MODEL A

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Final Proposal

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Problem Statement:

How might we develop affordable sensor technology to provide cities with a tool to manage the congestion that results from multimodal transportation on surface roads?

Who: Atlanta and similar cities
What: A tool to allow for real-time control of traffic congestion
When: The next three years
Where: surface roads
Why: To allow cities to prioritize certain vehicles or forms of transportation in real-time in order to reduce congestion and alter the flow of traffic

Significance

The problem space is centered around the issues associated with traffic congestion in major cities: traffic congestion slows the response time of emergency vehicles and extends commute times for drivers. Almost 30% of minor fender bender accidents occur in bumper-to-bumper traffic and could easily be avoided with smoother traffic flow (Impact Attenuators, 2008). The average American spends 38 hours a year stuck in traffic (The American Spends, 2013). With less traffic on surface streets, this number could be reduced dramatically, creating a more productive and less stressed society.

Poor signal timing attributes to 5% of traffic congestion in the US (Major Causes, 2016). Other causes include bad weather, work zones, and bottlenecks--all factors that are either uncontrollable or very difficult to control. Traffic incidents account for 25% of congestion (Major Causes, 2016). Because most roadway accidents occur during high congestion times, improving signal timing to meet the needs of each particular intersection at any given time can decrease the amount of accidents that occur, therefore dramatically decreasing congestion.

Improving traffic congestion will create safer roadways, allowing pedestrians and bikers to feel more comfortable on surface roads. Furthermore, it will improve the reliability of bus routes with quicker, more accurate timing, incentivizing public transportation and taking more vehicles off the roadways, improving traffic even further (Institute for Transport Planning, 2012). Due to the increase in public transportation usage that can occur, public transit systems will be able to invest in more routes and better vehicles, again improving the quality of transportation for those to are unable to afford other forms of transportation (Bouchard, 2015).

By improving traffic congestion, multiple groups of people and industry will be better connected to across the city.

Stakeholders

In this problem space, the stakeholder is anyone who needs to travel around the city via surface roads. In Atlanta, for example, where the public transportation system does not meet the needs of most people, a system that prioritizes MARTA buses could incentivize the use of public transportation. People would be more likely to drive electric vehicles, ride bikes, use public buses, or even walk if they knew that specific form of transportation could speed their commute and travel times. With our system, cities can have the tools to prioritize certain forms of transportation in order to decrease the amount of traffic on surface roads. Companies such as FEDEX, UPS, and USPS could pay for a certain priority in the system and be able to guarantee delivery times (Harps, 2005). The city has control over how they want to use the system and could choose to not allow companies or individual to pay for higher priorities. If they do allow companies and individuals to pay, however, this could fuel the city's economic dramatically.

Context and Existing Solutions

The city of Atlanta is infamous for its horrendous traffic, congested roadways, and even worse highways. As Atlanta continues to expand beyond its I-285 perimeter and as more commuters add to traffic flow both in the populous Downtown and Midtown areas and also in suburban communities, Atlanta's traffic congestion issues expand with it. Current data shows that Atlanta has the longest commute distance of all major cities in the country: 12.8 miles each way (Albright, 2015). The commutes are growing in distance and in time: the average metro commute is 29 minutes, with some suburbs ranging to an average commute of 36 minutes each way (Turner, 2014). While Atlantans are spending more and more time in their cars, mistimed stoplights only cause unnecessary pain and added delay. According to a WSB-TV report, traffic lights have not been synchronized on a city-wide level since the 1970s (Blau, 2015). In response to this, and as part of an effort to both decrease the number of cars on the road travelling only short distances and the environmental impact of exhaust, Atlanta is currently in the first year of a five year bond program, Renew Atlanta, aimed at repairing infrastructure within the city (FAQs, 2015). Renew Atlanta is working to connect and ensure the safety of communities, reduce congestion, and improve mobility for alternative forms of transportation "including pedestrians, bicyclists, motorists and transit riders of all ages and abilities" (FAQs, 2015). Of the $250 million bond package, the largest portion--16% of it ($40 million)--is dedicated toward traffic signals (FAQs, 2015). By replacing equipment, signal lights, and communication systems, the City of Atlanta is working to create optimized major thoroughfares throughout the city.

