



surtrac Smart Traffic Light

Non-Market Strategy Analysis Project Report

Department of Engineering and Public Policy
New Technology Commercialization: Non-Market Public Policy
Strategies for Entrepreneurs and Innovators

Carnegie Mellon University

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1.0 Executive Summary

Traffic congestion and vehicular emissions are some of the major issues faced by road users today. According to a recent Texas A&M annual mobility study, the average American commuter spends about 38 hours per traffic year in traffic jams.¹ This study identifies Washington DC as the the most traffic congested city in the U.S. followed by Los Angeles, with commuters spending as much as 67 hours spent in traffic per year. In developing a solution to this problem, the SURTRAC team designed a smart traffic control system that optimizes signal timings while allocating green time to different intersection phases based on vehicle presence, vehicle count and flow-through data collected by vehicle presence detectors at intersections. This approach to traffic control differs from methods previously used at it allows for real-time optimization of traffic controls by responding to changes in traffic conditions, while operating in a decentralized manner. It is designed to accommodate urban grid networks and road corridors with the aim of reducing the amount of time vehicles spend idling on roads while enabling an optimal use of road transportation networks and reducing the contribution from transportation to Green House Gas (GHG) emissions in the U.S. SURTRAC was invented by three (3) members of the Robotics Institute at Carnegie Mellon University, including research professor Stephen Smith and Project Scientists Greg Barlow and Xiao-Feng Xie. Currently, this team has achieved a number of successes with testing its technology, successfully filing provisional patent and also developed a partnership with the Pubic Works Department of Pittsburgh. The SURTRAC software was successfully piloted at 9 intersections in the East Liberty area of Pittsburgh and is in the process of bing expanded to an additional 31 intersections covering Point Breeze, Bakery Square and Baum and Centre. From this pilot project, the team was able to record significant savings in travel time and reduced emission levels showing results of 26% less time spent by vehicles on the roads with vehicles spending 41% less time idling and experiencing 31% fewer stops. The SURTRAC technology was also able to reduce vehicular emissions by 21% based on data collected from the intersections. In characterizing SURTRACs non-market, we identified the major issue the firm has set out to solve which is addressing issues that might affect the ease of acceptance of its technology by various stakeholders in its industry; focusing on the challenges: liability, privacy, and opportunities: funding and emissions the firm might both have to face and also could leverage as it works towards commercializing its technology. We also identified key institutions including both Federal and State Departments of Transportation, traffic control system manufacturers such as Siemens and McCain, the general public, governmental agencies like the Environmental Protection Agency (EPA), etc that would be interested in the workings and viability of this new technology and whose activities could significantly affect SURTRACs bid to commercialize its technology.

In this report, we started by giving an overview of the SURTRAC technology. We discussed SURTRACs traffic optimization technique, highlighting the various obstacles to adoption of the technology, standards and potential market the new innovation is looking to address. We then talked about the potential challenges the team might face going forward and also opportunities it could leverage in commercializing its technology, highlighting the policy context and various interest groups the SURTRAC team might need to engage with in trying to get its technology adopted. In our final recommendation for the SURTRAC team, we propose that they focus their marketing efforts on the emission reduction value proposition of their technology by targeting cities that are in noncompliance with National Ambient Air Quality Standards set by the Environmental Protection Agency. From our research, we also see that a number of funding opportunities exist for government agencies and cities in improving traffic safety and other usage metrics for their roads and we believe that companies like SURTRAC could create partnerships with these cities or agencies who might be interested in the ability of its technology in solving their needs in getting its product to market faster.

¹ Annual Urban Mobility Report, Texas A&M University, <http://mobility.tamu.edu/ums/>

2.0 Technology Overview

Scalable Urban Traffic Control (SURTRAC) is a smart-traffic light control system that optimizes the flow of traffic at already signalized intersections through the integration of its proprietary software with existing traffic control machines. According to a study by the Texas A&M Transportation Institute, more than \$121 billion was wasted as a result of traffic congestion (in vehicular emissions and idling time) in the United States alone. A wide range of technologies have been deployed for the resolution of these delays and emissions, however with the rapid urbanization of cities in the US and the complex road networks being built to service the growth in road users which is as a result of the growth in urbanization, more sophisticated traffic control technology is needed in abating this problems.

In working to resolve this problem, the team at SURTRAC has designed a traffic control system that optimizes signal timings while allocating green time to different intersection phases based on vehicle presence, vehicle count and flow-through data collected by vehicle presence detectors at intersections. This novel approach to traffic control differs from methods previously used as it allows for real-time second by second optimization of traffic controls and responsiveness to changing traffic conditions, while operating in a decentralized manner and designed to accommodate urban grid networks and road corridors. SURTRAC - the smart traffic control system was invented to solve these problems by 3 faculties in the Robotics Institute at Carnegie Mellon University. They include Research Professor Stephen Smith and Project Scientists Greg Barlow and Xiao-Feng Xie. The aim of this smart traffic light system is to reduce the amount of time vehicles spend idling on roads while enabling an optimal use of road transportation networks and reducing the contribution from transportation to Green House Gas (GHG) emissions in the U.S. Currently, this technology has reached several big progresses such as the provisional patent and partnership with the Public Works Department of Pittsburgh. Their pilot project has been proved to be very successful and will keep on expanding in the future.

The SURTRAC traffic control method is developed based on basic concepts in traffic control theory while using a new method of signal scheduling by treating traffic congestion problems as a single machine scheduling problem allowing for near-optimal optimization of traffic signal timing and phase scheduling problems.²

The key technical ideas that govern the operation of the SURTRAC system are:

- i. Schedule Driven Intersection Control: Here, traffic at each intersection is analyzed as a mathematical problem known as a “machine scheduling problem” where traffic flows are represented as aggregates or sequences of queues of vehicles for signal allocation purposes and these schedules are then used to decide whether to extend or switch phase between the different lanes which make up the intersections.
- ii. Schedule Driven Coordination: Here, schedules are communicated to downstream neighboring intersections, serving as inputs to these intersections in optimizing their traffic control. A spill back mechanism is created for coping with uncoordinated situations to account for changes in schedules.³

²Smith, S. F., G. J. Barlow, X.-F. Xie, and Z. B. Rubinstein. Schedule Driven Intersection Control. CMU-RI-TR-12-20, The Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, 2012.

³Xie, X.-F., S. F. Smith, and G. J. Barlow. Schedule-driven coordination for real-time traffic network control. In International Conference on Automated Planning and Scheduling (ICAPS), Sao Paulo, Brazil, 2012.

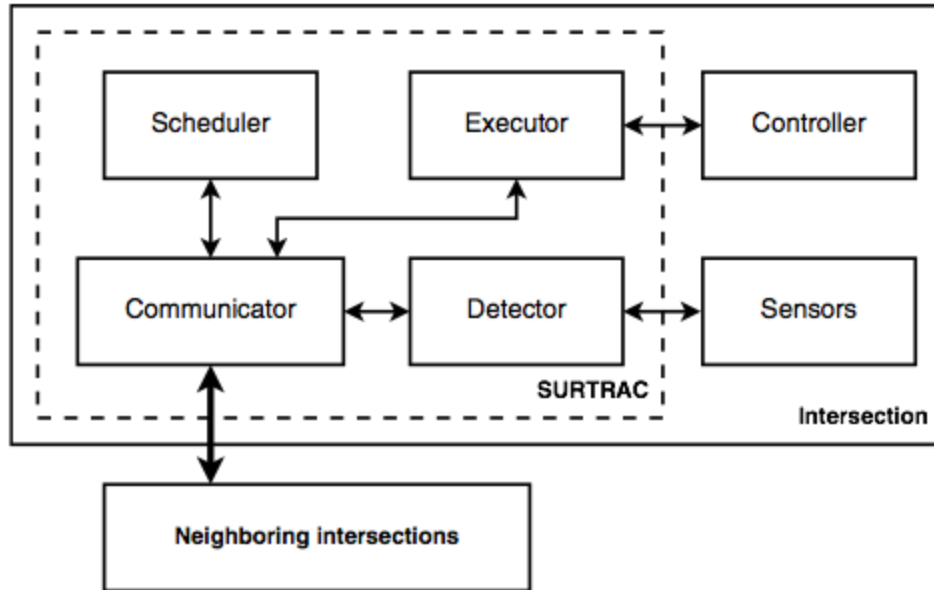


Figure 1: SURTRAC system diagram. The Detector interfaces with sensors located at the intersection, the Scheduler the Scheduler allocates green time based on incoming vehicle flows, the Executor interfaces with the controller to implement schedules generated by the Scheduler, and the Communicator routes messages locally and to/from neighboring intersections.

2.1 Technical Approach

The functional aim of the SURTRAC traffic control system is to enable real-time optimization of traffic control for urban (grid) road networks. It achieves this by adopting a decentralized method to traffic flow control at intersections where vehicle movement phases are developed independently for each intersection based on current traffic conditions detected by vehicle presence detectors at the intersections. In the event where more than one intersection is intended to be being controlled by the SURTRAC system, traffic along the grid or corridor of intersections is controlled in a coordinated fashion where planned outflows (or information regarding vehicular flow “out of an intersection”) are communicated to neighboring intersections and used to create green-corridors.

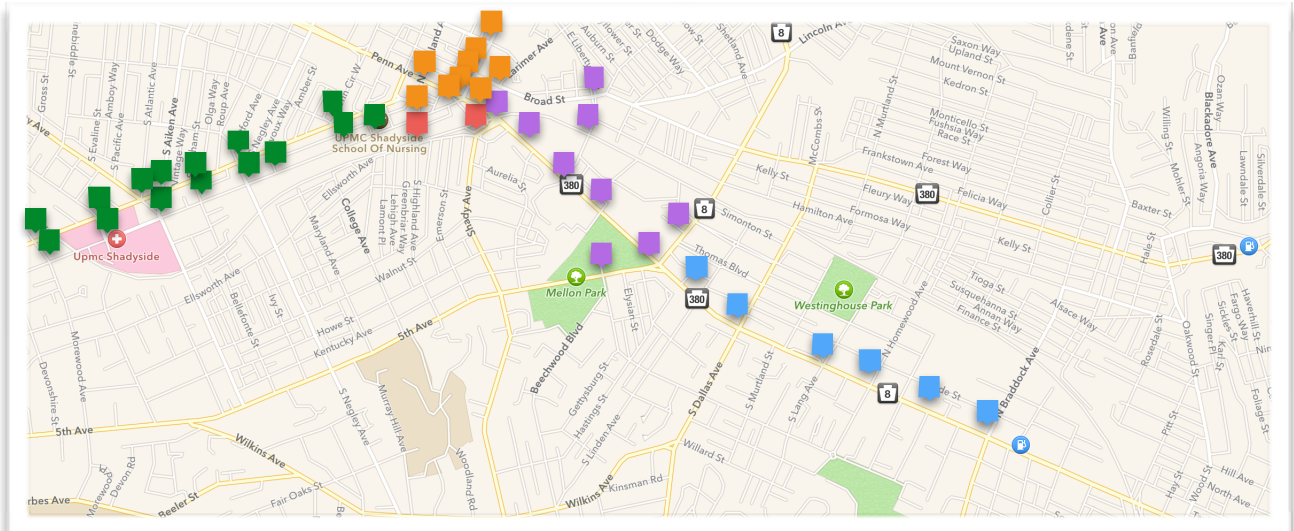
The control process for the SURTRAC traffic control system could be summarized as follows:

- Current traffic conditions are extracted from traffic sensor data systems/feeds which include CCTV cameras
- The SURTRAC system computes phase schedule that optimizes flow at intersections and sends command to controller when it is time to change phases
- The system communicates expected outputs/outflows or schedules to downstream neighbors to indicate incoming vehicular flows.

2.2 Current Implementation and Progress

In May 2012, the City of Pittsburgh Department of Public Works and Carnegie Mellon University entered into an agreement to deploy the SURTRAC Smart Traffic Light control system, after which a pilot project covering nine intersections in the East Liberty region of Pittsburgh was commissioned. Before the pilot test, control of these nine intersections was accomplished using coordinated timing plans that were optimized offline for AM and PM rush periods and simple actuated control (free mode) during non-rush periods.

Conducting a performance comparison of intersection traffic with the SURTRAC system installed against that of the previously existing traffic signal control scheme, traffic flow through



East Liberty (9)

Baum and Centre Avenue (22)

Bakery Square

Point Breeze (+9)

June 2012 **26% lower travel time - 41% less time idling - 31% fewer stops - 21% lower emissions** Today

Figure 2: SURTRAC Pittsburgh Pilot Project Timeline

the intersections improved significantly across a number of metrics ranging from travel time, speed, number of stops, wait time, fuel consumption and emissions with the improvements ranging from 20%-40% overall.⁴ The network of intersections spacing the pilot project was thus expanded to cover Penn Avenue up to Fifth Avenue, with a total of 18 intersections now controlled by SURTRAC. Though most of the pilot project has been focused on improving motorized traffic flow, the SURTRAC system is designed to optimize for all modes of travel, including pedestrians, cyclists, transit, and light vehicles. With improved sensors, like cameras for automatic pedestrian detection, SURTRAC can further improve service for all modes of travel, while still reducing vehicle delay and lowering emissions. The SURTRAC team is currently working to pilot advanced pedestrian, bike, bus, and connected vehicle detection to improve the operational capability of the SURTRAC system and to help make Pittsburgh a leader in intelligent transportation. The SURTRAC team is currently in discussions with the City of Pittsburgh Department of Works under a public-private partnership to further expand its control network by adding 31 more intersections in the East End over the next year, for a total of 49 surtrac intersections in Pittsburgh by mid-2015. They are also looking to other states and localities to expand testing and implementation.

