Red Rocks Community College
Intersections for the Future!

Alternative Traffic Control
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Intro Design/Engineering App
Spring Semester
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May 2, 2017

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Part I: Project Planning

Traffic lights, intersections, distracted drivers, and their interactions are considerable issues facing the public today. These problems have been relevant from the time of the first traffic signal installation in the early 20th century and have worsened since. Many drivers when waiting at a red light turn to their phones or other distractions to occupy their time. They often miss the light change to green as a result, only realizing the mistake when the orchestra of angry car horns pulls them back to reality.

The delay has two major effects. First, fuel from all vehicles immediately held back is wasted. Idling for a range of passenger cars varies from 0.2 to 0.5 gallons/hr (Gaines), and is likely higher for larger vehicles. Typical modern sedans produce around 0.588 grams/second or about 2000 grams/hour (Gaines) of CO_2 while idling. This seemingly small amount really adds up when multiplied by the millions of vehicles spread across the thousands of major and minor cities that are affected by these delays every day. The traffic stalling effect also causes fewer vehicles to pass through the light, further compounding the issue. Fuel consumption and excess emission production resulting from the delay has both environmental and economic impacts, affecting drivers and ultimately everyone on Earth.

Second, many accidents are undoubtedly caused by drivers surging ahead after a delay, missing pedestrians, bikers, or other drivers in their haste. The medical and car insurance impacts from this are often severe. The money, time, and medical services used or lost to these accidents would be better utilized elsewhere. Driver distractions are seemly getting more severe as technology progresses, so action is necessary to address the ever growing problem. A “AAA” case study showed that 6/10 accidents were caused by teenagers due to distracted driving. (John) A lack of corrective action will only serve to ensure the continued waste of fuel, unneeded production CO2 emissions, and economic impacts of avoidable accidents as described above. There are no project planning areas for this project

Several methods were used in our attempt to engage the community in the project planning process. First, we contacted the City of Lakewood traffic engineers via email for their expert opinions and suggestions. They provided excellent support and exposed us to valuable resources used for our project. Then, seventeen people were sent information regarding the project via email. The information described the scope of the problem, our proposed solutions, and the need for the project. Recipients were invited to review the information and provide feedback. A similar message containing the same information was also posted on a public social media page. Next, three citizens who are all drivers were interviewed over the phone. The conversation included the same information as the email. These individuals provided valuable insight on the project and suggested several alternatives. They all understood the need for the project and supported further work on it.

Part II: Existing Facilities

Nobody likes waiting on the internet, a place designed for instant gratification; but at least the internet has progress bars and buffer statuses for those unbearable moments. Once we step away from our computers we can quickly notice the infuriating lack of progress bars in life. Take for example, traffic lights in the United States. Traffic lights seem straightforward, if it's red it means stop, when it's yellow it means slow down, and if it's green it means go. However, there's way more to it than meets the eyes. People have sat at traffic lights for well over 7 minutes waiting on the red light to turn green, while there were no other cars visible for miles. For quite a while, since their implementation in 1912, traffic lights tell us when we must wait, but never how long you must wait.

Traffic signals were originally mechanical machines independent of each other until technological advancement improved their functionality and efficiency. The mechanical controllers use a group of wheels in contact with a bank of switches that correspond to the lights; wherever a section of the wheels has been broken away, the contacts will close and the corresponding lights will come on. Although modern microelectronics has invaded the world of traffic signal control, there are still some of the original controller boxes sitting on traffic corners. The computer adaptations of these mechanical controllers are ingenious. The older mechanical controllers can be outfitted with a lot of different options such as multiple timers, vehicle sensors, pedestrian buttons so the lights only cycle on request; they can also be hooked to each other as well to change the lights of different intersections in sequence. While the older mechanical controllers had seen some of their flaws improved by faster processors, have they changed? There were no major changes to insure safer and more reliable traffic systems.

In the 1990s some countries began experimenting with traffic lights by including a timer that told drivers just how long they had to wait before the light changed. The idea was to give more information to drivers so that they could make better, safer decisions around intersections, the most common places for vehicle collisions. This did not quite work out as planned. When Taiwan introduced traffic lights with timers in 2004, they began studying their effect on driver behavior. The research showed that when a timer counted down from green to red, crashes and injuries increased by 33 percent. The reason being was quite simple; drivers who saw that they had a few seconds remaining would speed up and sometimes plow into another car. Interestingly, the researchers also found that when the timer counted down from red to green, crashes and injuries fell by half. This version when implemented alone, made drivers safer by eliminating the stress and anxiety from anticipating the beginning of a green light. Researches around the world further prove that when red traffic lights have a countdown delay, "road rage, impatience, and general irritation are massively reduced when you can actually see the time you have to wait." Said Nenad Stanković Deputy Manager in Niš City Directorate for Public Transport.

It is rather irritating to pull up to a red traffic light that never seems to change. Uncertain of how long we must wait, even those who are normally in a "ZEN" state can easily be put on edge. Acknowledging the various studies on traffic light timers, many countries have already introduced timers on traffic lights to indicate the wait time and to help ease that anxious feeling. The United State may be a developed country, but we are behind on many advancements when compared to other countries. What would it take for that idea to catch on here in America?

Part III: Need for Project

Earth, the planet we live on. Humanity is at a point where our scientific discoveries can not only help the world but can also destroy it. Carbon emissions into the atmosphere is a problem not yesterday, not tomorrow, now. "Carbon emissions raise global temperatures by trapping solar energy in the atmosphere. This alters water supplies and weather patterns, changes the growing season for food crops and threatens coastal communities with increasing levels." (Cairoli) The technology humanity created to increase productivity and help people every day is killing the world we stand on. If we were to focus on the U.S.A, about 30% of our carbon emissions are caused by our transportation sector. Every second a vehicle spends on the road it uses gasoline to turn the belts and keep the car running, that gasoline when combusted releases carbon into the atmosphere. A typical passenger vehicle emits about 4.7 metric tons of carbon dioxide per year. Every mile driven results into about 411 grams of Carbon Dioxide emitted into the atmosphere. (EPA) Transportation within the USA is a major contributor to global warming which our project seeks to minimize.