Coupled with the arising of these new opportunities for improvement available in the Atlanta area, the city is ripe for additional incentive to utilize traffic signal synchronization on the roadways. Yet, Model A is not the first to attempt to solve this problem of congested roadways: two products, Opticom and Canoga, have already taken similar routes in changing the way that the mixed fleet moves. Opticom focuses on the ability to recognize when emergency vehicles or public buses are approaching intersections, so that the lights can be lined up in a manner that provides the vehicles to travel with as little interruption as possible when crossing the intersections (i.e. changing the lights to all be showing green in the direction of the path of an ambulance) (Opticom Transit Signal Priority, 2014). While this product in itself is beneficial in reducing delays in public transportation and emergency response times, the technology behind it is expensive and costs a city millions of dollars to implement—so it has currently only been implemented in wealthy areas that are able to gain funding from the state (City of San Mateo California, (n.d.)). With Renew Atlanta's total budget of $250 million over the next five years, a system like Opticom, costing around $35 million, would be too expensive a product for a city making its first step in repairing a backlog of $900 million infrastructure repairs (FAQs, 2015). Additionally, while Opticom addresses managing the cycle of lights to give emergency vehicles and public transportation vehicles the right-of-way, it does not address the everyday driver in a single-occupancy vehicle or emphasize the use of alternative forms of transportation. However, the product Canoga focuses on the mixed fleet of vehicles--not just emergency transport. Yet, Canoga operates in a different manner than Opticom: through the use of induction loops, Canoga is able to send signals to the intersection that certain classes of vehicles are approaching (Canoga, 2015). Canoga has the ability to recognize that variable vehicles exist in the mixed fleet, but can only recognize them based off of the location of the induction loop they drive over--if a bicycle signal is sent to the receiver, it is because a vehicle drove over the induction loop in the bicycle lane (Canoga, 2015). Because its operating system is so comparable to Opticom's, it, too, cost tens of millions of dollars to only implement in a few thoroughfares. While Canoga requires the tearing up of current streets to add the various induction loops and a great cost to the city that implements it, it accomplishes a similar goal as that of Model A: to recognize multimodal forms of transportation at intersections.

Opticom and Canoga are the two most comparable solutions that address the issue of congestion within the mixed fleet, yet they both leave room for improvement—Opticom only addresses a very specific situation and Canoga has a much higher cost than Atlanta can afford. Neither of these existing solutions address the buildup of commuters at intersections—either in personal automobiles or on motorcycles, bicycles, or scooters. With the ability to control lights remotely, Opticom and Canoga both leave room for the ability (in the future) to better regulate traffic and the mixed fleet based off of signals sent from vehicles to intersections through cheaper and more easily implemented means. Model A has the ability to enter this changing and evolving problem space in Atlanta as Atlanta not only invests in its general infrastructure, but as it vastly expands its signal timing and signal equipment. We have the ability to combine the guiding principle of both of these current solutions (providing a tool to remotely monitor vehicles at intersections) to reduce the congestion that plagues Atlanta at all hours of the day.

Why is this Still a Problem

Even though there are solutions both in the public and private sector addressing specifically the timing of traffic lights at crowded intersections, the continued advent and advancement of multimodal forms of transportation have only compacted the existing issues. Looking only at Atlanta, congested highways and roadways span the city and outlying suburbs throughout peak driving hours (and off-peak hours in the city center), causing increased average trip times.