An snapshot of the progress achieved in the testing of the SURTRAC system using pilots in Pittsburgh:

- 2010 – 2011: Development of core approach; Demonstration of effectiveness in simulation on Downtown Pittsburgh road network.
- 2011 – 2012: East Liberty Pilot Implementation
- 2013 – Present: Expansion of pilot test sites

2.3 Obstacles to Adoption

A few of the obstacles to the widespread adoption of new technology for improving the operations of traffic lights such as SURTRAC include:

⁴ SURTRAC: Scalable Urban Traffic Control

- Non-communication between vehicles and Traffic Lights: The technology would achieve optimum functionality if such traffic systems were able to communicate directly with vehicles themselves. However, as of yet most vehicles on the road are unable to communicate with the computer systems that town and city authorities use to control traffic lights.
- Costs: The costs of adopting new technology in the optimization of traffic signal control sometimes serves as a hindrance towards its adoption. This is because depending on the complexity of intersections, the control mechanisms needed might vary considerably in costs and the organizations whose jurisdiction the intersections are under might be wary of carrying out improvement projects as a result of the need to fund other projects.
- Privacy concerns from the use of close-circuit television: This is as a result of the use close-circuit television cameras as sensors for vehicle presence detection and monitoring of traffic conditions.⁵
- Perceived bias towards motorists: One of the major concerns towards the adoption of traffic signalization improvement technology like SURTRAC is its ability to reduce traffic delays while increasing vehicular speed through intersections. Thus, while this favors motorists, it leaves out other categories of users such as pedestrians and cyclists.
- Delayed reaction to faults in implementation due to drivers getting accustomed and dependent on the traffic signal plans.

2.4 Market

The SURTRAC system is designed as an add-on/plugin for existing traffic control installations as a means to optimizing their operations. It is targeted at Original Equipment Manufacturers (OEMs) of traffic control systems and also various organizations (governmental and nongovernmental) looking to mitigate the traffic delays on urban roads while reducing emission levels caused by traffic congestion by optimizing the present capacity of their traffic control installations. Governmental organizations that might be interesting in adopting the SURTRAC technology include the Federal and State Departments of Transportation, local transportation agencies, the Federal Highway Administration, etc. Private and nongovernmental organizations that would be interested in this technology would include traffic control equipment manufacturers, road construction companies, community associations, etc.

2.5 Technology Transfer

SURTRAC is currently a university project developed by Stephen Smith and Gregory Barlow, both Professors in the Robotics Institute at Carnegie Mellon University. Though research and product development for SURTRAC have since being carried out using CMU facilities, it is in the process of being spun out of CMU as an independent company. The founders are working with the Center for Technology Transfer and Enterprise Creation (CTTEC) at Carnegie Mellon University in working out the licensing and ownership rights that would accrue to the university in its contribution towards the formation of their company.

2.6 Intellectual Property

In June 2013, the SURTRAC team filed a provisional patent for their traffic optimization technology and are currently working with the CTTEC at CMU to make the actual patent application for their new technology. The provisional patent was filed to cover the technology behind the formulation of traffic control optimization problems as machine scheduling problems, which reduces the complexity of the search space and allows the problem to be solved extremely quickly.

⁵Is Traffic Signal Synchronization Justifiable?, Michael J. Vandeman, April 1994

2.7 Liability

Liability is a major concern of the SURTRAC team because they are developing technology that is directly related to the on-road safety of drivers. Malfunctions in their traffic control networks have the potential to cause accidents. The company has requested that we look more into the length of time for which the company is held liable after the software is installed on a traffic system. The management team is aware of existing frameworks where liability is shifted to the state or to the entity managing the roads as time progresses after the installation.

2.8 Open Source Software

The SURTRAC software has been designed as a proprietary software for optimizing the operations of existing traffic signal control installations to be sold to transportation agencies and manufacturers of traffic control systems.

The SURTRAC code is written with links to open source libraries but is not subject to any open source licensing terms.

2.9 Regulatory Approval

Working through the CTTEC at Carnegie Mellon University, the SURTRAC team won approval from the City of Pittsburgh Department of Public Works in June 2012 to pilot the traffic optimization technology on number of roads in Pittsburgh, PA, deploying the SURTRAC system at 9 intersections in the East Liberty region of Pittsburgh. The team is currently working on extending the project to cover a total of 31 additional intersections in the Pittsburgh area. Taking this approach to expanding the reach of its technology, the SURTRAC team would need approval from a range of government transportation ministries and regulatory bodies, depending on where they decide to install the systems in order to get their technology out in the field. For the Pittsburgh pilot program, interested parties ranging from the city traffic commissioner, local community boards, business improvement districts and the public were also engaged in the process of piloting the new technology.

2.10 Government Incentives

The SURTRAC technology is being developed as a software product and its inventors do not intend to go into the manufacture of turn-key traffic control systems. Thus, cities or agencies looking to adopt the technology would probably require specialized knowledge in going ahead with its deployment. This, in some cases, might prove a stumbling block for the team in gaining mass adoption of its system as it would require their hands-on presence during the system deployment process. It might also affect their negotiating and lobbying power for incentives as the specialist experience needed might seem to create less jobs than required, which sometimes is a criteria for the granting of Federal incentives to companies. The company however intends to provide full scale training for the traffic engineering staff of the respective agencies it would be working with as a means of knowledge transfer, thus enabling them to effectively take on ownership of the maintenance process of the system once deployed. It also provides a different set of benefits to both roads users and other interest groups including a reduction in traffic congestion and air pollution emissions including greenhouse emissions and particulate matter emissions. Thus cities not in compliance with Federal and State environmental regulations for particulate matter may have an incentive to invest in SURTRAC's technology. Upon incorporation of the company, the team may also be able to leverage these value propositions in applying for grants geared towards meeting greenhouse and particulate matter emission reduction initiatives and transportation congestion improvement goals.

2.11 Standards

As is the case for technologies associated with the transportation industry there are a plethora of standards that need to be met to ensure continuity, consistency and safety. Signalling and traffic control standards are of particular importance to an initiative like SURTRAC. Although the Federal Highway Administration develops standards and guidelines through the Manual on Uniform Traffic Control Devices (MUTCD) which apply to the usage of traffic control equipment, individual state and local agencies also provide their own versions and complementary specifications to these standards to suit their own road types. SURTRAC handles inputs and outputs to signal controller systems that are subject to federal and state standards. Thus, the SURTRAC technology works with existing standards (for timing and communication), but is itself not subject to any unique standards.

However a standard that might influence the adoption of the SURTRAC software is the National Transportation Communications for Intelligent Transportation System Protocol (NTCIP). The NTCIP is a family of standards designed to achieve interoperability and interchangeability between computers and electronic traffic control equipment from different manufacturers. The protocol is the product of a joint standardization project guided by the Joint Committee on the NTCIP, which is composed of six representatives each from the National Electrical Manufacturers Association (NEMA), the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers (ITE).⁶

2.12 Privacy

The SURTRAC system works by monitoring vehicles flow at intersections and their movement patterns as a whole not by capturing data on individual drivers. However, its use of close-circuit television cameras as sensors for vehicle presence detection and sensing traffic conditions. Some road users are concerned that the sensor technology used in distributed traffic control systems could be used for unwanted location tracking of individual vehicles. However, SURTRAC uses many of the same traffic sensor functionality that is already in place on roads today. Speed cameras and other forms of road monitoring have been functioning on U.S. roads for years and we believe that many of the same concerns could arise for SURTRAC.

2.13 Environment and Health

Traffic control technology are installed at intersections for a number of reasons. They include:

- i. To reduce the amount of time motorists spend on the road
- ii. To allow for more efficient use of road capacity by increasing throughput of vehicles through intersections
- iii. Reduced vehicular emissions from stationary vehicles on roads

The absence of traffic lights at intersections with significant traffic congestion add to the pollution of the atmosphere as stationary exhaust fumes from stationary cars introduce nitrous oxides and carbon dioxide, air pollutants into the atmosphere, serving as a significant contributor to climate change.

Thus, the use of traffic optimization signal software like SURTRAC in mitigating traffic congestion and vehicular emission issues present significant health and environmental benefits.⁷

⁶ National Transportation Communications for Intelligent Transportation System Protocol (NTCIP), <https://www.ntcip.org/info/default.asp>

⁷ Fuglestvet et al., Center for International Climate and Environmental Research (2007). "Climate forcing from the transport sectors"

2.14 Spectrum And Communications Concerns

SURTRAC relies on the use of vehicle presence detector equipment for real-time data collection of traffic flow information at intersections it is deployed at. These equipment operate and communicate with each other in compliance with the Dedicated Short Range Communications (DSRC) technology protocol, designed under the auspices of the International Telecommunications Union (ITU). The DSRC is a two-way short-to-medium-range wireless communications capability that allows for the communication of both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications, enabling very high data transmission rates critical in communications-based active safety applications. According to Federal Communication Commission (FCC) Report and Order FCC-03-324, the commission allocated 75 MHz of spectrum in the 5.9 GHz band for use by Intelligent Transportations Systems (ITS) vehicle safety and mobility applications.⁸ The SURTRAC system controls traffic by computing signal optimizations at individual intersections and then sharing the derived information with neighboring intersections as input for calculating appropriate signal timing for their current operations. Due to the fact that SURTRAC operates in a decentralized manner and data is distributed or broadcast to central locations only on demand, this communication protocol would play a significant role in its ability to function in a decentralized manner. Concerns, however could arise in the event of defective communication between control equipment at the different intersections in the SURTRAC control grid network. SURTRAC has been designed to address this issue by polling inputs from neighboring intersections in real-time to identify issues with non-transmission of required input data. In the event of such a disruption in communication, the signal timing for the intersection is computed using only data from the particular intersection while setting up a flag, alerting the required agencies of such communication disruption. However, though the success of the SURTRAC technology relies to a significant extent on the ability of the peripheral control equipment to function effectively for its own optimal operation, it is assumed that these equipment already exist at the intersections it would be deployed at. Communication compliance issues would thus only arise when the team would need to install additional control equipment or sensors that are not in compliance with the requisite standards. It would only be required to obtain permission for use of certain detector equipment that do not conform with the communication standards set out by the NTCIP.

⁸ Dedicated Short Range Communications, http://www.its.dot.gov/factsheets/dsrc_factsheet.htm, April 2014

3.0 Challenge and Opportunity Identification

3.1 Challenges

The SURTRAC team faces a number of challenges on how to ensure a wide-adoption of its technology. Though the SURTRAC smart traffic light system provides evidently significant value, the team still has to address these issues/challenges in order to make its technology attractive to institutions within its non-market environment.

3.1.1 Liability

Following from previous discussions, the SURTRAC team considers liability to be of major concern to the commercialization of their technology as it directly affects the level of safety of road intersections at which they are deployed. A simple malfunction of the control system has the potential to result in accidents on roads. The SURTRAC team has identified this issue to be of utmost importance and has begun looking into ways of ensuring optimal functionality of their software while trying to understand the laws guiding liability of affected parties in the event of an accident resulting from the malfunction of traffic control systems. This is because the issue of liability directly affects the viability of the SURTRAC value proposition both from both a customer-centric and investors perspective. The length of time for which OEMs are held liable after their systems are deployed at road intersections is presently defined according to the contract statement between the purchasing agency and manufacturer. This scenario would also apply to the SURTRAC technology though in the event of the deployment of its technology, liability would then have to be shared between it and the equipment manufacturers. A defined liability agreement that cuts across and thus and any clarification to this would go a long way in helping the team know what would be required of them in the event of a mishap due to a failure in the control mechanism of their technology. The SURTRAC team is aware of existing frameworks where liability is shifted to the state or to the entity managing the roads as time progresses after the installation and thus would like to come up with a more definite liability sharing structure as it directly affects the success of their venture.