Emissions are not only a problem for the environment, it also affects our economy because of it's effects on the environment. According to Naza in 2012 extreme weather conditions caused one billion dollars in damages within the United States alone. Events such as Hurricane Sandy and the Typhoon of Haiyan are becoming more frequent catastrophic events due to this. This uncontrollable destruction leads to ravaged communities and infrastructure typically taking years to repair often with the help of international aid. Another economic effect would be on the food supply. Carbon emissions also contribute to decreasing precipitation, changing the growing conditions for food crops in many areas around the globe. This decreases the crop yield every year which can cause food prices to rise around the world. The increase in spending due to these environmental issues are preventable or can be minimized if we focus on the causes of them.

Lastly, it takes a small temperature change to have enormous environmental effects. By a simple change of 2.5-5 degrees Celsius, thousands of feet of ice have melted away within the USA alone. (Cairoli) This not only affects the shorelines by making them rise creating a problem for every inhabitant in coastal areas, but also releases everything trapped within the ice. The most concerning aspect of this fact are the frozen pathogens, ancient viruses which have thought to be extinct have been found within the ice, and active when unfrozen. Diseases such as the black plague and smallpox have been found within the melted ice. This is a major social concern, if people need to worry about their cities being flooded by rising waters or the resurrection of ancient plagues such as the black plague, then new methods must be developed to eliminate these concerns.

Part IV: Alternative Design I

A) **Description:**

An alternative design considered for combating this issue are redesigned traffic lights. The traffic light would have a screen next to it which would display road conditions or traffic information for cars so they could pick the quickest route home. Also, A timer would be put on the red light which would be visible to cars but not pedestrians by making the outer edges of the light act as a countdown. This is accomplished by putting additional red bulbs around the traditional light which would be on a timer each one going out after the other. When all red lights surrounding the main red light go out the light changes green. As for placing timers on green lights, a major problem found by studies in Shanghai China shows an increase in accidents in intersections when timers are displayed on green lights. Drivers have a tendency to speed up in order to make the light, even if there is only two seconds left on the timer. On the contrary, timers on red lights showed a decrease in traffic accidents by about half and an increase in traffic flow, meaning more cars get through the intersection more effectively and quickly. (Ramona) Therefore, this design and all other considered designs with traffic light timers are designed to display timers only for red lights. Also, if drivers know red lights are more reliable with timing and that they will make it through the intersection faster than before if they stop at red lights, this could potentially decrease the amount of red lights run.

B) **Design Criteria:**

A sustainable world is one in which human needs are met equitably without harm to the environment, and without sacrificing the ability of future generations to meet their needs. This Design minimizes fuel consumption by vehicles and accidents on the road. This benefit meets the requirements for a sustainable world due to the minimization of carbon output in the atmosphere from vehicles and repairs.

This design was initially purposed to get people through the intersection faster by reducing delay at red lights by showing when the light would turn green. It was also intended to show drivers information on traffic in the surrounding area so they could pick the quickest route to their destination. These benefits would allow cars to reach their destination faster reducing the amount of carbon emissions and helping the environment. Further research into this project showed that the timer would not only accomplish this but would also reduce accidents caused in the intersection. This not only benefits our initial idea but also reduced the amount of CO2 emissions caused by accidents, such as car/structure repair.

C) **Design Schematic:**

Figures 4-1, 4-2, 4-3 show our initial prototypes. The Arduino UNO would calculate when the next light will change and display the time until the change on the LCD screen. Figure 4-1 shows the wire layout of our system while Figure 4-2 is an artist rendition of our system. Figure 4-3 shows what the system would look like to oncoming drivers.