Despite the fact that the traffic problem in Atlanta has been growing throughout the recent decades, single-driver cars remain the dominant form of transportation. Public transportation, including MARTA, GRTA, and CCT, is infamously considered to be ineffective because it does little in connecting the urban sprawl of Greater Atlanta to Metro Atlanta; the buses take too long and the trains travel only along two main paths, so it is underutilized and provides little change in the number of cars on the road. Atlanta does not currently host expansive miles of bicycle paths for urban riders and commuters, so the majority ride in the same lanes as automobile traffic (Atlanta Bicycle Coalition, 2014). As the mixed fleet becomes increasingly more mixed and congests roads beyond their previous capacities, commuters spend more time sitting in traffic and less time at work, home, or other destination points. While the solutions currently on the market have the potential to alter the timing of intersections so that cars will move more freely through them, they are only being implemented in wealthy areas that have the resources to devote $35 million to stoplight timing. Considering that Atlanta only has $40 million to spend on the signals themselves, their equipment, and their timing, the $35 million necessary to only effect change on certain corridors is too much of a cost to a city that has not reworked the signal timings of all of the lights in the city in four decades. Additionally, neither system is able to count the volume of cars at each intersection, travelling in each direction; when Canoga is tripped, it works comparably to a typical induction loop, in that it recognizes that a vehicle is present, but cannot recognize more than the amount of cars that has tripped it.

By placing a form of electronic identifier on vehicles to communicate with the intersection to announce their arrival, Model A is focusing in on the area neglected by Opticom and Canoga: the everyday commuter stuck in the middle of the line at an intersection in peak-hour traffic. When peak-hour traffic congests intersections to the point where stacking prevents cars from moving through in one light rotation, drivers are forced to sit and wait in an awkward in-between stage during which they must simply wait in limbo before they can arrive at their destination. By reporting the volume of cars at intersections, Model A picks up where the other solutions leave off: we use their idea of traffic preemption, but implement it based off of the number of commuters travelling in a certain direction. The gathered data is then used to make a decision: which direction the light should face green. Currently, these decisions are made by trial and error monitoring with traffic engineers standing at intersections during certain hours of the day. Yet, this method still leaves the need for data from the dynamics of outside factors that alter the flow of traffic on a daily, weekly, or monthly basis that cannot be represented by trial and error attempts.

Proposed Work:

Goal

Our goal for this project in the next 1-2 years is to develop electronic identifier that can be mounted to a bicycle and a receiver that can be simply incorporated into the computer cabinet at a stoplight. This will be considered a success at "provid[ing] cities with a tool for managing congestion." Included in reaching this goal would be a test at a minimum of one intersection as a proof of concept of both the reliability of the technology and its effectiveness at reducing congestion. The impact will be measured in the effectiveness of the test at reducing the commute for cyclists passing through the test intersection(s). With a completed system and the results from the test, we will look to find a way to scale this system up immediately to a greater number of intersections and a greater variety of vehicles.

Objective #1: Reduce Commuting Time for Certain Classes of Vehicles

Background:

One of our main objectives in order to achieve our goal is to reduce commuting time for certain vehicles, whether it be buses, government vehicles, streetcars, or bicycles. The problem, however, has to do with commutes in cities such as Atlanta. Cities have significantly more traffic lights than other locations, especially in concentrated downtown business districts, and according to a study done by the Federal Highway Administration, traffic signal preemption can cut waiting time at traffic lights by 30-45 seconds. Our ability to implement this technology and reduce commuting time for individual drivers will determine our ability to widen our scope to prioritization of vehicles. At certain intersections, corridors, or, potentially, all traffic lights, this preemption and prioritization could reduce commute time for all vehicles, but has the potential to incentivize the use of certain methods of transportation. If we fail to reduce commute time for vehicles, we will fail to reduce commute time for all modes of transportation, and overall commute time and congestion will continue to increase.

Methods:

1. Use one intersection as a proof of concept; prove that the technology works on automobiles.
2. Observe a popular Atlanta route and record the commute time without implementation of the technology.
3. Plant the intersections of the observed route with the technology, and record the new commute times.
4. If commute times for has improved, implement the technology on several more intersections.
5. If the technology continues to work, implement it on other vehicles such as buses, government vehicles, or streetcars.
6. If the technology continues to improve commute time, implement the technology with all vehicles on the road to maximize traffic light efficiency.

Outcomes:

The success of the project will be determined by our ability to reduce commute time for the vehicles with which we implement our technology. If all goes well, the technology will be implemented on a large scale, and it could drastically improve commuting times in the city for all vehicles. A failure would mean that we have not improved commuting time. In fact, there is a possibility that the traffic light preemption could increase commuting time and be counterproductive. The success of our project hinges on whether we can reduce congestion for targeted vehicles.