3.1.2 Privacy

Public opinion regarding use of Closed Circuit Television (CCTV) equipment as vehicle presence detectors at intersections have in recent times been discussed in a number of institutional settings. Though these equipment have long being used in tandem with traffic control systems, the SURTRAC platform leverages them extensively in its ability to obtain real-time information on traffic flow at intersections it has being deployed at. Speed cameras and other forms of road monitoring have been functioning on US roads for years and we believe that many of the same concerns and public sentiment it has accrued could also apply to SURTRAC. One key example would be issues relating to the use of Red Light Cameras in traffic control in the United States. Red Light Cameras are traffic monitoring devices that capture images of vehicles which have entered an intersection against a red traffic light. They are used by traffic control authorities in automatically photographing vehicles that run red lights, providing evidence that assists these agencies in the enforcement of traffic laws against drivers who run against red lights. These devices have two methods of operation. A category of red light cameras operate by regularly recording videos of the intersections where they are installed while taking snapshots of vehicles that are sensed to have “beat” the red lights. The second category of red light cameras operate by monitoring traffic flow at intersections while getting triggered (and taking a snapshot of the number plate of the respective vehicle) only when a vehicle enters the intersection after the traffic light has turned red. These videos and/or still images are then stored on computers servers owned by the monitoring agencies for use in identifying the erring drivers. A law enforcement official will review photographic evidence from the scene to determine

whether the driver is in violation of the stop red-light signal.⁹ Though it is stated that the intent of red light cameras is not to capture data on individual drivers, but on intersections and patterns as a whole, it is generally believed that since these equipment could be used in identifying erring drivers, they could also be used in generally monitoring individuals. Proponents of the use of red light cameras cite their use in increasing the safety levels of roads. Proceeds from fines paid by erring drivers are also used in funding traffic improvement and signalization projects in states where they are installed at intersections. An example would be the joining of the city of Pittsburgh in the Red-Light Enforcement Program, with the city deciding to install red-light traffic cameras on about 20 intersections across the state in 2014. Proceeds from this program would go towards the replacement and upgrade of traffic signals at intersections in various locations across the state including Fourth Avenue and Broadway Street, Fifth Avenue, McKeesport etc. Still a study of the operations of red-light traffic cameras show that the existence of these equipment at intersections often to lead to an increase in vehicular crashes (especially), with an increase in vehicular crashes by an amount of 20% and personal injury by 21% after the red light cameras are installed.¹⁰ Also, the use of red-light cameras are considered an invasion of privacy due their video and image capture abilities. In trying to dissuade public fear regarding the issue of privacy, agencies championing the advantages of red-light cameras claim that “you have no expectation of privacy if you break the law”.¹¹ However, this argument is flawed as it only stands true if the cameras are 100% accurate, which they are not. To further buttress this point, camera manufacturers themselves claim that existing systems in operation up to 40% of the time, give erroneous results. Thus, privacy features as an important issue for traffic light control manufacturers. however, seeing that the SURTRAC system is a software product that plugs into existing traffic control systems in optimizing their operational abilities, the issue of privacy might not be a big hindrance to its adoption or commercialization.

3.1.3 Costs

The costs of adopting new technology in the optimization of traffic signal control sometimes serves as a hindrance towards its adoption. This is because depending on the complexity of intersections, the control mechanisms needed might vary considerably in costs and the organizations whose jurisdiction the intersections are under might be wary of carrying out improvement projects as a result of the need to fund other projects. Currently, the SURTRAC software costs \$20,000 per intersection it would be installed at and would significantly reduce as the number of additional intersections it is deployed at in a road network increases. However, this costs would have to compared against that of either maintaining status quo (basically leaving the road users to suffer costs from delays in transportation or costs due to a polluted atmosphere) or adopting a competing technology. Examples of these competing technologies include: RHODES and PRODYN both of which are research projects just like SURTRAC on adaptive traffic control and are mostly used by Traffic Control System manufacturers in developing the control mechanism behind their machines. The deployment and maintenance of the SURTRAC system would also require expert knowledge of its operations to be carried out successfully. Thus, the team intends to provide prospective agencies or machine manufacturers with required trainings on how to deploy the system to ensure effective roll out of the platform at the intersections.

⁹ Traffic Light Violation, <http://www.asiagw.com/traffic-light-violation.htm>, June 2013

¹⁰ An analysis of North American Red-Light Camera Studies and Reports, StPeteCameras.org, January 4, 2011

¹¹ The Arguments Against Red Light Cameras, <http://www.stpetecameras.org/home/for-and-against-rlcs/the-arguments-against-red-light-cameras>

3.2 Opportunities

3.2.1 Funding

The commercial viability of SURTRAC's technology provides the most significant opportunities for the company. SURTRAC's business model has the potential to be successful as a high-margin, big-customer software and consulting business. However, it would need to show significant value to its potential investors or agencies looking to leverage its working operations in ensuring its profitability. One of the sources of funding the team is currently considering is investments from venture capital firms. These firms typically make their investment decisions based on a number of criteria ranging from the potential market size of a company's product, growth rate of actual customers, Intellectual Property (IP) ownership, growth in revenue/sales number. They would also want to see traction in these companies before they make their investment decisions. Seeing that SURTRAC is still in the process of being incorporated into a company and also that they still have only filed a provisional patent application, their proposition might not be as attractive to venture capital firms at this point in time. Pending the their receipt of the patent application in 2014 and hopefully based on the success of the pilot project, they should be able to successfully solicit funds from private investors.

Government Grants or Contracts

Various government grants exist in the United State through which companies with new technology designed to address issues relating to road-use safety, traffic congestion delay and vehicular emissions reduction could leverage the opportunity in bringing their products to market.

The SURTRAC technology delivers 3 key benefits to road users which could be categorized into the following:

- i. an improvement in traffic congestion, thus reducing the amount of time motorists spend on roads
- ii. improved vehicular flow and road usage patterns, allowing for more efficient use of road capacity by increasing throughput of vehicles through intersections and
- iii. a reduction in GHG and particulate matter emissions

These benefits help make it a suitable applicant for government grants as its value proposition matches directly with the purpose of the intended grants in resolving traffic congestion issues sustainably while also reducing the amount of emissions from vehicles on roads.

3.2.2 Emissions

Stationary vehicles in traffic contribute significantly to the increase in air pollution in cities with high traffic congestion rates. In 2011, 56 billion pounds of carbon dioxide was emitted into the atmosphere as a result of traffic congestion, amounting to about 380 pounds of CO₂ emissions per auto commuter. According to a study by researchers at the Center for Risk Analysis at the Harvard School of Public Health, "congestion in the USA's 83 largest urban areas last year led to more than 2,200 premature deaths and a related public health cost of at least \$18 billion".¹² Also, even with the introduction of electric vehicles from the likes of Tesla and the increase in adoption of hybrid vehicles across the U.S., a significant number of states still battle with the issue of vehicular emissions. A recent State of the Air report from the American Lung Association shows that California even with the recent uptake of hybrid vehicles, still is

¹² Emissions from Traffic Congestion May Shorten Lives, Harvard School of Public Health, www.hsph.harvard.edu/news/hsph-in-the-news/air-pollution-traffic-levy-von-stackelberg/

classified as the state with the most polluted cities.¹³ We believe that this presents an opportunity for the SURTRAC team to position its product as an emission reduction technology seeing it improves the flow of vehicles through intersections, significantly reducing the amount of emissions from these vehicles into the atmosphere.

¹³ Most Polluted Cities U.S., <http://www.stateoftheair.org/2014/city-rankings/most-polluted-cities.html>

4.0 Policy Context and Policy Forum

4.1 Policy Context

Despite significant investments in traffic control/congestion mitigation technologies, traffic congestion has been a source of major concern in cities across different states in the United States. On average, drivers in the US wasted 12.5 hours in traffic congestion in the trailing last year.¹⁴ Also, traffic congestion increased by about 9.3 percent from May 2012 to May 2013 in the U.S. Increased vehicular road usage has also resulted in an increase in vehicular emissions across the US.

In resolving these congestion issues, a number of systems have been developed in the US to enhance the operations of traffic control systems before SURTRAC. Some of them include:

- RHODES – Real-time Hierarchical Optimization Distributed Effective System; University of Arizona, Siemens Traffic Solutions
- RTTRACS – Real Time Traffic Adaptive signal Control System; PB Farradyne, FHWA
- ATSAC – Automatic Traffic Surveillance and Control; Los Angeles Department of Transportation (LADOT)
- OPAC – Optimization Policies for Adaptive Control; University of Lowell, U.S. Department of Transportation (U.S. DOT)
- ACSLite - Adaptive Control Software; Federal Highway Administration (FHWA).¹⁵

Though most of the above systems provide some form of actuated control of traffic systems, leveraging the use of sensors and centralized monitoring of traffic at intersections in enabling coordinated traffic control and though their use has provided significant improvements in traffic across different locations in the USA, a number of drawbacks still exist in their use.

They function mostly as centralized systems from which issues relating to latency and real-time reaction of traffic control to traffic conditions at respective intersections could occur. Also, due to their centralized operational model, traffic control projects using any of the technologies require significant amount of capital investments as a minimum number of intersections would have to be deployed at the same time to leverage the savings in delay and signal timing coordination that would arise from the system.

As is mentioned above, SURTRAC system doesn't have these defects and will better solve these challenges and turn them into opportunities.

4.1.1 Vehicular Emissions

According to the SURTRAC report, from the perspective of improving the quality of the air, which was the motivation behind the funding for this project, overall emissions are reduced by 21%.¹⁶

The table below shows the results of this study done at 10 cities and the equivalent social costs of the deaths resulting from vehicular emissions.

¹⁴ Inrix Scorecard, <http://scorecard.inrix.com/scorecard/>

¹⁵ Adaptive Traffic Control Systems in the United States, Matt Selinger, P.E., PTOE and Luke Schmidt, HDR Engineering, Inc., September 2009

¹⁶ SURTRAC: Scalable Urban Traffic Control, Stephen F. Smith, etc. TRB 2013 Annual Meeting

Urban area	Deaths	Social costs (in millions)
Atlanta	70	\$549
Boston	16	\$125
Chicago	251	\$1,982
Denver	24	\$192
Detroit	76	\$603
Houston	35	\$277
Los Angeles	426	\$3,362
Miami	40	\$316
New York	337	\$2,658
San Antonio	10	\$80

Table 1: Estimated number of premature deaths and associated public health costs in 2010 from traffic congestion in selected urban areas.
 Harvard Center for Risk Analysis, Harvard University School of Public Health

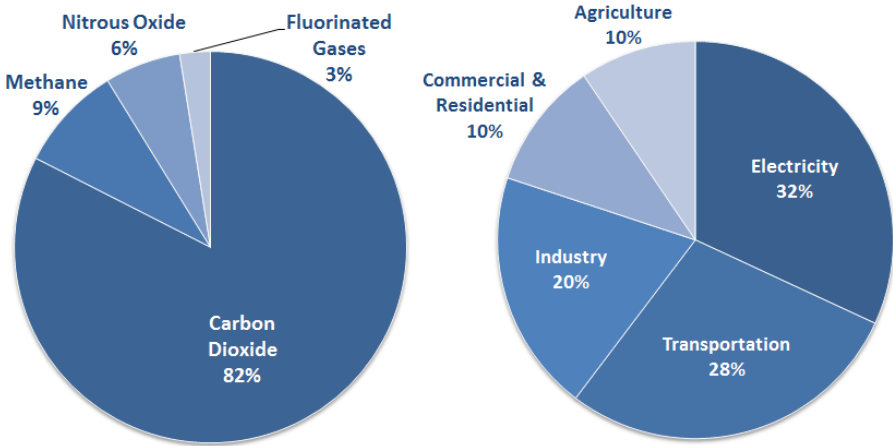


Figure 3: Sources of Green House Gas Emissions

Also, according to the EPA, “greenhouse gas emissions from transportation accounted for about 28% of total U.S. greenhouse gas emissions which amount to 6,702 Million Metric Tons of CO2 equivalent, making it the second largest contributor of U.S. greenhouse gas emissions after the Electricity sector” in 2011.¹⁷

As demand approaches the capacity of a road (or of the intersections along the road), extreme traffic congestion sets in, increasing the emission levels in the atmosphere.

According to performance improvement data at the nine intersections in Pittsburgh, comparing the SURTRAC pilot project over the pre-existing traffic control scheme, SURTRAC provides a significant amount of improvement in traffic flow and a reduction in the level of vehicular emissions upon deployment.

Quantifying the absolute impact of SURTRAC on vehicular emissions, it is necessary to once

¹⁷ Sources of Greenhouse Gas Emissions, <http://www.epa.gov/climatechange/ghgemissions/sources/transportation.html>

again consider traffic volumes through the pilot test site, Table 2 below indicates projected savings in fuel and pollutant emissions while considering an average of 29,940 vehicles per day. The SURTRAC pilot project resulted in an estimated daily savings in fuel of 247 gallons, implying a daily reduction in emissions of 2.253 metric tonnes. Thus, an annual projection of reductions in vehicular emissions this, could yield a total reduction of 588 metric tonnes from the continued operation of the SURTRAC system at the nine intersections.