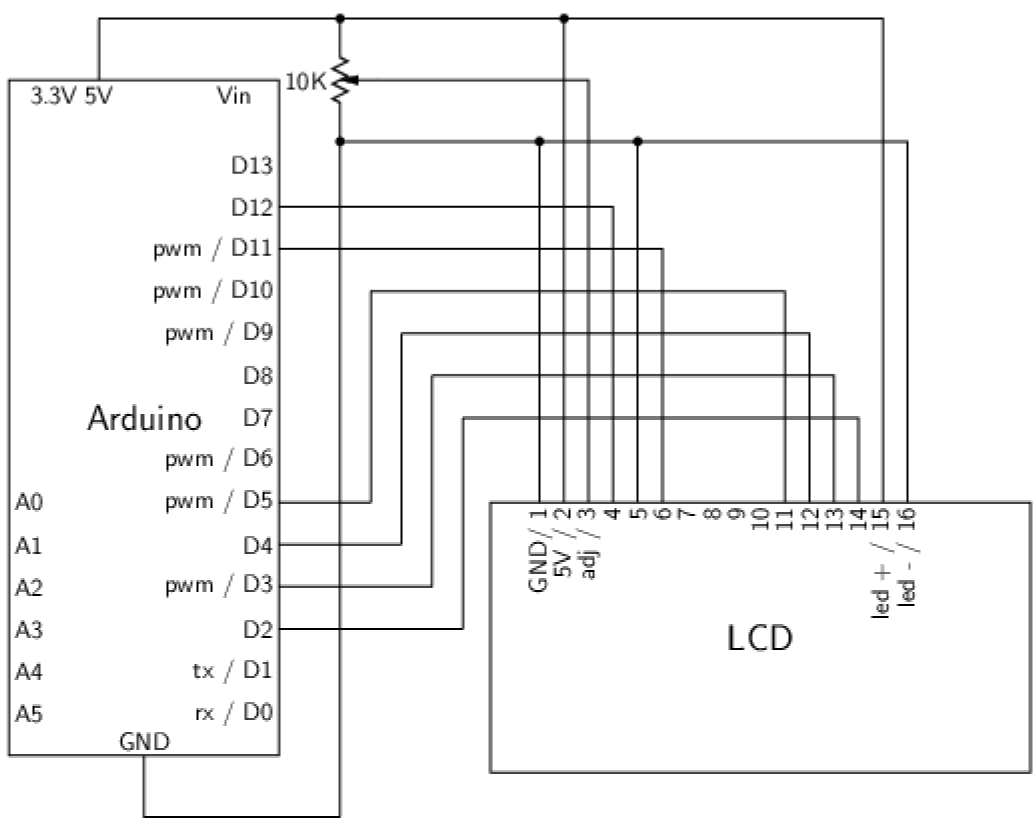


FIGURE 4-1: Wire Layout and Connection Map for Traffic Light Timer System

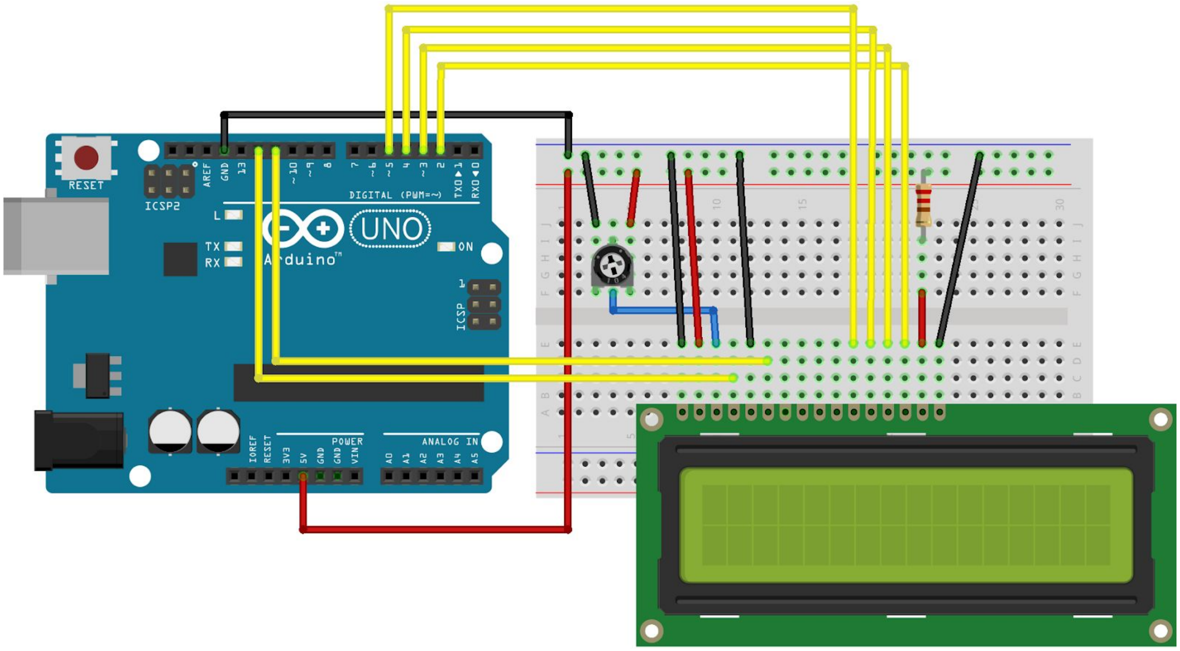


Figure 4-2: Artist Rendition of Traffic Light Timer System

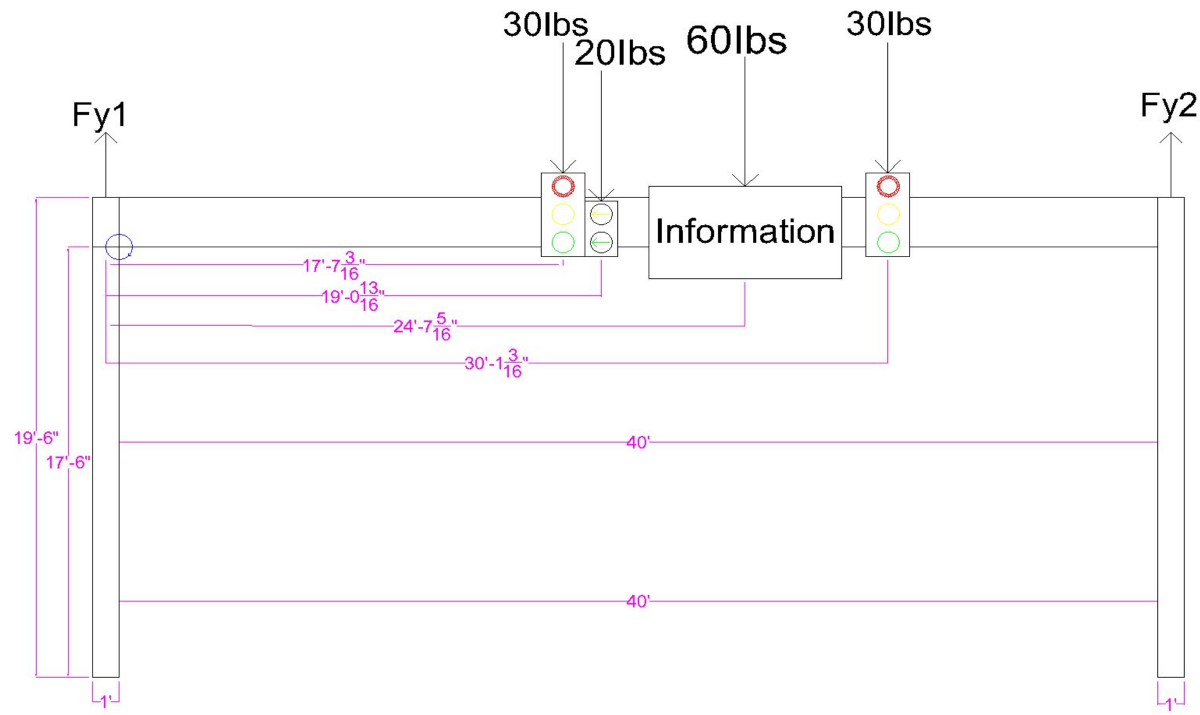


Figure 4-3: Street View of Traffic Light

D) Land Requirements:

The land required for the installation of this device would be anywhere a potential traffic light could be placed or updating pre-existing traffic lights. However, for the installation of the first few lights would have to be done at an intersection of medium traffic throughout the day. Since this device has never been tested in the United States, studies would first have to be run in order to obtain the effectiveness of the lights. Therefore, the intersection of W6th Ave Frontage Rd and Arbutus Dr, outside of Red Rocks Community College 13300 W 6th Ave, Lakewood, Co 80228 would be a good intersection to start with. It has moments of high traffic in the mid day when students leave school and go home and also low traffic moments when not many people go through the traffic light. Also, a pre-existing light is already there making installation of the two screens onto the lights cost effective since a brand new traffic light wouldn't have to be installed, simply updating the one already there. This would allow us to obtain substantial statistical information allowing us to measure the real effectiveness of our design in the United States. Also, since that particular intersection is a city street we would have to obtain permission from the city of Lakewood in order to install this design on their light as well as to study it.