Anticipated Problems:

There are a few problems that we anticipate will arise in implementing our solution. The chief problem will be in convincing people (The Department of Transportation or the general population) that vehicles should be given preemptive technologies. We also anticipate that using a preemptive technology will initially increase commuting time, as we (or the DOT) figure out the most efficient way to utilize wide scale preemption technology. These obstacles could be challenging, but they are not impossible to deal with and should not halt our project.

Objective #2: Incentivize Alternate Forms of Transportation

Background:

What once started out as just a railway junction, the city of Atlanta has become one of the busiest cities in the nation, boasting over 5 million jobs to the metro area (Hudson, 2015). Since only approximately 450,000 people live in the city limits of Atlanta, a mass commute from surrounding suburbs into the city runs like clockwork before and after the nine-to-five workshift (United States Census Bureau, 2015). In a 2013 study, Atlanta ranks in the top 20 cities in the nation for passenger trips on mass transit (MARTA), bus agencies (MARTA), commuter buses (GRTA and CCT), transit vanpool usage, and heavy rail-riders; yet, these options of transporting the large suburban commuter population into the city center still appear as a taboo or exist only for those who are unable to afford their own automobiles (American Public Transportation Association, 2015). The data does not seem to correlate - how do comparatively successful public transportation methods still result in one of the longest commute times in the nation? In an attempt to manage congestion in large urban cities like Atlanta, alternate forms of transportation must be equally or ideally more attractive than the current methods. This is both an important and necessary facet of problem solving because our sensor technology will not impact current traffic patterns unless a significant portion of daily commuters are incentivized to make a change in their daily habits.

Methods:

In order to quantifiably define the success of our proposed solution, we must first outline the variables that would incentivize an alternate form of transportation. Model A created a comprehensive list of factors that would have to change in order to decrease commute times on surface roads, and hypothetical questions future users would pose. As follows, the variables are:

- Route - Would this alternative route decrease my commute time during peak and off hours?
- Distance - Through an alternative form of transportation, would my commute be shorter? More accessible?
- Safety - Would I feel just as or more safe on my daily commute? Would I worry less about the safety of my personal belongings and myself?
- Options - Do substitute transportation methods give me more authority over when I leave and when I arrive? Do I have more than one choice in choosing an alternate method of commuting?
- Convenience - Would I be going out of my way to try something new? Would I see immediate results? Would it be comfortable?

In theory, *at least* one of these variables must be met on a case-to-case basis for the idea to catch on and cause change. As of now, the vast majority of suburban Atlantans are too comfortable sitting in their car for almost an hour a day inching their way to the city center. In essence, the incentive is not a monetary or tangible reward, rather the incentive is a reduction in the daily hassle of planning around road congestion and traffic (or sitting through it).

Outcomes:

The success of incentivizing different modes of transportation is, for the most part, easily gaugeable. Time taken, distance traveled, and number of transportation options are all concrete numbers. However, some may value the more qualitative incentives, such as safety and convenience, more than the measurable variables and lead to simple "Yes" or "No" answers. As a result, there is a balance of qualitative and quantitative data that could lead great insight into the success of this program. An ideal outcome would be an overall decrease in average commute time, indicating that Atlantans are finding alternative commuting methods that would decrease the congestion on surface roads and increasing diversity in multimodal transportation.

Anticipated Problems:

In speaking with several professionals, one major anticipated problem would be the initial approval of the general metro Atlanta public. Our solution would start with a simple implementation on one form of transportation in hopes to reduce the commute time along test routes. Eventually, our technology would become more scaleable, covering more incentive variables and opening options of prioritization to other modes of transportation (like mass transit and carpooling). However, the relative "success" in decreasing the commute time for commuters already located in the heart of the city or close to their offices could become overshadowed by the many commuters who are faced with still having to wait in traffic along I-75, I-85, I-285, and other *non*-surface street systems. On the other hand, once scaled to consider the longer commutes, the disgruntled suburban public would no longer be as upset and would ideally experience a shorter commute time, possibly even enjoying a new, more efficient surface street route that takes them to work.

