost - Building Rent, machinery
  - Variable Cost - Labor & Materials

**Mission Achievements**
- Reduce travel time by 20%
- Wait times at intersections up to 10%
- Emissions rates up to 20%

http://www.businessmodelegeneration.com

**Image 8 Reducing Traffic Challenges - Mission Model Canvas (Created by Author)**
Reducing Traffic Challenges

VALUE PROPOSITION CANVAS – REDUCING TRAFFIC CHALLENGES

**Value Proposition: Smart Traffic Lighting System**
- **Gain Creators**
  - SurTrac: Smart Traffic Light sensors with Cameras and Lamps
  - Inventory of all sensors and lamps kept locally in City of Pittsburgh.
  - Company branding
  - Balance inventory, on time deliveries and manage supplies
  - Maintain supply skills & capabilities
  - Monitor quality at every step

**Beneficiaries: Technology Suppliers**
- **Gains**
  - Ownership of sensors, lamps, and camera equipment
  - Competitive advantage
  - Meet timelines
  - Inventory
  - Quality testing
  - Ordering
  - Delivery
  - Warranty agreements

**Value Proposition: Smart Traffic Lighting System**
- **Gain Creators**
  - SurTrac: Traffic Light sensor gather and evaluate data on traffic patterns through the use of cameras, radar signals, and a network of coordinates.
  - Each sensor only focuses on one intersection.
  - The sensor communicates with other intersections based on the data collected.
  - Lost time sitting in traffic can be used more productively.
  - Stop eating harmful chemicals in the environment.
  - Relief from congestion anxiety and stress.
  - Avoid traffic annoyances and spend time with family or home chores

**Beneficiary: Road Users**
- **Gains**
  - Reduce travel time
  - Reduce wait times at intersections
  - Reduce emission rates
  - Feel Good/ Tenacity, free driving
  - Lower Driving Risk
  - Save too much time on the road
  - Burn less gas and emissions
  - Feel less stressed and angry
  - Annoyances while driving

PREPARED BY RAJEEV GUPTA 12/10/2018 – CAPSTONE PROJECT – REDUCING TRAFFIC CHALLENGES

Image 9 Value Propositions of Technology Suppliers (Created by Author)

Image 10 Value Propositions of Road Users (Created by Author)
VALUE PROPOSITION CANVAS – REDUCING TRAFFIC CHALLENGES

Image 11 Value Propositions of Service Provider (Created by Author)

Image 12 Communication between Key Partners & Beneficiaries to Achieve the Mission (Created by Author)
Works Cited

AICPA. (2014). *The importance of internal control in financial reporting and safeguarding plan assets*. Retrieved from AICPA:


https://transportation.arlingtonva.us/streets/traffic-signals/


http://www.cityofirvine.org/signal-operations-maintenance/advantages-traffic-signals


https://products.currentbyge.com/transportation-lighting/led-traffic-signals/gtx-heated-shell

Reducing Traffic Challenges

Design-concept-info-sheets. (2018). Retrieved from Mid-Block Crossings:
https://wjbproject.com/assets/design-concept-info-sheets.pdf


https://www.washingtonpost.com/local/despise-your-commute-metro-uber-and-lyft-are-conspiring-to-make-it-worse/2017/12/04/cca0cebe-d915-11e7-b1a8-62589434a581_story.html?utm_term=.7e46d0c75aa0

Feiner, L. (2018, November 5). Crystal City locals expect surging property prices, heavy traffic and lots of jobs if Amazon comes. Retrieved from CNBC TECH:

Fox, P., & Henry, J. (2018, November 13). Virginia Tech's Innovation Campus was key to attracting Amazon to Northern Virginia. Retrieved from WUSA9:
Reducing Traffic Challenges


https://prezi.com/hz2ruu95dkcx/traffic-control-and-management-system/


Reducing Traffic Challenges

amazon-hq2-if-it-cant-cope-now-with-gridlock-and-housing-costs/2018/05/12/a175afb0-4991-11e8-8b5a-3b1697adcc2a_story.html?utm_term=.019675af5d24


https://www.rapidflowtech.com/surtrac/how-it-works


https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa10005/brief_5.cfm
Reducing Traffic Challenges

*Smart Traffic Signals*. (2012). Retrieved from CMU:

https://www.cmu.edu/homepage/computing/2012/fall/smart-traffic-signals.shtml


Timeanddate. (2018). *Travel Time Calculator*. Retrieved from Time and Date:

Reducing Traffic Challenges


https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa10005/docs/brief_5.pdf

http://www.virginiadot.org/newsroom/media_faq.asp

http://www.virginiadot.org/about/resources/codeofethicsB.pdf

https://vaperforms.virginia.gov/transportation_trafficCongestion.cfm

http://www.experts123.com/q/what-influences-traffic-congestion.html


https://www.ri.cmu.edu/publications/schedule-driven-intersection-control/