E) Potential Construction Problems:

Potential construction problems with this design would be obtaining permission from the owners of the traffic lights, that being city, county, or state, in order to install or update traffic lights. Since minimal information has been obtained on the effectiveness of traffic light timers within the U.S.A convincing individuals to fund our design or allow us to update pre-existing lights could turn into a problem. If the study done in China proves viable here reducing accidents by about half, this could prove an invaluable investment to insurance companies trying to save money on having to rebuild cars, the state saves money by not having to replace damaged property, but could also potentially save lives which also helps the profits of life insurance companies. Therefore, the main construction problem being faced would be pitching this design to corporate leaders, state legislators, that our design is a good investment.

Another construction problem looked at was the additional weight being added to the light. The additional screen added to the light system can add up to 50-75lbs, which is a substantial amount of weight. However, most traffic lights are made out of galvanized steel for strength and corrosion-resistance purposes. Galvanized steel has a yield strength of 35,000-49,000 psi. Which means all traffic lights constructed out of this material are applicable for this design. Some traffic lights are made out of fiberglass which has a yield strength of about 30,000psi, which means most all traffic lights are susceptible to this update. However, even though most traffic lights are made out of galvanized steel and fiberglass not all traffic lights are. Therefore, another construction problem would be finding areas of low-medium traffic for study purposes, which are made out of materials which can support the additional weight of the update.

F) Sustainability Considerations:

The sustainability of this design would be about the same as a normal traffic light, with routine maintenance there would be no reason for the system to fail, therefore the predicted lifespan of our design would be roughly the same as a normal traffic light, 15-20 years.

G) Cost Estimates:

Cost Estimates is hard to predict since no studies have been run within the United States. So, the annual cost to maintain a pre-existing light is $8,000 per year this does not include fuel, time delay, and accidents occurring at the traffic light. (Traffic Signals). If we take the studies done in Shanghai China as well as the average cost of accidents within the United States at intersections we can get the statistics we are looking for. If 4 collisions happen at high traffic intersection per year, resulting in $30,000 each worth of damages per year. Preventing 2 of those collisions saves $60,000 per year. Predicting the cost of the screens, we would need 1 weatherproof screen as well as installation fees. Also, an updated traffic light would have to be installed with the special timing system on the red light. Simply going on amazon and picking the most expensive weatherproof screen would be $6000, also the updated traffic light would need additional red light bulbs and programming bringing a net cost of about $12000. Then the screen needs to be installed and programed and so does the light, another $5000. Also, the screen displaying traffic information would have to come from somewhere, so paying a news channel for their traffic information to display on the screens could result in another possible $5,000 per year. The total cost to install would be $17000. Also, annual maintenance on the screens would be negligible in comparison to the rest of the traffic light and electricity fees of $8000 per year. Now, all the numbers are presented at worst case scenario. We do not need $6,000 screens but for arguments sake, we will predicts the worst possible case scenario so this design is only uphill from there.

Part	Cost	Initial Cost	Total Expenses Yearly
Weatherproof Screen	$6000		
Installation	$5000		
Service (yearly)	$5000		
Maintenance (yearly)	$8000		
		$24,000	$13,000

Table 4-1: Traffic Light Timer Installation Cost Estimates

Without the update: Predicting the lifespan of the light is only 5 more years (again: worst case scenario): (-$120,000-$8,000)*5= -$640,000. This light is costing $640,000 over five years.

With the update: Predicting the lifespan of the light to only be five years, also preventing two $30,000 accidents per year: -$60,000-$17,000-$13,000= -$90,000 for year one when update occurs. For four other years (-$60,000-$13,000)*4= -$292,000. Therefore this light is costing $85,000+$292,000= $377,000 over the course of five years.

Conclusion: $640,000-$377,000= $263,000 : This design can save $236700-$289300 over the course of 5 years. Which isn't even the full lifespan, 15-20years of a new traffic light.

This analysis is done at a high traffic intersection which cannot be implemented immediately since we first need statistical evidence of how Americans will interact with this update. But the potential savings of $263,000 over five years is well worth the risk. However, this analysis does not include the traffic screen and the amount of fuel saved/time saved by drivers. All that analysis would simply result in further savings. Even if studying this design at a lower collision intersection results in the loss of $20,000, it is well worth the investment of possible saving for higher collision intersections.

Part V: Alternative Design II

A) **Description**:

A roundabout is a circular slab placed in the middle of the intersection which usually has one to two lanes going all the way around. Cars can only go counterclockwise around the intersection and in order to excite a certain way cars have to be in a certain lane. Such as if a car wants to go straight or turn right they have to be on an inside lane. The bigger the roundabout the more cars can fit into the intersection. Also, cars attempting to go into the intersection must yield to cars already in the intersection. And, since cars can only go counterclockwise around, other cars attempting to enter only have to look left in order to know when their turn is to enter.

A roundabout has one exit for every spinning city blocks that it touches. The world's most famous roundabout is charles de gaulle at the Arc de Triomphe in Paris which touches twelve city blocks resulting in a total of twelve exits. It was completed nearly 350 years ago in year 1670. More effective roundabouts are known as “Magic roundabouts” which seemly strike fear into drivers at first glance. However, it makes better uses of an intersections footprint than our conventional roundabouts. Upon first sight of Swindon’s magic roundabout one can only draw the conclusion that it’s insane and will never work. Unlike regular roundabouts where traffic moves one direction counterclockwise, in Swindon’s circle traffic moves both ways. It consist of 5 mini roundabouts arranged around one big central roundabout which goes in reverse (Clockwise). In actuality, it is a small five-sided city blocks with a roundabout at each corner. Contrary to what people think at first glance, this roundabout has been successfully working for over 60 years.