Objective #3: Increasing the Efficiency of Mobility (Long Term: Less Energy and Fewer Vehicles)

Background:

Traffic congestion, seen throughout metro and the greater Atlanta area, results when there are too many vehicles for the available road space, causing drivers to become gridlocked and drive times to increase drastically. Congestion can occur in any system of infrastructure in any location, but, in general, it is most often experienced with the greatest severity in and around the major central business districts during the morning and afternoon peaks of rush hour. Road congestion may be related to one of two sets of conditions: either inefficiencies within the traffic flow system or the demand placed on the system (or a combination of the two conditions) (Robinson, 1984).

A key objective of our project is to increase the efficiency of vehicular mobility in a multimodal fleet of vehicles currently on the road. This is a long term goal due to projection that the immediate effects of the project will be far outweighed by the long term effects of easing traffic mobility and reducing congestion on surface roads. Simply stated, the objective over time is to reduce the number of vehicles on the road at the same time by reducing travel times and to simultaneously reduce the total energy consumed by the various modes of transportation. With a greater use of mass transit and reduction in the use of individual vehicles, the roadways become more clear and the time taken to commute from point A to point B is reduced.

Methods:

To see whether the objective has been achieved or rather whether the solution is working towards the objective, we plan to run experiments and collect data relating to the number of vehicles and number of commuters.

The different variables to best evaluate whether our solution is working in the long run are:

1. Number of Vehicles at Intersections (where implemented)
   - A decrease in the number in the total number of vehicles on surface roads would lead to an increase in mobility as well as a reduction in the total congestion.
   - This would be best estimated by the number of vehicles at stop lights.
2. Time Taken to Commute
   - The time taken to commute should theoretically be far less with greater mobility and lower congestion if those people are using the solution.
   - This would be calculated by checking the times of comparison over a period of time
3. Volume of Commuters Using Transport with Our Solution Implemented.
   - With the proposed system, the most effective and efficient use of the system would be the actual implementation and utilization of the system by drivers on the road, indicating that commuters are disincentivised against transport methods which are not prioritized.
   - This would be checked by monitoring the inventory and amount of our product sold/affixed onto various forms of vehicles.

Outcomes:

With the proposed solution in mind, after implementation, the desired outcome will be years away. The initial implementation would be congestion-heavy intersections and surface roads. Immediately, we hope to see a reduction in time travelled specifically for the category of vehicles on which we first decide to implement our solution. This, we hope, positively incentivizes the use of transportation methods which are privy to the benefits of the reduced time (i.e. the vehicles on which these electronic tools are attached) that would increase mobility as well as reduce congestion on roads.

Anticipated Problems:

One major anticipated problem is to determine whether this solution would be in effect long enough for collected data to show whether this system should be implemented in Atlanta and similar cities. Without having a proper place to gauge the effectiveness of the solution, there can be no increase in mobility and nor reduction in commute time thus we can say that there'll be no reduction in congestion.