Table 2: Summary of Pilot Test Results

Percent improvement	Average Vehicles	Travel Time %	Speed %	Number of Stops %	Wait Time %	Emissions %
AM Rush	5228	30.11	33.78	29.14	47.78	23.83
Mid Day	8007	32.83	48.55	52.58	49.82	29.00
PM Rush	9548	22.65	27.45	8.89	35.60	18.41
Evening	7157	17.52	27.81	34.97	27.56	14.01
Overall	29940	25.79	34.02	31.34	40.64	21.48

Table 3: Projected Emissions Savings from Pilot Project at 9 Intersections

Emissions	Daily (kg)	Annual (tonnes)
Fuel Consumption	247 gal	64,580 gal
Carbon Dioxide (CO ₂)	2213.85	577.82
Carbon Monoxide (CO)	17.30	4.51
Nitrogen Oxides (NO _x)	3.37	0.88
Volatile Organic Compounds (VOC)	4.01	1.05
Hydrocarbons	14.90	3.89
Total Emissions	2253.42	588.41

These results show the effectiveness and potential of the SURTRAC traffic light system in reducing both emissions and vehicular delay on urban road networks.

4.1.2 Congestion Costs

Across the U.S., in addition to being a waste of valuable time, congestion costs also included:

- A waste of 2.9 billion gallons of fuel due to congestion in 2012
- \$121 billion worth of congestion-related delay and fuel costs are realized annually

- Per commuter average cost of \$818 per year, up from \$342 in 1982 (adjusted for inflation).¹⁸

Using Pittsburgh as a case, in January 2014, the Pittsburgh Department of Public Works moved to approve the upgrade of downtown intersections with brand new traffic lights and control signals, starting with 11 selected intersections, connecting the lights via fibre optic cables to enable for a centralized control at the Department of Public Work's control room in city hall. This came as a second phase of signal upgrade/traffic light replacement project that started over 50 years ago.¹⁹ Still the congestion issues at various intersections in Pittsburgh still persist.

According to the report of SURTRAC, with respect to improved efficiency of vehicular flow through the intersections, average travel times through the pilot site are reduced by over 25%, average vehicle speed is increased by 34%, the number of stops is reduced by over 31%, and the average wait time is reduced by over 40%.²⁰

4.1.3 Liability

Understanding the issues relating to liability is a major point of concern for the SURTRAC team as their technology directly affects the safety levels of road intersections they are installed at. Traffic signals control the right of way for the different classes of road users and a malfunction in their operations has the potential to cause accidents, exposing the company to the risks of liability suits. Research into the liability issues due to accidents or mishaps on roads from malfunctioning traffic control equipment shows that liability is most times shared between a number of parties including the equipment manufacturer for example Siemens Traffic Solutions, driver(s) and other categories of road users involved in the accidents, government agencies in charge of maintaining the control system and sometimes the state government. There are no definite standards guiding the formula for sharing liability between the different groups highlighted above thus leaving the decision up to the judiciary systems of the states the accidents occur, in the event affected parties resort to resolving the issues in court. Using an example from one of the cases we identified, the company has requested that we look more into the length of time for which the company is held liable after the software is installed on a traffic system. The SURTRAC team is aware of existing frameworks where liability is shifted to the state or to the entity managing the roads after a certain period of time post-installation.

4.2 Policy Forum

Decisions regarding road infrastructure are often made with input from several different constituencies. Depending on where an intersection is planned, environmental constituencies, economic development organizations, commuter interests, as well as political interests must be taken into account. These issues are debated in forums such as regulatory rule commentary sessions, and community and/or economic development board meetings. On many occasions, elected politicians will also want exert influence over traffic planning process--- particularly if it affects important voting constituencies, jobs or growth.

¹⁸ TTI's 2012 URBAN MOBILITY REPORT, David Schrank, Bill Eisele, Tim Lomax, Texas A&M Transportation Institute The Texas A&M University System <http://mobility.tamu.edu>, December 2012

¹⁹ City Plans to Phase Out 50-Year-Old Traffic Signals in Downtown Pittsburgh, <http://wesa.fm/post/city-plans-phase-out-50-year-old-traffic-signals-downtown-pittsburgh>

²⁰ Real-time traffic control for urban environments: expanding the SURTRAC testbed network, Gregory J. Barlow, etc. The Robotics Institute, Carnegie Mellon University, 2014

Institutions and Interest Groups

a. Federal and Department of Transportation (F-DoT)

The top priorities at DOT are to keep the traveling public safe and secure, increase their mobility, and have the transportation system contribute to the nation's economic growth.²¹ Therefore, the Department of Transportation will care about all the things related to this issue, including the traffic safety (NHTSA, FHWA) or the regulations of the transportation system (FTA). Since SURTRAC produces a number of benefits to road users, namely a reduction in traffic congestion, and a reduction in GHG and particulate matter emissions, they could help it make the case for a Transportation Investments Generating Economic Recovery (TIGER) grant, which is offered by the Federal Department of Transportation (DOT). When the company is officially incorporated, it would also be eligible for various state and local grants geared toward meeting GHG reduction and transportation improvement goals.

b. Federal Highway Administration (FHWA)

The Federal Highway Administration (FHWA) is an agency within the U.S. Department of Transportation that supports State and local governments in the design, construction, and maintenance of the Nation's highway system.²² It also provides state and local governments with a variety of funding opportunities and technical support focused on transportation system performance and the corporate capacity of the resources. Seeing that the SURTRAC technology reduces emissions and helps enhance the efficiency of transportation networks it is a new technology that meets the future requirements of FHWA, thus it could potentially seek funding and technology support opportunities from the administration.

c. Federal Energy Regulatory Commission (FERC)

The Federal Energy Regulatory Commission, or FERC, is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil.²³ They are interested in providing consumers with reliable, efficient and sustainable energy. As the commission is required by the Government Performance and Results Act (GPRA) to develop and maintain its strategies, FERC is now aiming to apply the latest technologies related to an effective energy consumption and guide state and local governments to reach a more effective management of energy and energy cost reduction. These policies will obviously in favor of the technology of SURTRAC.

d. State and Local Governments

As is mentioned in the challenges/opportunities section, government as a customer will be a challenge for SURTRAC. Focusing on governmental contracts or engagements with public entities as a major source of revenue is difficult and may require acceptance of long lead-times. Furthermore, depending on the system of contract award, SURTRAC may have difficulties standing out in a field of competitors that may cost less, or that have advantage of being an incumbent contract winner. Flexibility can also be limited by the ability of the municipal or state organization to nimbly react to project-altering developments. However, the favor of the technologies that could reduce heavy traffic, emissions and energy costs among the policies of several administrations still exist at the state or local government level, especially for the cities that have goals or requirements on these reductions. As in the case of the PennDOT's ARLE

²¹ United States Department of Transportation, <http://www.dot.gov/about>

²² U.S. Department of Transportation, Federal Highway Transportation, <https://www.fhwa.dot.gov/about/>

²³ Federal Energy Regulatory Commission, <http://www.ferc.gov/about/about.asp>

Funding Program, it is made available from the Pennsylvania Department of Transportation. Established in 2010, its aim is to use extra revenue generated from the Automated Red Light Enforcement program to fund projects focused on increasing road safety usage throughout Pennsylvania. Seeing that the use of traffic lights increases the level of safety for the different types of road users, especially pedestrians and cyclists, SURTRAC would be able to leverage this funding opportunity to scale its operations as it sufficiently qualifies for this program.

What's more, since SURTRAC is a decentralized system, it has many advantages compared with some of the existing centralized systems. However, the replacement may cost a lot of money. In this situation, we would like to suggest the team not only search for cities that has reduction requirements, but also the governments that do not have any centralized systems now.

e. Institute of Transportation Engineers (ITE)

The Institute of Transportation Engineers is an association of transportation professionals who are responsible for meeting mobility and safety needs. It facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of ground transportation.²⁴ A number of scenarios exist through which the SURTRAC team could benefit from the ITE. One of these ways include industrial recognition or endorsement of its technology by the agency as it is referred to as one of the key agencies in the United States focused on advancing or championing the application of innovative technical solutions to traffic safety and congestion problems. Also, the ITE could also provide an avenue through which the SURTRAC team could gain accreditation as it works towards the applying for grants in funding its operations.

f. National Electrical Manufacturers Association (NEMA)

The National Electrical Manufacturers Association (NEMA) is an association of electrical equipment and medical imaging manufacturers in the United States. It provides a forum for the development of technical standards that are in the best interests of the industry and users, advocacy of industry policies on legislative and regulatory matters, and collection, analysis, and dissemination of industry data.²⁵ Also, a number of product groups under the NEMA have direct involvement in the transportation infrastructure, including Transportation Management and Associated Control Devices (Intelligent Transportation Systems), Electric Vehicle Supply Equipment and Outdoor Lighting.²⁶ Considering the fact that the SURTRAC system is a software product, it might not necessarily have a direct relationship with the NEMA. However the NEMA influences/oversees the operational capacity and standards of use of traffic control equipment which the SURTRAC system leverages in conducting its operations, thus engagement with the association might be necessary during the identification and selection of control equipment e.g. vehicular presence detectors.

g. American Association of State Highway and Transportation Officials (AASHTO)

AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments. Its primary goal is to foster the development, operation, and maintenance of an

²⁴ Institute of Transportation Engineers (ITE) Website, <http://www.ite.org/aboutite/index.asp>

²⁵ National Electrical Manufacturers Association (NEMA) Website, <http://www.nema.org/About/pages/default.aspx>

²⁶ Transportation - NEMA, <http://www.nema.org/Policy/Pages/Transportation.aspx>

integrated national transportation system ²⁷ by setting up a body which publishes specifications, test protocols and guidelines which are used in highway design and construction throughout the United States. Though it is not a government organization, it engages in the design of policies and the structural design of roads, also contributing to research on the effective use of new technologies to improve the usability of roads in the United States. Thus it might (not directly) help SURTRAC lobby with related departments and agencies in creating and revising standards of traffic control system and also liability and privacy issues involved in on-road cases.

h. Traffic Control System Manufacturers

The SURTRAC system is designed as an add-on/plugin for existing traffic control installations as a means to optimizing their operations. It is targeted at Original Equipment Manufacturers (OEMs) of traffic control systems. Thus, OEMs would be interested in understanding how the SURTRAC software interfaces with their current systems, how it improves the operational capability of their traffic control system and the optimization technology behind its operations. This provides a direct sales channel for the SURTRAC team as they could leverage building relationships with existing OEMs, working with them to ship traffic control systems already embedded with their optimization software. OEMs can really support SURTRAC and make it success or can be a big obstacle and prevent it from development. Thus how to work with OEMs is a big challenge for the SURTRAC team.

i. Environmental and Privacy Advocate Agencies

Environmental Protection Agency (EPA)

EPA continuously works to address issues relating to climate change through standards that reduce carbon pollution in cities across the U.S. It is charged with developing standards focused on preventing harmful pollution from power plants, vehicles and other sources.²⁸ Based on this, we believe that the EPA would definitely be interested in the vehicle emission reduction ability of SURTRAC system as it would help cities across the United States get in compliance with the state emission level requirements set by the agency.

Privacy Advocate Agencies

Privacy issues are mainly in a state level. Almost every state has its own privacy advocate agencies and deal with their state range problems. For example, the privacy office of Defense Information System Agency is working on to balance the agency's mission needs for information with the mandatory privacy protection for individuals.²⁹ The West Virginia State Privacy Office serves the citizens of the State by managing the protection of personally identifiable information (PII) collected and maintained by Executive Branch agencies.³⁰ Also, the Department of Justice of California is seeking to work with companies on privacy trends and offers best practice guidance.³¹

In the privacy area, there are currently no standards on traffic systems. We would like to

²⁷ American Association of State Highway and Transportation Officials (AASHTO), <http://www.transportation.org/Pages/Organization.aspx>

²⁸ United States Environmental Protection Agency, <http://www.epa.gov/climatechange/reducing-emissions.html>

²⁹ U.S. Department of Defense, Defense System Information Agency, <http://www.disa.mil/About/Legal-and-Regulatory/Privacy-Office>

³⁰ West Virginia State Privacy Office, <http://www.privacy.wv.gov/Pages/default.aspx>

³¹ State of California Department of Justice, Office of Attorney General, <http://oag.ca.gov/privacy>

suggest the SURTRAC team working on establish standards or regulations in this field and this should be beneficial for both of the company and government.

5.0 Range of Outcomes

5.1 Factors

5.1.1 Liability

Traffic control systems that provide erroneous control signals are potential causes of accidents to road users. Though a review of liability cases due to malfunctioning traffic control equipment shows that liability is most often shared between a number of parties including the equipment manufacturer, the government and the accident victims, the fact that the new proposed technology like SURTRAC assumes control of the allocation of signal timing and phase sharing at intersections might affect the willingness of OEMs or government agencies to adopt it as it introduces a potential new layer of liability issues beyond the control they already have on the operations of traffic control systems.