B) **Design Criteria**:

A sustainable world is one in which human needs are met equitably without harm to the environment, and without sacrificing the ability of future generations to meet their needs. This design minimizes accidents which occur on the road, however this keeps cars are on the road for a longer period of time. However, this design minimizes repair and maintenance costs. Therefore, it meets the requirements of providing a more sustainable world due to the reduction of carbon emissions.

Energy and the environment was our team's main objective, in order to accomplish this reducing driver distraction in order to get drivers through the intersection quicker was our main idea. A roundabout forces people to pay attention 24/7 since they are looking for an opening into the intersection. Also, roundabouts allow a constant stream of cars through them; they eliminate idling time since there is a car always going through the intersection. However, even though driver distraction is decreased, research shows cars spend the same time if not longer when going through roundabouts since roundabouts are very susceptible to traffic jams. Therefore, a roundabout proves to be very effective for energy and the environment on low-medium traffic roads.

Although many Americans dislike roundabouts, researches shows that roundabouts in general when implemented has reduced well over 30% of fatal crashes at the intersection. According to statistics from AutoAccidents, there's an estimated 165,000 accidents occurring annually in intersections caused by red lights only. Swindon says it's roundabout has only seen one fatal crash in the past 5 years.

Additional Benefits:

i) 37% reduction in overall collisions
ii) 75% reduction in injury collisions
iii) 90% reduction in fatality collisions
iv) 40% reduction in pedestrian collisions

C) Design Schematic:

As shown in Figure 5-1, most roundabouts only have one lane forcing cars to only travel in one direction. The roundabout in Figure 5-1 is the most common and the simpilist type of roundabout you might find in the world.

Figure 5-1: Image of Standard Roundabout

D) Land Requirements:

The land requirements for a roundabout would be about the same as a traffic light. However, a roundabout requires more area in order to work. Where a normal traffic light would fit, a roundabout might not since an intersection needs a certain amount of area in the center of it in order to pour the cement into the middle to make the roundabout. A normal roundabout requires about a 10 ft radius center for the cement, this is for a one lane roundabout. An additional 12 ft is required for the road going around the roundabout. Therefore, an intersection requires a minimum radius of 22 ft to work.

E) Potential Construction Problems:

The most prominent problem with implementing roundabouts is construction. Traffic lights have already been built everywhere and in order to build roundabouts the traffic lights would have to be torn down which would be quite costly. Also, as mentioned in “Land Requirements” not all intersections can support a 44 ft diameter roundabout. Also, building a roundabout is more difficult since construction is done in the middle of the intersection while building a traffic light can be done on the sides. Making building a roundabout quite inconvenient for drivers and difficult for construction workers.

F) Sustainability Considerations:

A roundabout has proven to be the most sustainable alternative since it doesn’t require constant maintenance and any form of fuel in order to function. Therefore, a roundabout is not only sustainable but also highly efficient.

G) **Cost Estimate**:

A roundabout costs on average $250,000, but the range of costs vary depending on their size. Costs ranging anywhere from $194,000 to $500,000. For a roundabout ment to support low-medium range traffic we’ll overestimate the price for worst case scenario. Therefore a roundabout to support our purposes would cost near $300,000. Roundabouts eliminate yearly costs since there is not cost associated with maintaining them like there are with traffic normal lights. Also, the reduction in collisions reduces annual costs by the state and drivers. Which also helps CO_2 emissions since no energy is wasted in rebuilding broken materials. However, studies show roundabouts increase the amount of time cars have to spend on the road which would increase CO_2 emissions from idle time. The cost of building a traffic light ranges from $250,000-$500,000. Also maintenance fees amount to about $8,000 per year. Over the course of 5 years the roundabout will cost a total of $300,000 while reducing traffic accidents saving more money. However, with a traffic light over the course of 5 years will acquire an additional $40,000 worth of maintenance. Making the roundabout far more cost effective.

Part VI: Alternative Design III

A) Description:

One alternative considered was the transmission of timing, traffic, and emergency information directly to cars waiting at traffic lights. The information would be sent from the traffic light via Bluetooth or some other wireless media. Then, the data would be displayed inside for the driver in such a way as to prevent distraction. Approaching the problem in this way would naturally eliminate the need for displays on the traffic signals themselves but would function in a similar manner.

This solution would be paired with the installation of non-idling systems in as many new vehicles as possible. The non-idling systems turn off the engines of cars when they're stopped, rapidly restarting the engine when needed. Regardless of delays or driver distractions, widespread utilization of this feature would heavily reduce wasted fuel and emissions from all vehicles.

B) Design Criteria:

A sustainable world is one in which human needs are met equitably without harm to the environment, and without sacrificing the ability of future generations to meet their needs. This design minimizes driver distraction allowing drivers to reach their destination faster which minimizes carbon emissions from fuel consumption and repair costs of collisions due to the reduction of accidents. Therefore this design meets the sustainable world criteria.

To be a viable alternative, these solutions combined must:

1. Address or make immaterial the driver distraction problem
2. Address or make immaterial the lack of emergency information problem
3. Be a feasible solution

C) Design Schematic:

Figure 6-1 is the functional schematic for the data transmission system. This system would be installed on all ground vehicles allowing them to easily receive messages from other vehicles and roadside equipment.