Project Team

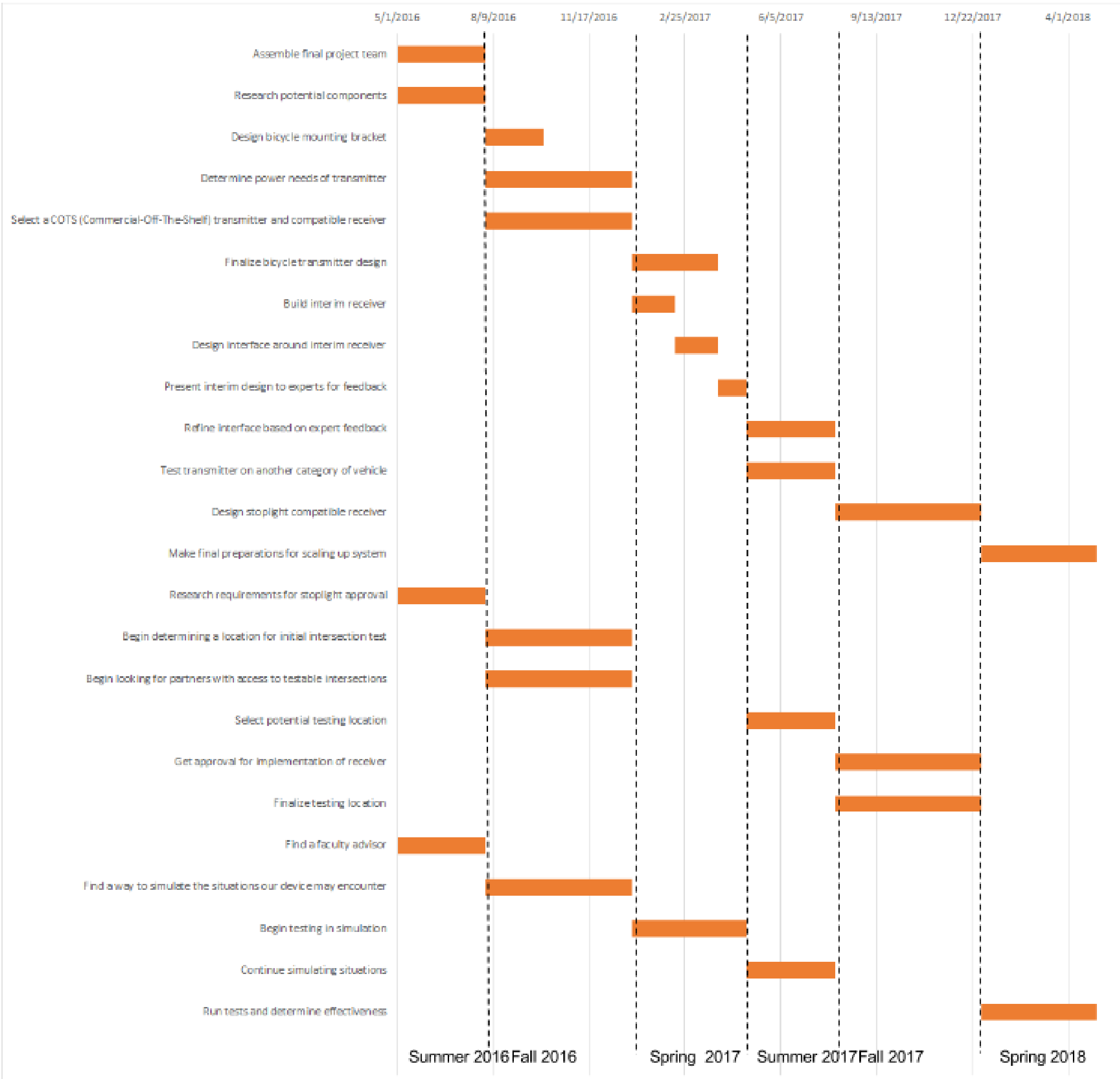
Our team would be composed of 5-6 members in a variety of different roles outlined below.

- Project Lead - 1 person
  - The Project Lead will be responsible for managing team dynamics as well as bridging the gaps between the different systems that the other team members are working on. They must have knowledge with all aspects of the project and be able help out with any of the other team responsibilities as needed.
- Traffic Management Lead - 1 person
  - The Traffic Management Lead would focus on optimizing the implementation of our system at an intersection. They would be responsible for simulating the possible effects of our system as well as designing tests for it. Making sure that our product will have a positive impact on congestion will rest on this person.
- Signals Team - 2-3 people
  - The Signals Team would be responsible for the bulk of the design of our project, including the electronics necessary for the transmitter, the receiver in the stoplight cabinet, and interface for adjusting our system. This will require knowledge of signal processing, programming, radio-frequency engineering, and possibly even cybersecurity in order to successfully implement this system. This team is the largest due to this variety of needs to make it successful.
- Outreach Lead - 1 person
  - The Outreach Lead will be responsible for the outward communication of our team, particularly with governments and other potential users of our system. They will need to thoroughly understand the technical aspects of the project and be able to communicate them to both those technically literate and those who are not. They will also be responsible for managing the image of our system in order to overcome potential concerns about its effectiveness.