Based on our research and speaking with people knowledgeable in this field, we have identified the following strategies we think SURTRAC might leverage as it works towards commercializing its technology:

a. Maintaining Status Quo

Issues due to liability currently exist in the traffic control systems. In Pennsylvania for example, the responsibility of liability from road traffic accidents are shared between a range of institutions, including the victims, the state or owners of the traffic light implementation, the traffic control manufacturers and sometimes insurance companies. The amount to be paid and the liability sharing formulae is most times determined in courts as there are no certain laws guiding the process of allocating responsibility between the affected parties. This process is highly undefined as it rests in the hands of the judiciary system to both identify fault and allocate responsibility to all the affected parties. Thus seeing that SURTRACs technology depends on existing controllers to function and also that when deployed, it directly takes over control of the flow of traffic at those intersections, it would also be required to share responsibility in the event of an accident due to a malfunctioning of the traffic control system. However, an investigation into the cause of the accident to ascertain the true cause of the accident would have to be performed in order for liability to be appropriately apportioned. SURTRAC would only be held liable in the event of the identification of a direct link between the allocated phase movement designated by its software at the particular point in time as the cause of the accident. It is not a unique problem to the SURTRAC team. From the above, it is clear that this would not be a good strategy for the firm to engage in as it leaves it at the mercy of the judiciary system to determine its fate. As a young company, it would have to take the necessary precautionary measures to protect itself against this as it almost equates to flying blind on the part of the company if it does not work to address these issues before going forward to commercializing its technology.

b. Liaise with Pennsylvania Department of Transportation in defining new software operational standards and maintenance programs for its technology upon deployment

SURTRAC has a number of functional characteristics that distinguishes it from existing traffic control systems. These include its ability to operate in a decentralized manner, managing and optimizing the flow of traffic both at individual intersections and in a network/grid of interconnected intersections; the ability to take into consideration other modes of transportation and road users including cyclists, pedestrians, special utility vehicles etc. and also the ability to react to and solve traffic flow congestion in real-time. Our strategy in this case is for the SURTRAC to develop both operational and maintenance standards for its technology where it defines the operational requirements and functionality of its software. In doing this, it would be able to work with the adopting agencies in ensuring that they adhere to these requirements. The

operational standard should adequately describe the modes of operation of the SURTRAC technology and how it interfaces with the turnkey systems of the control system manufacturers in optimizing the flow of traffic at the intersections. While designing this standard, the company should also take into consideration the various events that could lead to a malfunction or defect in operation and define steps to mitigate them. This document would serve as a guide for both the company and also agencies, cities or states looking to adopt the SURTRAC technology guiding the deployment process while serving as a reference guide. A maintenance standard would help SURTRAC define the maintenance practices that need to be conducted in defined time intervals at the intersections to ensure continuous effective operation of their platform. The development of these two standards would both help SURTRAC ensure its technology is constantly operating at its optimal functionality while providing the company a solid base to reference in the event of a liability suit brought against it such that it can defend itself knowing that it had clearly defined the operational capacities of its technology and performed the necessary while could take advantage of them and liaise with PennDOT or other related agencies in defining new software standards and maintenance programs for its technology. However, this strategy may turn out to be not very effective and efficient. New liability standards and regulations may also face strong oppositions from other traffic control systems and also several other Original Equipment Manufacturers since this could lead to their extra payments on safety and liability improvements.

5.1.2 Resources

The costs of adopting new technology in the optimization of traffic signal control sometimes serves as a hindrance towards its adoption. This is partly because of issues relating to the complexity of intersections and possibly new control mechanisms introduced by technologies such as SURTRAC. Thus the organizations whose jurisdiction the intersections fall under might be wary of carrying out improvement projects as a result of the need to balance their available funds across different projects on their annual spending agendas. Also, the possible need for specialists in installing and maintaining these systems may require a reasonable amount of capital allocation and time and would thus serve as both a challenge to the SURTRAC and organizations looking to adopt its technology.

Though unit maintenance costs for the system is yet to be defined, the maintenance of the system is also important since it is directly related to the liability and long-run costs of the system. As it is a seemingly new system for the control of traffic signals, it might also require specialists to install and maintain it.

5.1.3 Portability to OEM Traffic Control Systems

The SURTRAC system operates by interfacing with existing communications and traffic signaling protocols and equipment already installed at various intersections. Hence, the system must be portable to the different traffic control machines from various traffic control system OEMs. In doing this, it would have to ensure that the signal control operation resulting from its adoption still conforms to required operational standards such as MUTCD and NTCIP, set by agencies such as the FHWA, ITE and NEMA. OEMs looking to adopt the SURTRAC software would thus be inclined to require some sort of guarantee that the SURTRAC system, coupled with their traffic controllers, still conforms to the set standards while also significantly improving the operational characteristics of the intersections they are installed at. Also, government agencies looking to improve the traffic congestion issues on their local roads by adopting this new technology would be interested in ensuring that the SURTRAC traffic control system not only optimizes traffic flow but also conforms to the operational standards set by these standards creating agencies.

5.1.4 Compliance with Standards

Traffic control systems are most times designed to meet a number of standards developed by both governmental and private standard agencies. Some of these standards include the following:

Manual of Uniform Traffic Control Devices (MUTCD)

Developed by the Federal Highway Administration, the MUTCD defines the standards by which traffic signs, road surface markings, and signals are designed, installed, and is used to provide guidance about the general functionality of traffic control devices to ensure the uniformity of traffic control devices developed by different OEMs. All traffic control devices to be deployed in the U.S. must conform to this standard. However, SURTRAC is a software component that serves as a plug-in into existing traffic control systems, thus its operating as a Traffic Control System is not be defined according to the guidelines of the MUTCD but rather the NTCIP and ATC discussed below.

National Transportation Communications for Intelligent Transportation System Protocol (NTCIP)

The NTCIP is a group of standards designed to enable interoperability of different electronic devices installed at intersections to improve the flow of traffic through them. It is maintained by a Joint Committee on the NTCIP, which is composed of six representatives each from the National Electrical Manufacturers Association (NEMA), the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers.³² It is comprised of a collection of standards that define the communication protocols used by different traffic control equipment (Traffic signals, Closed Circuit Television CCTV cameras, Vehicle count stations, Freeway ramp meters, Video switches, Transportation sensor systems, Field master stations for traffic signals, Transit priority at traffic signals, etc.) in communicating with each other and the central control centers. The SURTRAC system would have to either adhere to or operate in such a way as to incorporate standards from the NTCIP in its operations seeing that it relies on the interoperability of equipment from a wide range of suppliers for optimal functionality.

Advanced Transportation Controller (ATC)

Like the NTCIP, the ATC is defined by the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE) and the National Electrical Manufacturers Association (NEMA) under a Memorandum of Understanding (MOU). It defines the interface for Operational Users of Traffic Control Systems to interact with the application programs that are the primary tasks of the controller unit within the transportation system.³³ The ATC standard provides an open platform for hardware and software for a wide variety of Intelligent Traffic Systems applications. It specifies a wide variety of hardware, the Linux operating system, and a defined API layer which ATC applications are required to use. Seeing that the SURTRAC system would ultimately replace the programming interface with which traffic engineers interact with the Traffic Control Systems, it would have to conform to the standards of the ATC.

³² National Transportation Communications for Intelligent Transportation System Protocol, <http://www.ntcip.org>

³³ Advanced Traffic Controller, ITE Website, <http://www.ite.org/standards/atc/>

In deploying its technology at road intersections, SURTRAC might not be required to entirely meet any of the standards above as its solution is functionally an optimization algorithm. However, the SURTRAC technology still has to conform to the above listed standards as they both influence and govern the adoption of traffic control devices (which SURTRAC essentially interfaces with) by departments of transportation or any entity looking to deploy traffic control systems in the U.S.

5.1.5 Public Sentiment

A number of road users have expressed concern regarding the sensor technology used in distributed traffic control systems and also the fact that the use of traffic optimization technology such as SURTRAC might result in an overall increase in vehicular speed on roads as they reduce vehicular wait times, which would prove favorable to motorists but unfavorable to other categories of road users. Close Circuit Television (CCTV) cameras used as traffic vehicular sensors are capable of being used in monitoring movement of vehicles and this might lead to public reaction towards their being used for unwanted location tracking of individual vehicles. However, SURTRAC uses many of the same traffic sensor functionality that is already in place on roads today. Speed cameras, Red-Light cameras and other forms of road monitoring equipment have been functioning on US roads for years and we believe that many of the same concerns which could arise have possibly being addressed and the same would apply for SURTRAC. The intent of the traffic monitoring sensors is not to capture data on individual drivers, but to be used in detecting vehicular presence at intersections so more appropriate signal timing and phase allocations could be made to lanes requiring “right of way”.

Another factor that might significantly influence how successful SURTRAC would be with getting its traffic control system adopted is a combination of how it crafts its value proposition, how this proposition relates to the various needs of the institutions with interests in its activity and its ability to deliver value on its proposition. Also of importance would be its ability to influence the various interests groups (by lobbying or otherwise) to focusing on governmental contracts or engagements with public entities as a major source of revenue is difficult and may require acceptance of long lead-times. Furthermore, depending on the contract award method in place, SURTRAC may have difficulty standing out in a field of competitors that may cost less, or that have advantage of being an incumbent contract winner. Flexibility can also be limited by the ability of the municipal or state organization to nimbly react to project-altering developments.

5.1.6 Availability/Source of Capital

Given the options SURTRAC has in either raising capital from investors to fund its business or to rely on government agencies for contracts which would constitute its major source of revenue, it has to make the best bet in its approach towards raising capital in scaling its operations. Though its technology might not be as attractive to venture capital, a number of other sources through which it could either raise funds towards its growth or generate revenue exist. Government agencies with interest in transportation provide a number of grants towards projects like SURTRAC as they affect causes like reducing vehicular emissions, improve the safety and congestion issues on roads, in which they are interested. The SURTRAC team could also consider partnering with OEMs in rolling out their software as part of a bundle traffic control solution. This would enable fast and more effective roll out of its product on a larger scale.

5.2 Effectiveness and Efficiency Analysis

5.2.1 Summary of Potential Policy Options

a. Status Quo

The SURTRAC team has achieved these progresses below:

- 2010 – 2011: Development of core approach; Demonstration of effectiveness in simulation on Downtown Pittsburgh road network.
- 2011 – 2012: East Liberty Pilot Implementation
- 2013 – Present: Expansion of pilot test sites

In June 2012, SURTRAC team deployed a pilot of the surtrac system on nine intersections in the East Liberty neighborhood of Pittsburgh. The crossing of three major roads (Penn Circle, Penn Avenue, and Highland Avenue) leads to changing traffic patterns throughout the day, making it difficult to manage congestion with conventional traffic signal control methods. According to the testing data, SURTRAC reduced travel times more than 25% on average, and wait times were reduced an average of 40%.³⁴

They were achieved in the testing process of the SURTRAC system using pilots only in Pittsburgh. Thus, if leave it to status quo, the team may keep on expand the testing extend in Pittsburgh and perhaps other nearby cities. Since the team is now working on with the Centre for Technology Transfer and Enterprise Creation at Carnegie Mellon University on the formation of their company, they will soon meet the problems brought by the expansion of their clients.

b. Liability

As Professor David Tungate, Associate Teaching Professor of Law at Carnegie Mellon University suggested, SURTRAC could work by improving the instructions or give obvious warnings in the event of a malfunction, but it may be difficult for the company to add these things to the system due to its need for more control over the traffic control systems it is plugged into. It should also be noted that, since the company has achieved several progresses in Pittsburgh, we could on the other hand talk to the city of Pittsburgh and find out the effectiveness of the previous testing process.

c. Funding

The TIGER program has just refreshed into a new period from March, 2014 and the company could get an award up to \$35 million. In each round of TIGER, DOT receives many applications to build and repair critical pieces and passenger transportation networks. The program requires all applicants detail the benefits their project would deliver for five long-term outcomes: safety, economic competitiveness, state of good repair, livability and environmental sustainability.³⁵ Upon to these descriptions, SURTRAC's smart traffic light system is undoubtedly a competitive project. SURTRAC could look for a TIGER grant from the Federal Department of Transportation. It would need to work with various state Departments of Transportation and Departments of Public Works, selling them on the value proposition of their technology and how it addresses the various road transportation issues they intend to address while lobbying them to apply for the TIGER grants.

³⁴ SURTRAC Website, <http://www.surtrac.net/pilot/>

³⁵ United States Department of Transportation, <http://www.dot.gov/tiger>

d. Emission and Traffic Congestion Reduction

Since the SURTRAC software could be deployed incrementally, the team could take advantage of its decentralized system in lobbying cities that may have interests in their products to incrementally adopt their product as their needs arise and as they see the benefits of the system at intersections it has been deployed at. Currently the city of Pittsburgh has “Green Building” program.³⁶ Though the program is designed to reduce the impacts on environment from buildings, including CO₂ emissions, it also aims to encourage sustainable transportation. The city is now working on increasing biking and public transportation use to decrease the pollutions. However, these steps are not enough and the city is looking for other ways to reduce the emissions from transportation part. Since this project is directly beneficial to technologies and companies like SURTRAC, not on a city or state level, SURTRAC could take advantage of that and looking for support both on funding and market expansion.