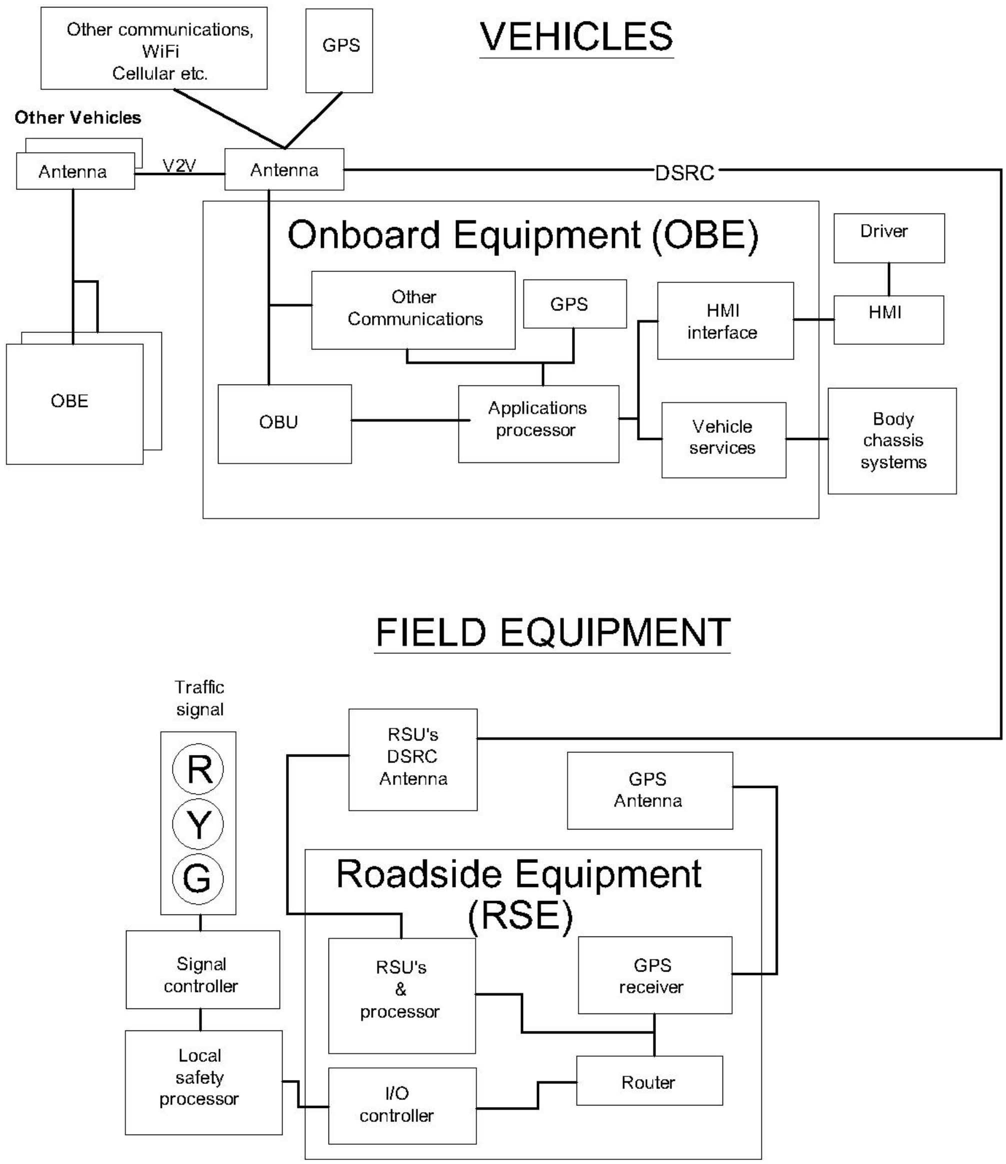


Figure 6-1: Schematic for Data Transmission System By: Its Joint Program Office, USDOT

D) Land Requirements:

No new sites or easements are required for this alternative. The equipment would be installed in vehicles or existing traffic lights. Traffic lights and the property they are on are generally owned by the state, city, or county that they are in. Therefore, no acquisitions, leases, or access agreements are needed.

E) Potential Construction Problems

No significant potential construction problems are applicable to this alternative. New communications equipment will be installed into existing traffic lights, which may require some traffic redirection.

F) Sustainability Considerations

There are many environmental, social, and economic benefits connected with this alternative. Because the the system would greatly help to maintain an increased level of traffic flow and would minimize jams, the general public would spend less time driving. This social benefit would potentially result in a happier and more productive population, stimulating the economy. More efficient traffic also means a lower rate of fossil fuel consumption and CO2 production. Emergency vehicles can reach their destinations faster, protecting property and saving many lives as a result. Citizens can spend their saved gas money elsewhere, stimulating the economy. Minimizing carbon emissions would also potentially save untold millions in damages from the effects of climate change. Smog is produced primarily by the burning of gasoline and diesel fuel by vehicles. The idling system and more efficient traffic would mitigate smog production, thereby minimizing smog's negative health effects. Millions of dollars and thousands of man-hours spent by medical professionals treating those unessesarily affected by smog would be applied elsewhere, saving many lives. Finally, humans would also benefit from the reduced level of automobile accidents caused by surges at intersection. Again, this saved money and time would be better utilized elsewhere. All of these effects combined vastly outweigh the manufacturing, maintenance, installation, and resource costs, making this option a resilient, green, and sustainable solution.

G) Cost Analysis

Tabel 6-1: V2I Installation Cost Estimates

Cost of V2I installation	Estimated number of intersections with traffic lights in the US	Total Cost	Yearly Additional Cost per light
$52,650	300,000	$15,485,000,000	$2,000-3,000

Part VII: Alternative Selected

A) Life Cycle Cost Analysis:

	Alternative I	Alternative II	Alternative III
Life Estimate (Years)	15-20	50	15-20
Estimate Accident Cost Reduction %	50	37	Untested
Yearly Estimated Saving ($): Assuming $120,000 worth of damages yearly	60,000	44,000	Unknown
Materials Cost ($)	12,000	Unknown	≈45,000
Yearly Cost ($)	13,000	0	11,000
Net Upgrade Cost ($)	17,000	Non Applicable	51,650
Net Construction Cost ($)	≈380,000	≈200,000	≈410,000
Does it save time	Yes	No	Yes
Alternative Ranking (1-3)	1	2	3

Table 7-1: Economic Effects estimates/averages per traffic light

Each alternative already has it's own life cycle cost analysis constructed in the cost estimates section, through this analysis we were able to determine that Alternative 1 proved to be the most effective. The price for building and implementing new roundabouts where a simple traffic like could be updated prove to be exponentially higher. Also, for alternative 3 to work every car in America would have to be updated or everyone could not benefit from that design. Therefore, since the annual cost per year of the lights of alternative 1 would range around $13,000 with an estimated $236700-$289300 worth of savings, Alternative I is the clear choice.