Timeline

- Summer 2016
  - Assemble final project team

    - Research potential components
    - Research requirements for stoplight approval
    - Find a faculty advisor
- Fall 2016
    - Design mounting bracket
    - Determine power needs of transmitter
    - Select a COTS (Commercial-Off-The-Shelf) transmitter and compatible receiver
    - Find a way to simulate the situations our device may encounter
    - Begin determining a location for initial intersection test
    - Begin looking for partners with access to testable intersections
- Spring 2017
    - Finalize transmitter design
    - Begin testing in simulation
    - Build interim receiver
    - Design interface around interim receiver
    - Present interim design to experts for feedback
- Summer 2017
    - Refine interface based on expert feedback
    - Continue simulating situations
    - Select potential testing location
    - Test transmitter on another category of vehicle
- Fall 2017
    - Design stoplight compatible receiver
    - Get approval for implementation of receiver
    - Finalize testing location
- Spring 2018
    - Run tests and determine effectiveness
    - Make final preparations for scaling up system



5/1/2016
8/9/2016
11/17/2016
2/25/2017
6/5/2017
9/13/2017
12/22/2017
4/1/2018
Assemble final project team
Research potential components
Design bicycle mounting bracket
Determine power needs of transmitter
Select a COTS (Commercial-Off-The-Shelf) transmitter and compatible receiver
Finalize bicycle transmitter design
Build interim receiver
Design interface around interim receiver
Present interim design to experts for feedback
Refine interface based on expert feedback
Test transmitter on another category of vehicle
Design stoplight compatible receiver
Make final preparations for scaling up system
Research requirements for stoplight approval
Begin determining a location for initial intersection test
Begin looking for partners with access to testable intersections
Select potential testing location
Get approval for implementation of receiver
Finalize testing location
Find a faculty advisor
Find a way to simulate the situations our device may encounter
Begin testing in simulation
Continue simulating situations
Run tests and determine effectiveness
Summer 2016
Fall 2016
Spring 2017
Summer 2017
Fall 2017
Spring 2018

Budget

Names	Costs	Notes
Materials and Supplies		
Transmittor Prototype	$100.00	
Power System Prototype	$200.00	
Reciever Prototype	$500.00	
Equipment		
Traffic Simulation Software	?	Possibly something that can be used by partnering with a Lab at Georgia Tech
Services		
Interface Development	$200.00	
Travel		
Meeting with Experts	$200.00	Depending on how far we have to travel to meet experts to get their insights on our final prototype
Total	**$1,200.00**	

Expectations

By the end of year 2 of our project, we will have a completed system that is ready to be produced and implemented on a wide scale. Each component of the tool we have designed will be finalized and ready for production. The transmitter will be fully developed and easily adaptable to any type of vehicle. It will have been thoroughly tested in a variety of possible situations and able to perform in a way deemed adequate by both our group and the industry standards. In addition to this, by the end of year 2, the receiver will have gone through a number of iterations, culminating with a design that is compatible with the existing traffic light cabinet and approved by the Department of Transportation for use in traffic lights. This will require us to work closely with the Civil Engineering Department here at Georgia Tech to make use of their connections to both government and industry, which will be needed to get this approval. Within the Civil Engineering Department, we also have to work on finding a Lab that focuses on traffic simulation in order to help us calibrate our tool for applications in the real world.

Funding for this project could come from a variety of different sources, as it fits into a number of different categories within transportation. The U.S. Department of Transportation offers a variety of grants that possibly relate to our project, including those about connected cars, public transportation, and freight transportation. The US government announced a Smart Cities Initiative to allocate and invest over $160 million in federal research to help communities tackle local challenges such as reducing traffic congestion, fighting crime, etc. Possibly, we can present to them our solution to reduce commute time and hence congestion. If they can be convinced of its importance to modernizing the flow to traffic in major cities, we could potentially work with implementing our solution on a wider scale and that may help increase the impact of the system in multiple urban environments.

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