Examples of other cities in the U.S. that have adopted some form of resolution of this issue include:

- City of Phoenix: “Reduce GHG emissions from city operations to 5% below the 2005 levels by 2015,”³⁷ has direct goals in reducing traffic lights and system’s GHG emissions.
- City of Boston: “Transportation currently contributes 27% of Boston’s greenhouse gas emissions,”³⁸ is still looking for companies and organizations to join their “Boston’s Complete Streets” project. The city has considerations on reducing delay and wait time at intersections and is looking for help to solve this problem.
- Washington, D.C.: “Government is to reduce greenhouse gas emissions 30% by 2020,”³⁹ and its exact reductions will depend on the mix of technologies selected by the District Department of Transportation (DDOT). They have conducted some actions on reducing the traffic light consumption and is looking for more diversified projects.
- New York City: “New York City has reduced citywide greenhouse gas emissions by 19 percent since 2005, on track to achieve a 30 percent reduction ahead of the PlaNYC 2030 goal”.⁴⁰

e. Partnerships

There are currently two companies as instances that we found may have interest in smart systems like SURTRAC. The Traffic Control Corporation has many well-developed product including cameras and control panels. They believe they could expand their sales if cooperate with other companies that work on traffic control systems or materials of the devices. As for another company--- the Control Technologies, it provides variety of products from the equipment to system. Therefore, these companies may turn out to be competitors of SURTRAC system. However, opportunities about for cooperation in the traffic light control industry and might be considered an option if the opportunities arise.

³⁶ Pittsburgh, Office of Sustainability, <http://www.pittsburghpa.gov/green/transportation.htm>

³⁷ 2012 Greenhouse Gas emissions Reduction Report, Arizona State University

³⁸ Boston Transportation Department, Boston Complete Streets, <http://bostoncompletestreets.org/about/>

³⁹ The District of Columbia, District Department of Environment, <http://ddoe.dc.gov/publication/climate-opportunity-climate-action-plan-district-columbia>

⁴⁰ City of New York news, December 30, 2013

5.2.2 Overview of Policy Strategies and Effectiveness/Efficiency Analysis

a. Privacy (Goal): Quelling motorists concern regarding use of technology to monitor individual traffic patterns and other personal activities

Policy Strategies	Case	Effectiveness	Efficiency
Status Quo	Of concern to the public but not that much to OEMs and government agencies	<ul style="list-style-type: none"> May involve in some privacy issues 	<ul style="list-style-type: none"> Generally accepted as an issue thus would be easy to adopt
Traffic Camera Privacy laws & Lobbying	Some states already have these laws in place e.g. Appleton, Wisconsin; Enforce monitoring privacy standards and requirements	<ul style="list-style-type: none"> In favor of some privacy advocate organizations 	<ul style="list-style-type: none"> Might be opposed by OEMs as it could reduce sales
Standards	Administrative safeguards, security technology and audit processes	<ul style="list-style-type: none"> Help related agencies and state government 	<ul style="list-style-type: none"> Needs lobbying and several times of revise

Privacy - Ease of Acceptability and Equity

Policy Strategies	Effectiveness	Efficiency
Status Quo	0	0
Work with PennDOT and other state DOTs in developing Traffic Camera Privacy Policy laws and regulations	0	-
Work with AASHTO, ITE and NEMA in developing new privacy standards guiding administrative safeguards and security technology of traffic monitoring technologies	0	-
Lobby congress to enforce monitoring privacy standards and requirements	0	-

b. Liability (Goal): Assessing liability due to respective parties in the event of an accident

Policy Strategies	Case	Effectiveness	Efficiency
Status Quo	Undefined liability terms; shared according to court injunction amongst interest groups	<ul style="list-style-type: none"> • Could be trapped in serious lawsuits • Disadvantage in future marketing 	<ul style="list-style-type: none"> • May take a lot of time and money in the future
Liaise with State DOTs in proposing safety operational standards for software used in traffic controllers	OEMs might not be open to it as it disrupts status quo and might increase developmental costs	<ul style="list-style-type: none"> • Help on both law and market aspects 	<ul style="list-style-type: none"> • Fairly easy to create buy in as with Pittsburgh experience • Leverage Pittsburgh experience in expanding
Trade associations with OEMs in lobbying for a cap on liability pay-outs	Adds structure and size to potential pay-outs enabling SURTRAC and fellow OEMs better prepare	<ul style="list-style-type: none"> • Reduce the potential liability affects from OEMs 	<ul style="list-style-type: none"> • Lobbying can cost a lot of time

Liability - Ease of Acceptability and Equity

Policy Strategies	Effectiveness	Efficiency
Status Quo	-	-
Lobby congress to enforce monitoring privacy standards and requirements	+	+
Trade associations with OEMs in lobbying for a cap on liability pay-outs	+	0

c. Emissions (Goal): Improving the level of vehicular emission levels in the cities across the U.S. and leveraging initiatives led by the E.P.A. in reducing them

Policy Strategies	Case	Effectiveness	Efficiency
Status Quo	<ul style="list-style-type: none"> EPA National Ambient Air Quality Standards EPA existing emission levels for vehicles Laws exist but not much enforcement 	<ul style="list-style-type: none"> No obvious benefits 	<ul style="list-style-type: none"> No further cost
New strategic initiatives with OEMs centered on emissions and cleaner cities e.g. with Siemens & IBM – Smart Cities, etc.	Establish new initiatives for the collaboration of OEMs towards less emissions and greener cities	<ul style="list-style-type: none"> Easy to get support from OEMs 	<ul style="list-style-type: none"> This will favor OEMs and can easily get their support
Lobbying	Lobbying congress to enforce laws/standards in cities with least emissions level sustainability compliance	<ul style="list-style-type: none"> Could expand potential market 	<ul style="list-style-type: none"> Lobbying with congress can cost a lot of time

Emissions - Ease of Acceptability and Equity

Policy Strategies	Effectiveness	Efficiency
Status Quo	0	0
New strategic initiatives with OEMs centered on emissions and cleaner cities e.g. with Siemens & IBM – Smart Cities, etc.	++	+
Lobbying congress to enforce laws/standards in cities with least emissions level sustainability compliance	+	0

d. Funding (Goal): Enabling access to growth capital or revenue generation streams for SURTRAC technology

Policy Strategies	Case	Effectiveness	Efficiency
Status Quo	Relying on government contracts for support	<ul style="list-style-type: none"> • Relying on current fundings 	<ul style="list-style-type: none"> • Acceptable depending on the weight of the value proposition
Grants from agencies like AASHTO, ITE, NEMA & Lobbying for pilot tests display technology	Grants for projects focused on improving traffic flow, safety and emission reduction projects on roads e.g. TIGER, ARLE	<ul style="list-style-type: none"> • Could support future development • Pilot is a great way to begin with the market expansion 	<ul style="list-style-type: none"> • Easily accessible by both agencies and local governments
Seeking Venture Capital/ Private investments	Funding opportunities for expansion	<ul style="list-style-type: none"> • Opportunities to develop stand alone systems • Support future development 	<ul style="list-style-type: none"> • May need to display current situation in detail and lobbying
Partnerships with OEMs	Licensing partnerships with OEMs	<ul style="list-style-type: none"> • Could make the technology more acceptable by DOTs 	<ul style="list-style-type: none"> • Need lobbying • May involve contract issues

Funding - Ease of Acceptability and Equity

Policy Strategies	Effectiveness	Efficiency
Status Quo	0	0
Applying to grants from agencies like AASHTO, ITE, NEMA	++	++
Seeking Venture Capital/Private investments	+	+
Partnerships with OEMs in rolling out software pre-installed	+	+

Key: “+” = metric goal is very likely to be achieved, “+” = metric goal is likely to be achieved; “-“ = metric goal is not likely to be achieved; “0” = metric goal may or may not be achieved (“neutral”).

6.0 Bargaining Context and Spreadsheet

6.1 Analysis of Potential Allies and Adversaries

6.1.1 Potential Allies

a. Federal Departments and Administrations

Federal transportation agencies, a wide range of resources the SURTRAC team could leverage in getting its technology out for deployment. Examples of these agencies or departments include the Federal Transit Administration (FTA), Federal Highway Administration (FHWA), Federal Energy Regulatory Commission (FERC), National Highway Traffic Safety Administration (NHTSA) and NEMA National Electrical Manufacturers Association (NEMA). For example, the NHTSA and FHWA are charged with the definition and enforcement of Federal Motor Vehicle Safety Standards in addition to overseeing the allocation of funds to maintenance and construction projects on roads across the United States. The FTA on the other hand provides financial and technical assistance to local public transit systems. These agencies thus exert influence on the roads in cities the SURTRAC team hopes to get its product deployed at. They also provide avenues for grants applications as they constitute agencies which which grants like the TIGER, ARLE or even the CMAQ grants are meted out. Thus they could significantly influence the ability of the SURTRAC team to successfully spread out their network of smart traffic lights as they have vested interests in the safe use of roads in the U.S., in addition to the effective use of new technology to improve the road usage habits of the citizens of the United States.

b. Environmental Protection Agency (EPA) and State and Local Governments

The state and local governments both serve as potential customers to SURTRAC. However, this could be both an opportunity and a challenge. In favor of technologies that could significantly reduce heavy traffic, vehicular emissions and costs due to delay in traffic, these institutions provide opportunities and also grants to companies like SURTRAC in deploying their technologies across road networks within their jurisdictions. An example would be SURTRACs partnership with the Pittsburgh Department of Public Works in June 2012 to pilot its technology across a number of intersections within the city. Starting out with 9 intersections, the project has since been expanded to cover a total of 40 intersections. The SURTRAC team could hence take advantage of the possibility of creating relationships with transportation or works departments in cities across the U.S. in pushing out its technology. One way it could do this would be identifying cities in noncompliance with vehicular emission levels stipulated by the Environmental Protection Agency (EPA). The EPA is charged with the responsibility of “maintaining and enforcing national standards under a variety of environmental laws, in consultation with state, tribal, and local governments”⁴¹ ensuring environmental laws and regulation passed by the United States Congress are adhered to. In addition to its numerous functions, it oversees the improvement initiative of various environmental components, including air quality, chemicals, waste, water etc. Specifically as it affect the SURTRAC team, it publishes a standards (including the Clean Air Act, under which the National Ambient Air Quality (NAAQ) Standards resides). Via the Clean Air Act, it sets national air quality standards for particulate matter and a number of other pollutants (including ozone, nitrogen oxides, carbon monoxide, sulfur dioxide and lead) that are considered harmful to public health and the environment while periodically reviewing the standards and updating them to ensure that they provide adequate health and environmental protection to citizens of the United States. As part of the Clean Air Act, it publishes a yearly list of cities in noncompliance with the air quality standards stipulated in the

⁴¹ EPA Website, <http://www2.epa.gov/aboutepa>

NAAQ standards.

Below is a map of the cities in and around Pennsylvania, termed non attainment cities, that are not in compliance with the NAAQ standards for the PM 2.5 (with PM 2.5 meaning particulate matter smaller in size than 2.5 micrometers of which vehicular emissions are part of) specification.

The SURTRAC team could thus leverage the opportunity in identifying these cities or municipalities while actively targeting them in their lobbying or marketing efforts for their product, based on its value proposition to reduce emission levels by about 21%, in helping them get in compliance with the required standards, especially for the cities seeking ways of reducing their emissions.

c. Other Equipment Manufacturers

The SURTRAC software is targeted at optimizing traffic control equipment developed by Original Equipment Manufacturers (OEMs). Thus, OEMs would be interested in understanding how the SURTRAC software interfaces with their current systems and how it improves the operational capability of their traffic control system. This provides a direct sales channel for the SURTRAC team to market the technology directly to OEMs interested in improving the operational capacity of their traffic control systems as they could leverage building relationships with existing OEMs, working with them to ship traffic control systems already embedded with their optimization software. However, as SURTRAC is a decentralized system, cities already with centralized system or other kind of smart traffic system installed may not be potential customers or allies.

6.1.2 Potential Adversaries

a. Competitors of other systems and products' companies

Manufacturers of traffic control systems could be serve as allies and adversaries to SURTRAC as it works towards the commercialization of its product. In resolving the congestion issues, a number of systems have been developed in the US to enhance the operations of traffic control systems. For instance, developed as a low cost and easily implementable solution, the ACS-Lite is one of FHWA's newest adaptive in 2005. Also, LADOT has developed the ATSAC system and it was upgraded from a responsive to a more adaptive system in 2000s.

However, these systems function mostly as centralized systems, from which issues relating to latency and real-time reaction of traffic control to traffic conditions at respective intersections could occur. Also, due to their centralized operational model, traffic control projects using any of the technologies require significant amount of capital investments as a minimum number of intersections would have to be deployed at the same time to leverage the savings in delay and signal timing coordination that would arise from the system.

b. Organizations concerned about the safety and liability of SURTRAC System

Traffic signals control the right of way for the different classes of road users and a malfunction in their operations has the potential to cause accidents, exposing the company to the risks of liability suits. Some organizations concerned with public safety and transportation liability may have questions on the SURTRAC system and the issue of liability could further alienate them if it is not address appropriately.

c. Citizens and Organizations concerned about the privacy issues of SURTRAC

Some of the road users are concerned that the sensor technology used in distributed traffic control systems could be used for unwanted location tracking of individual vehicles. Since the intent of SURTRAC system is not to capture data on individual drivers, but on intersections and patterns as a whole, it could be a tough process for the team to convince and persuade the public not to worry about the privacy problem.