B) Non-Monetary Factors:

Alternative I- Proved to be the best for Non-Monetary Factors. This was discovered through interviews with the general public and through observation. When asked about Alternative 1 people seemed excited, they would love red light timers this way they knew exactly how long they had to wait. We also discovered that most people would like the additional screen displaying road conditions, even if they only glance at it once they still become safer more conscientious drivers since they know the conditions of the surrounding area a little bit better.

Alternative II- When the topic was brought up of additional roundabouts people did not seem to sway with the idea. They believed that roundabouts were difficult to manage and unpredictable. They forced constant stressful attention on the drivers even if they would be waiting there for up to 20 min since a slow steady flow of traffic would be going through the roundabout. Also, when asked about magic roundabouts people didn't know what they were, and when showed a picture they liked the idea even less due to the complexity of the contraption. The public even shows their dislike for roundabouts on the road, when going through them bigger vehicles tend not to turn much and simply jump the curve of the inner circle of the roundabout. Also, if lower cars clip the curve while going around that is additional damage to their car. Therefore, even though roundabouts are safer than normal traffic lights, the public would rather have a normal traffic light in most intersections.

Alternative III- To most people Alternative III was a great idea, but impractical. In order for it to work everyone would need a new car or their current car would have to be updated, and who's going to pay for that update? The general public doesn't want more money taken away from them when taxes are already taking a good portion of that now. So even though people liked the sound of Alternative III, they would much rather keep the current system or go to Alternative I

Conclusion: Even though Alternative I was not as cost effective as Alternative II, the monetary value far outways the life cycle cost analysis. Also, our primary objective was to reduce pollution by getting cars off the road, this is made possible only if cars get to their destination faster. Alternative II showed the exact opposite, people actually wait longer at large roundabouts than they do at traffic lights. That is, while they generally continue moving slowly, the total time to get through the intersection is slightly longer. Therefore, Alternative I was the clear choice saving the most money yearly and covering our initial primary goal.

Part VIII: Proposed Project: Alternative I

A) Description

A light post at least 17ft above the ground and 40ft wide allowing 4 lanes through it, 2 going in each direction. This design looks like a standard traffic light set above major roads. The key difference is the timer and screens placed on the horizontal pole above the ground. The screen would display traffic information and weather conditions. The timer would be placed around the red light like a normal clock. There would be red light tic marks going around the clock which would show cars how much longer they had to wait.

B) Design Schematic:

Figure 8-1: Korean Red Light Timmer

i. Timers on red lights have already been implemented in South Korea but not in the USA. Figure 8-1 shows a red light timer already implemented in Korea.

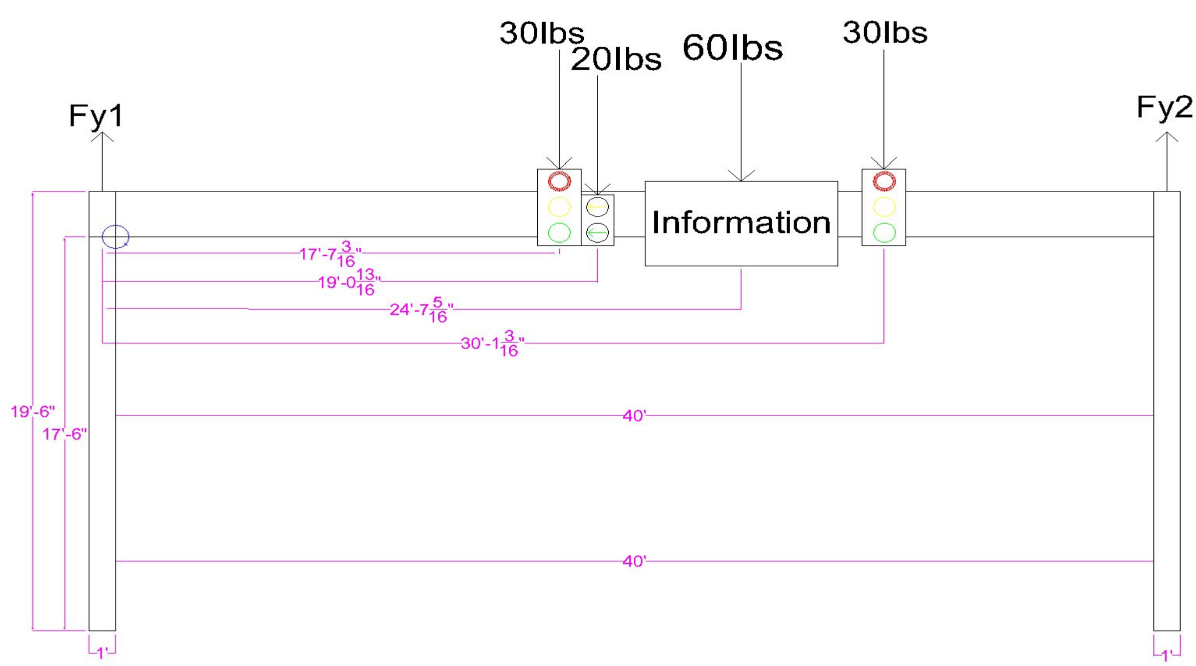


Figure 8-2: Driver View of Design

ii) Figure 8-2 shows the driver's view of the traffic light as well as the statics and stress analysis of the design. The additional weight caused by the screens will not cause any problems based on the materials traffic lights are currently constructed out. Galvanized Steel has a yield strength of close to 480MPa, which is more than strong enough to support our system.