6.2 Overview of Policy Strategies and Responsiveness/Equity Analysis

a. Privacy (Goal): Quelling motorists concern regarding use of technology to monitor individual traffic patterns and other personal activities

Policy Strategies	Case	Equity	Ease of Acceptability
Status Quo	Of concern to the public but not that much to OEMs and governmental agencies	<ul style="list-style-type: none"> Impacts public the most Should be addressed by government and OEMs 	<ul style="list-style-type: none"> Generally accepted as an issue thus would be easy to adopt
Traffic Camera Privacy laws & Lobbying	Some states already have these laws in place e.g. Appleton, Wisconsin; Enforce monitoring privacy standards and requirements	<ul style="list-style-type: none"> State DOTs and regulating agencies e.g. ASSHTO, ITE Public interest groups OEMs 	<ul style="list-style-type: none"> Might be opposed by OEMs as it could reduce sales
Standards	Administrative safeguards, security technology and audit processes	<ul style="list-style-type: none"> Most attractive to institutions, however competitors might be divided 	<ul style="list-style-type: none"> Extension of existing standards

Privacy - Ease of Acceptability and Equity

Policy Strategies	Equity		Ease of Acceptability	
	Public	Institutions	Public	Institutions
Status Quo	+	0	-	0
Work with PennDOT and other state DOTs in developing Traffic Camera Privacy Policy laws and regulations	0	+	0	0
Work with AASHTO, ITE and NEMA in developing new privacy standards guiding administrative safeguards and security technology of traffic monitoring technologies	0	+	0	++
Lobby congress to enforce monitoring privacy standards and requirements	0	+	0	+

b. Liability (Goal): Assessing liability due to respective parties in the event of an accident

Policy Strategies	Case	Equity	Ease of Acceptability
Status Quo	Undefined liability terms; shared according to court injunction amongst interest groups	<ul style="list-style-type: none"> Not favourable Impacts all interest groups 	<ul style="list-style-type: none"> Undefined liability terms Shared according to court injunction amongst interest groups
Liaise with State DOTs in proposing safety operational standards for software used in traffic controllers	OEMs might not be open to it as it disrupts status quo and might increase developmental costs	<ul style="list-style-type: none"> PennDOT and other state DOTs most impacted 	<ul style="list-style-type: none"> Fairly easy to create buy in as with Pittsburgh experience Leverage Pittsburgh experience in expanding
Trade associations with OEMs in lobbying for a cap on liability pay-outs	Adds structure and size to potential pay-outs enabling SURTRAC and fellow OEMs better prepare	<ul style="list-style-type: none"> OEMs including Siemens, IBM Congress Public 	<ul style="list-style-type: none"> In-existent associations Provides opportunities for concert lobbying efforts Might result in public backlash

Liability - Ease of Acceptability and Equity

Policy Strategies	Equity		Ease of Acceptability	
	Public	Institutions	Public	Institutions
Status Quo	+	+	+	+
Lobby congress to enforce monitoring privacy standards and requirements	+	+	+	+
Trade associations with OEMs in lobbying for a cap on liability pay-outs	0	+	+	-

c. Emissions (Goal): Improving the level of vehicular emission levels in the cities across the U.S. and leveraging initiatives led by the E.P.A. in reducing them

Policy Strategies	Case	Equity	Ease of Acceptability
Status Quo	<ul style="list-style-type: none"> EPA existing emission level standards for cars EPA National Ambient Air Quality Standards Laws exist but not much enforcement 	<ul style="list-style-type: none"> All categories of interest groups Favours only cities with complaint emission levels 	<ul style="list-style-type: none"> Acceptable in compliant states Enforcement would allow for compliance across all cities in the US
New strategic initiatives with OEMs centered on emissions and cleaner cities e.g. with Siemens & IBM – Smart Cities, etc.	Establish new initiatives for the collaboration of OEMs towards less emissions and greener cities	<ul style="list-style-type: none"> OEMs should be most interested Municipalities and state DOTs 	<ul style="list-style-type: none"> Fair chance of creating buy-in from OEMs Opportunity for product differentiation and industry leadership
Lobbying	Lobbying congress to enforce laws/standards in cities with least emissions level sustainability compliance	<ul style="list-style-type: none"> Governmental agencies Congress 	<ul style="list-style-type: none"> In-existent associations Provides opportunities for concerted lobbying efforts

Emissions - Ease of Acceptability and Equity

Policy Strategies	Equity		Ease of Acceptability	
	Public	Institutions	Public	Institutions
Status Quo	+	+	0	-
New strategic initiatives with OEMs centered on emissions and cleaner cities e.g. with Siemens & IBM – Smart Cities, etc.	+	+	+	+
Lobbying congress to enforce laws/ standards in cities with least emissions level sustainability compliance	0	+	0	+

d. Funding (Goal): Enabling access to growth capital or revenue generation streams for SURTRAC technology

Policy Strategies	Case	Equity	Ease of Acceptability
Status Quo	Relying on government contracts for support	<ul style="list-style-type: none"> Government agencies; state DOTs 	<ul style="list-style-type: none"> Acceptable depending on the weight of the value proposition
Grants from agencies like AASHTO, ITE, NEMA & Lobbying for pilot tests display technology	Grants for projects focused on improving traffic flow, safety and emission reduction projects on roads e.g. TIGER, ARLE	<ul style="list-style-type: none"> OEMs and grant providing agencies Opportunities to develop standalone systems Might not favor competitors 	<ul style="list-style-type: none"> Easily accessible on display of alignment between projects and agency initiative Perception of derived value
Seeking Venture Capital/ Private investments	Funding opportunities for expansion	<ul style="list-style-type: none"> Opportunities to develop stand alone systems Might result not favor competitors 	<ul style="list-style-type: none"> Need for display of company growth
Partnerships with OEMs	Licensing partnerships with OEMs	<ul style="list-style-type: none"> Increase in adoption rate of technology; ease of acceptance by DOTs 	<ul style="list-style-type: none"> Might be hindered by liability issues

Funding - Ease of Acceptability and Equity

Policy Strategies	Equity		Ease of Acceptability	
	Public	Institutions	Public	Institutions
Status Quo	0	+	0	+
Relying on government contracts for support	0	+	0	+
Applying to grants from agencies like AASHTO, ITE, NEMA	0	++	0	++
Seeking Venture Capital/Private investments	0	+	0	+
Partnerships with OEMs in rolling out software pre-installed	0	++	0	++

Key: “+” = metric goal is very likely to be achieved, “+” = metric goal is likely to be achieved; “-“ = metric goal is not likely to be achieved; “0” = metric goal may or may not be achieved (“neutral”)

7.0 Proposed Commercialization Strategies

Having highlighted the strategies that the SURTRAC team could leverage in commercializing its technology, we would hence discuss the most effective of them while providing an overview of the various opportunities open to the company going forward. Our research shows that the main challenges the SURTRAC would have to address at this point include public sentiment towards the implementation of this technology, liability and privacy issues that could arise from the use of complementary equipment in monitoring traffic conditions at intersections. Opportunities the company could act upon include funding opportunities and working with cities that are not in compliance with the National Ambient Air Quality Standards which is defined by the Environmental Protection Agency (EPA).

7.1 Public Sentiments and Privacy

As highlighted in section 5.1.5, due to the opinion of the road users who might think its technology mostly caters to only one category of road users, the SURTRAC might face some resistance to the deployment of its technology.

Before projects like these are carried out, public opinion are usually sort, as it helps in gathering information about the ease of use of the intersections to be signalized while also giving the road users the opportunity to contribute towards the effective use of the new technologies in solving the problems they currently experience. Also, its helps to provide the public with information about how their tax dollars are being spent.

In the Pittsburgh area, the SURTRAC team worked on a number of instances to engage the public by educating them on how their technology works and how it would solve the traffic congestion issues on the roads they ply. They also created avenues (on their website and in public forums) through which the public could share their opinion and give feedback and have received both positive and somewhat negative feedback, even with the proposed value proposition of their new technology.

Of the issues identified from the feedback they had received, quite a number of respondents highlighted the tendency of re-signalized/optimized traffic control systems to cater to mostly motorists, leaving off other categories of road users including pedestrians, cyclists, city buses and special vehicles (e.g. ambulances, fire trucks, etc.). This view is mostly shared by these road users who do not actively drive. Improved traffic control systems are generally seen to increase the speed of vehicles through intersections as vehicular delays are reduced and the amount of “green-time” allocated to vehicles increase in frequency. However, the SURTRAC software has been developed to cater to all types of road users. Its configuration allows it to take into consideration the different categories of road users, allocating green time to them upon detection of their need to use the intersections.

In resolving this issue, SURTRAC would need to effectively communicate the operation capability of its technology as it effectively to the public by using its affiliation with Carnegie Mellon University and the pilot project it has successfully implemented at various intersections in Pittsburgh to engage the local media in cities where its technology would be deployed in publicizing the effectiveness of its technology in addressing traffic congestion issues while also taking into consideration cyclists, pedestrians and special utility vehicles. A typical example would be the Pittsburgh Gazette’s coverage of the SURTRAC pilot project. Though the publications concerning the successful pilot projects highlighted the advantages of the SURTRAC system, these platforms could also be used in addressing public issues relating to

public opinion about the SURTRAC technology.

7.2 Liability

As highlighted in section 5.1.1, liability is still a challenge the SURTRAC team would face in working towards the commercialization of its technology. Traffic control systems invariably contribute to how safe roads and intersections are for road users. It is also widely known that issues due to liability affect all interest parties (including the state, traffic control manufacturers like Siemens, McCain; smart traffic system developers like SURTRAC and the victims of the accidents) in the event of a mishap or accident at roads with traffic control systems installed.

Currently, liability is apportioned between these interest groups based on the results of investigations into the the actual causes of the accident. Thus, traffic control manufacturers and smart traffic system designers alike are allocated responsibility respectively in the event that the investigations reveal a negligence on either of their parts that might have resulted in the accident in question. The issue of fault and legal liability in most car accident and personal injury lawsuits are basically resolved by establishing who was negligent.

In conducting our analysis, we find that a strategy to mitigate issues due to liability by lobbying the various interest groups, advocating for a cap/limit on the amount in claims that would be paid by a company like SURTRAC in the event of such an accident might prove both a good and bad strategy. On the bright side, it puts a limit to how much a company like SURTRAC might be required to pay in the event of a liability issue, giving it both an idea of the liability costs upfront while also making it attractive to investors. However, this strategy would prove extremely unpopular with a significant portion of the interest groups (especially the accident victims) as it makes it seem like SURTRAC is trying to absolve itself from paying the required fees for the damage incurred by the victims. A more appropriate strategy for SURTRAC to defend itself against liability issues would be for it to develop maintenance programs for its software and then work with various state governmental associations, while entering into collusion with its competitors in the development of safety and liability standards for traffic control software. This strategy would adequately address the issues due to potential tort claims as it will allow for the standardization of how traffic control software work while highlighting possible operational issues that might result from using them, making it a publicly available reference. This way, it is clear from the onset that operational issues might arise from the use of traffic control software or even machines. Developing maintenance programs also helps by giving SURTRAC a good positioning, showing its commitment to ensuring the effective operational capacity of its software while putting it in good standing with cities which it is in talks with about adopting its technology.

7.3 Emissions

One of our proposed strategies for the SURTRAC team is to position its product as a technology that significantly reduces the amount of emissions from the transportation sector. This strategy would rely heavily on the Environmental Protection Agency and its identification of cities in the U.S. in non-compliance with the National Ambient Air Quality (NAAQ) Standards under the Clean Air Quality Act.

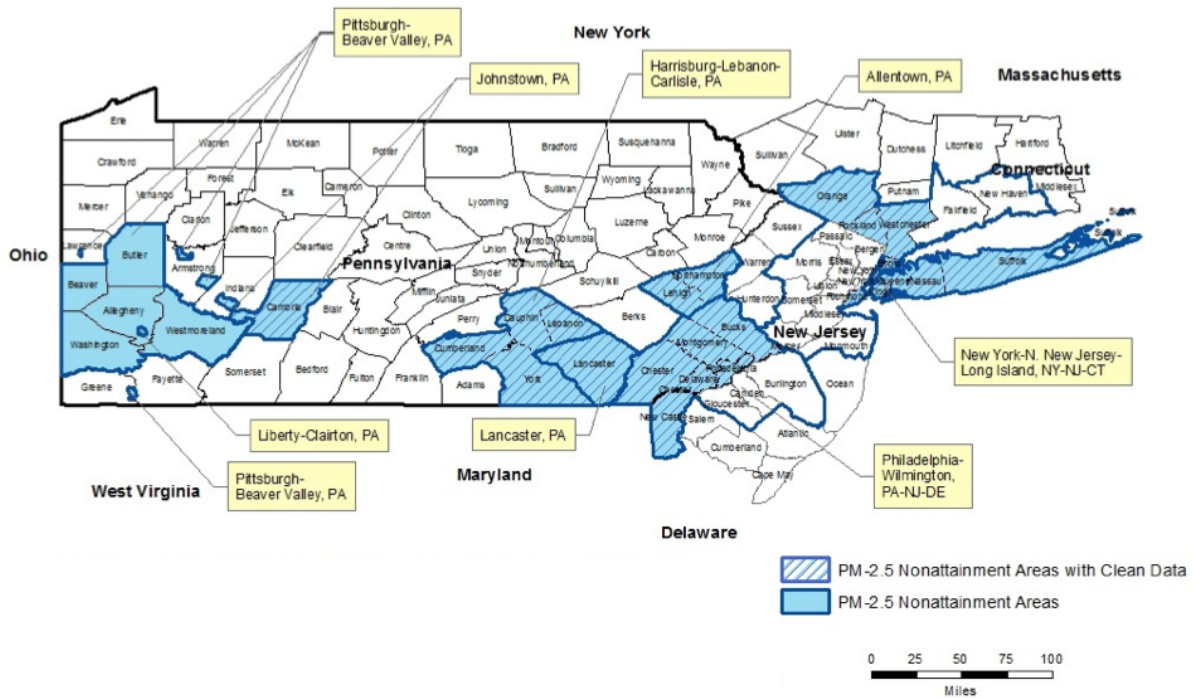


Figure 4: Pennsylvania, New York, New Jersey, Connecticut, Delaware PM-2.5 Non-attainment/Non-compliant Areas

Figure 3 above shows a snapshot of the cities in and around Pennsylvania that are not in compliance with the EPA NAAQ standards. These include cities like Allentown, Lancaster, Liberty-Clairton; all with Particulate Matter (PM)-2.5 levels above the stipulated levels specified emission levels in the Clean Air Act for cities in the U.S. We proposed that SURTRAC leverage this information and targeting their marketing efforts directly at these cities. Leveraging the success of their pilot project in Pittsburgh, the SURTRAC team could successfully reach out to these cities and partner with them in launching pilot projects to showcase the functionality of its technology and the benefits that could accrue to them from deploying its technology.

7.4 Funding Strategy

Both federal Department of Transportation and several state level DoTs offer a series of founding programs for projects that could effectively improve the traffic flow. Also, several agencies, like EPA, provide a lot of opportunities for programs that could effectively reduce emissions. Our proposed strategy for SURTRAC team is to leverage grants offered by agencies like the American Association of State Highway and Transportation Officials, Federal Highway Administration and the Environmental Protection Agency to cities looking to deploy focused on improving the safety levels of roads while also reducing the level of emissions in cities across the U.S. This could be done in tow ways. The first would be to identify cities who have applied to grants for improving their traffic safety infrastructure and just like in the emissions strategy, focus

their marketing activities on them. The second method would be to research on the grants highlighted in the previous chapter and work with departments of works or transportation in cities where they have been able to create relationships in applying for those grants. Some examples of the grants we suggested include:

a. Transportation Investment Generating Economic Recovery (TIGER) Grants

Offered by the United States Department of Transportation, the TIGER grant is designed to provide sponsorship opportunities for national projects in road, rail, transit and port improvement activities. Since 2009, the United States Congress has set aside \$4.1 billion through the TIGER Grant program towards these projects in enabling the DOT to assess a broad broad of projects based on their merits and potential impact to the society in which they are implemented, helping to ensure that American taxpayers are getting the highest value for their money.

Previous TIGER grants allocations have been divided into the following: \$1.5 billion for TIGER I which was used to fund a total of 51 innovative capital projects, \$600 million for TIGER II, used to fund 42 capital projects and an additional 33 planning projects; \$526.944 million for FY 2011 awarded to 46 capital projects in 33 states and Puerto Rico, \$500 million for FY 2012 awarded to 47 capital projects in 34 states and the District of Columbia, \$473.847 million for FY 2013 awarded to 52 capital projects in 37 states, and \$600 million for the FY 2014 round of TIGER Grants.

The TIGER fund is designed to cater to projects that would otherwise be challenging to fund through existing programs, enabling the DOT to use a rigorous process in making the investment decisions to select sustainable projects with exceptional benefits while exploring ways to deliver projects faster and save on construction costs.

b. Automated Red Light Enforcement (ARLE) Funding Program

This funding program is made available by the Pennsylvania State Department of Transportation. Established in 2010, its aim is to use extra revenue generated from the Automated Red Light Enforcement program to fund projects focused on increasing road safety usage throughout Pennsylvania. The program provided \$4.7 million in funding to projects improving safety, enhancing mobility and reducing congestion on roads in Pennsylvania. The ARLE grant is provided by the local Department of Transportation at Pennsylvania and is accessible to the following type of organizations:

- Local authorities (counties, municipalities, and other local boards or bodies having authority to enact laws relating to traffic
- Metropolitan Planning Organizations (MPOs)
- Rural Planning Organizations (RPOs)
- County planning organizations
- Commonwealth agencies

Seeing that the use of traffic lights increases the level of safety for the different types of road users, especially pedestrians and cyclists, SURTRAC would be able to leverage this funding opportunity to scale its operations as it sufficiently qualifies for this program.

Thus the SURTRAC team would have to collude with one of the above category of qualified applicants in pushing for its technology to be implemented as one of the techniques of improving road safety. Seeing that optimizing the operations of traffic lights increases the level of safety for the different types of road users, especially pedestrians and cyclists, SURTRAC would be able to leverage this funding opportunity to scale its operations as it sufficiently

qualifies for this program.

c. Moving Ahead for Progress (MAP-21) Act

Initiated in 2012 when President Obama signed the 2-year transportation re-authorization bill, The MAP-21 Act consists of a set of laws focused on helping the Federal Motor Carrier Safety Administration (FMCSA) in its mission to reduce crashes, injuries and fatalities involving large trucks and buses.⁴² It is general knowledge that most road accidents occur at intersections and thus the ability to reduce these incidents could go a long way in improving the level of safety on our roads. This new law provided about \$561 million in FY 2013 for road accident mitigation projects and the sum of \$572 million has been earmarked for FY 2014 in continuation of these projects. A SURTRAC deployment at an intersection could significantly improve the safety level of the intersection as it improves the allocation of “go-times” to each adjoining road, improving the overall use of the road. It could also be programmed to give priority to special utility vehicles such as public transportation buses and ambulances, allowing these vehicle types to preempt the traffic control systems when they are in close proximity to the intersections and thus allocating right of passage to them. This could significantly increase the safety levels of these roads, thus incentivizing agencies or states looking to improve their road safety levels to adopt the SURTRAC technology.

d. Congestion Mitigation and Air Quality Improvement (CMAQ) Program

The CMAQ is a program that was jointly administered by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) in 1998 to address issues relating to attaining the National Ambient Air Quality Standards (NAAQS) in the U.S. It was implemented to support surface transportation projects and other related efforts that directly contribute to air quality improvements and congestion relief, strengthening the link between transportation and air quality planning. It has provided nearly \$30 billion in funding to State DOTs, metropolitan planning organizations for projects focused on mitigating the impact of transportation on the environment, by addressing issues pertaining to non-attainment or maintenance for ozone, carbon monoxide, and/or particulate matter.⁴³ It could thus be said to provide funding for air quality projects to states that have no non-attainment or maintenance areas. Pursuing the strategy of identifying cities in non-compliance with the EPA Clean Air Act, this program would be a great source of funding for SURTRAC. Like the TIGER and ARLE grants, this program does not provide funding directly to private companies with traffic congestion alleviating technologies, so the SURTRAC team would have to work with the various states and public agencies in securing these funds for implementing their technology.

e. Siemens Technology to Business Initiative

The Siemens Technology to Business Initiative is a platform designed by the company to leverage new technologies in the traffic control space in advancing the development of more adaptive and automatic traffic control systems. This initiative works by “seeking out the latest technology innovations from startup companies, individual inventors, universities and research labs, using a variety of approaches for these engagements, ranging from contract work with the startup companies, to hiring the innovators, to licensing their technologies”.⁴⁴ With offices in the United States, China and Munich, it provides both funding opportunities for organizations or companies with technology that could either complement theirs or create new ways of solving

⁴² MAP-21 - Moving Ahead for Progress Act, <http://www.fmcsa.dot.gov/mission/policy/map-21-moving-ahead-progress-21st-century-act>

⁴³ Congestion Mitigation and Air Quality Improvement (CMAQ) Program, http://www.fhwa.dot.gov/environment/air_quality/cmaq/

⁴⁴ Siemens Technology to Business, <http://www.ttb.siemens.com/en/index.htm>

traffic congestion issues in cities across the world. It also enables collaboration between different actors in the traffic control space, providing these new and innovative startups and companies with access to venture capitalists looking to fund new ventures in the traffic control space and Siemens executives.

We believe that this presents one of the most promising opportunities for the SURTRAC team, seeing its affiliation with Carnegie Mellon University and also the effectiveness of its solution from the Pilot projects conducted in Pittsburgh. Signing up for this initiative only requires SURTRAC to make an application on the Siemens TTB website with the application requiring the company to field a few questions regarding a brief overview of their technology, the problem the technology has been designed to solve, the new value being introduced by their technology and some information about the founding team. We believe through this initiative, the SURTRAC team would be able to leverage the resources of the Siemens platform in reaching out to potential investors, increase the publicity of its technology and creating a ready market for its technology.

8.0 Conclusions

In conclusion, we see that the current method of adaptive traffic signal control consists of platforms that either aggregate traffic flow data and coordinate network control centrally or drive local intersection control with static, pre-computed global coordination plans.⁴⁵ However, the SURTRAC system is a decentralized control system designed to cater to urban road networks with heavy and complex traffic flows. This decentralized system provides huge advantages compared to the existing systems and has proved by the pilot project operated in Pittsburgh to offer significant value to agencies and cities that might be interested in adopting its technology. Based on these advantages, SURTRAC has the potential to win big in new markets as it continues to seek avenues for advancing its technology. We have looked at the current situation of SURTRAC and identified several important issues that they need to solve (focusing on liability and privacy challenges) or can take advantage of aspects of their technology (including traffic congestion and emissions reduction opportunities) they could leverage in marketing their technology to the various interest groups. Our proposition for the company is a 3-part strategy. One, it needs to focus on its emission reduction value proposition as its core selling point as this might prove a path of least resistance for the company to sell its technology to the various interest groups. Across the U.S., Green House Gas emission is a hot topic of discussion and the SURTRAC teams ability to leverage the opportunity this presents would give it in-road into the various states or agencies it is looking to market its product to. One way to also leverage this recent growth in concern about the emission levels is for the company to aggressively market its technology to cities that are not in compliance with the National Ambient Air Quality standards set by the EPA. We also suggest that in addressing challenges due to liability issues that it might have to deal with, the SURTRAC team should work with various state departments of transportation in developing safety standards and maintenance programs that govern the methods of operation of software that control traffic control systems. This way the team takes the opportunity of possibly pioneering the development of traffic control software operational standards, seeing that the current standards that exist are mostly focused on the operational methods of the hardware components of traffic control systems. These standards would thus help prevent potential issues due to inefficient operations of traffic control systems at intersections as it allows for periodic checks and improvement in signal timing allocation. It also helps put the company in a good position to defend itself in the event of an accident at an intersection due to a malfunction of the traffic control system as it shows the portion of traffic control operation the SURTRAC software is responsible for. Thus the SURTRAC team could focus on improving the operations of its system to ensure its absolved of any potential claims by accident victims in the event of a liability lawsuit. We have also suggested several funding opportunities we believe the SURTRAC team could leverage going forward in expanding the reach of their technology. These funds are mostly available to governmental agencies looking to reduce road congestion, improve mobility and road usage for all categories of road users, while enhancing the safety levels of road transportation and also reducing vehicular green house gas emissions. Though most of them are not provided directly to private companies, the SURTRAC team could work towards developing relationships with the various agencies that potentially qualify for these funds or grants and work with them in both applying for these grants. Its aim in this stead would be leverage the gains from its technology while establishing the required partnerships in lobbying these agencies to adopt its product in their proposed projects. Another funding opportunity the team could leverage is creating license partnerships with manufacturers of traffic control systems like Siemens and McCain. Siemens in particular has an process termed the Technology To Business Initiative which is focused on leveraging partnerships with startups and university research programs in identifying new technology that could be put towards improving road safety and advancing adaptive road traffic control. This initiative provides access to capital and collaborative research towards development advanced traffic

⁴⁵ Smart Urban Signal Networks: Initial Application of the SURTRAC Adaptive Traffic Signal Control System, Stephen F. Smith etc. The Robotics Institute, Carnegie Mellon University

control systems. We thus see that a number of opportunities exist for SURTRAC to get its technology to market in an effective and efficient way. Adopting these strategies would help provide the SURTRAC the opportunity to increase engagement with their technology while providing cities that have opted to deploy their optimization tool significant benefits in reduced traffic congestion, improvement in usage of road facilities and reducing the contribution of transportation to Green House Gas (GHG) and particulate matter emissions.