$$\Sigma F_x = 0$$

$$\Sigma M = F_{y_1}(0)+(17.60\text{ft})(30\text{lbs})+(19.07\text{ft})(20\text{lbs})+(24.61\text{ft})(60\text{lbs})+(30.10\text{ft})(30\text{lbs})-41.0\text{ft}(F_{y_2})$$

$$0=526.0\text{ftlbs}+381.4\text{ftlbs}+1476\text{ftlbs}+903\text{ftlbs}-41.0\text{ft}(F_{y_2})$$

$$F_{y_2}=\frac{3288{\cdot}4ftlbs}{41.0ft} = 80.20lbs$$

$$\Sigma F_y=F_{y_1}+F_{y_2}-30\text{lbs}-20\text{lbs}-60\text{lbs}-30\text{lbs}$$

$$0=F_{y_1}+80.20\text{lbs}-140\text{lbs}$$

$$F_{y_1}=59.8\text{lbs}$$

F_{y_1}=59.8lbs $F_{y_2} = 80.20lbs$

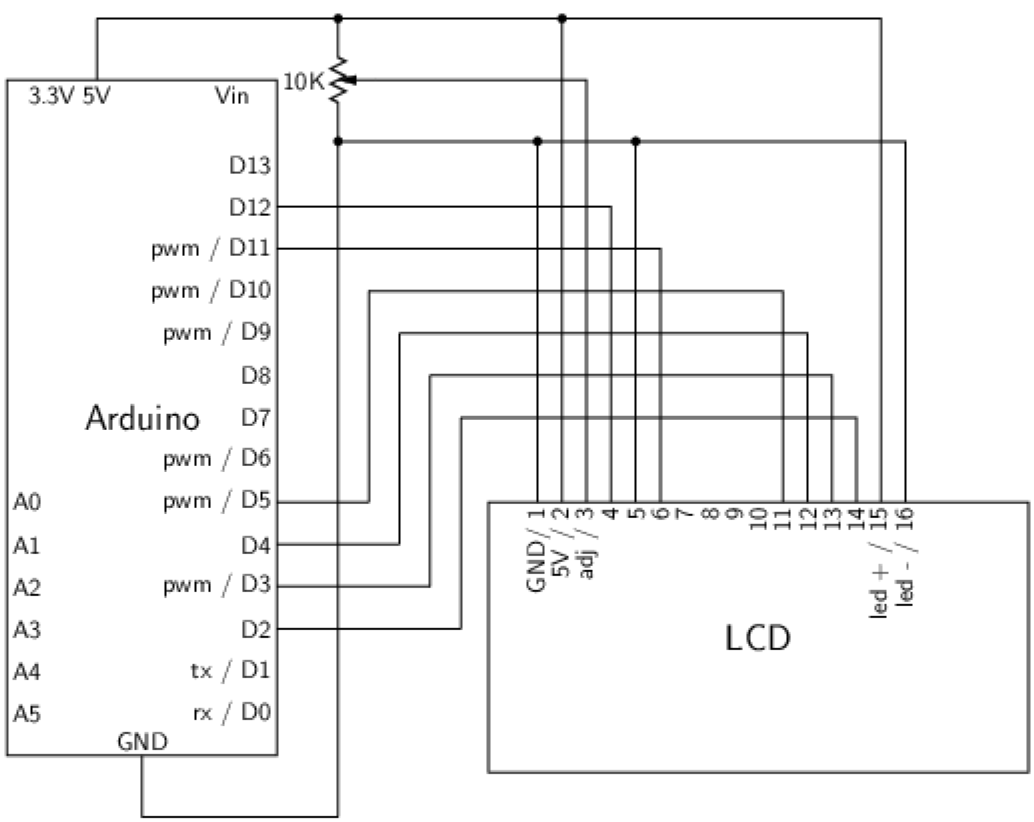
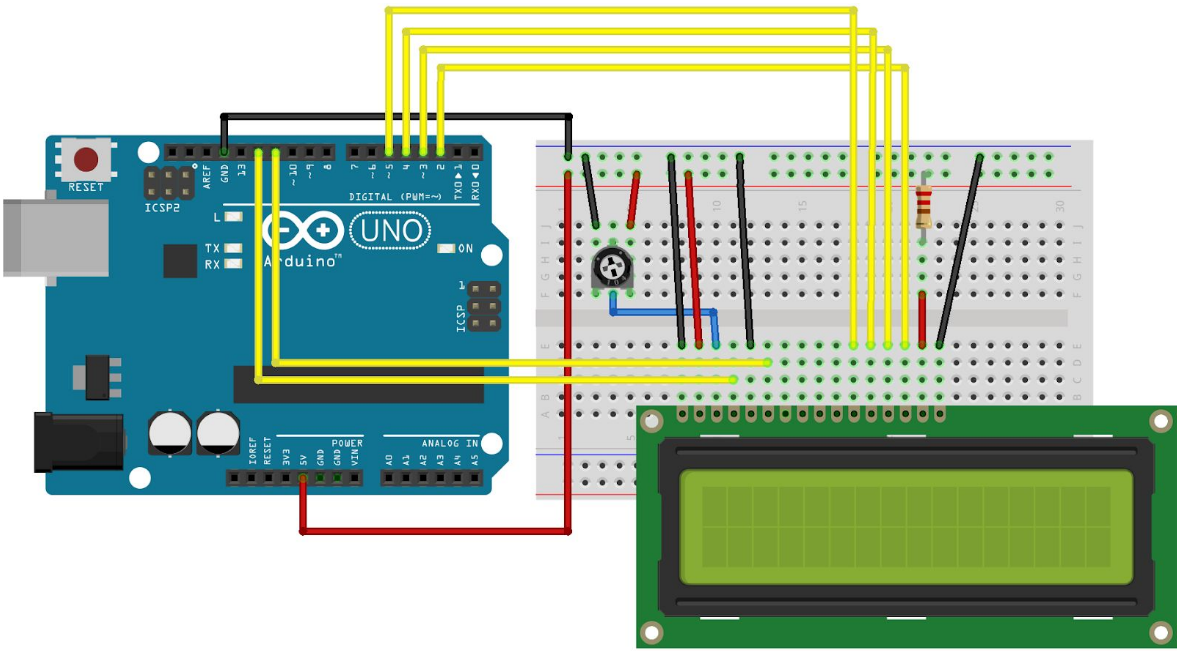


Figure 8-3:Wire Layout and Connection Map for Traffic Light Timer System



` Figure 8-4: Artist Rendition of Traffic Light Timer System

Figures 8-5 to 8-7 shows the design for our modeled traffic light cut down to about 1/30th of the size of a normal traffic light

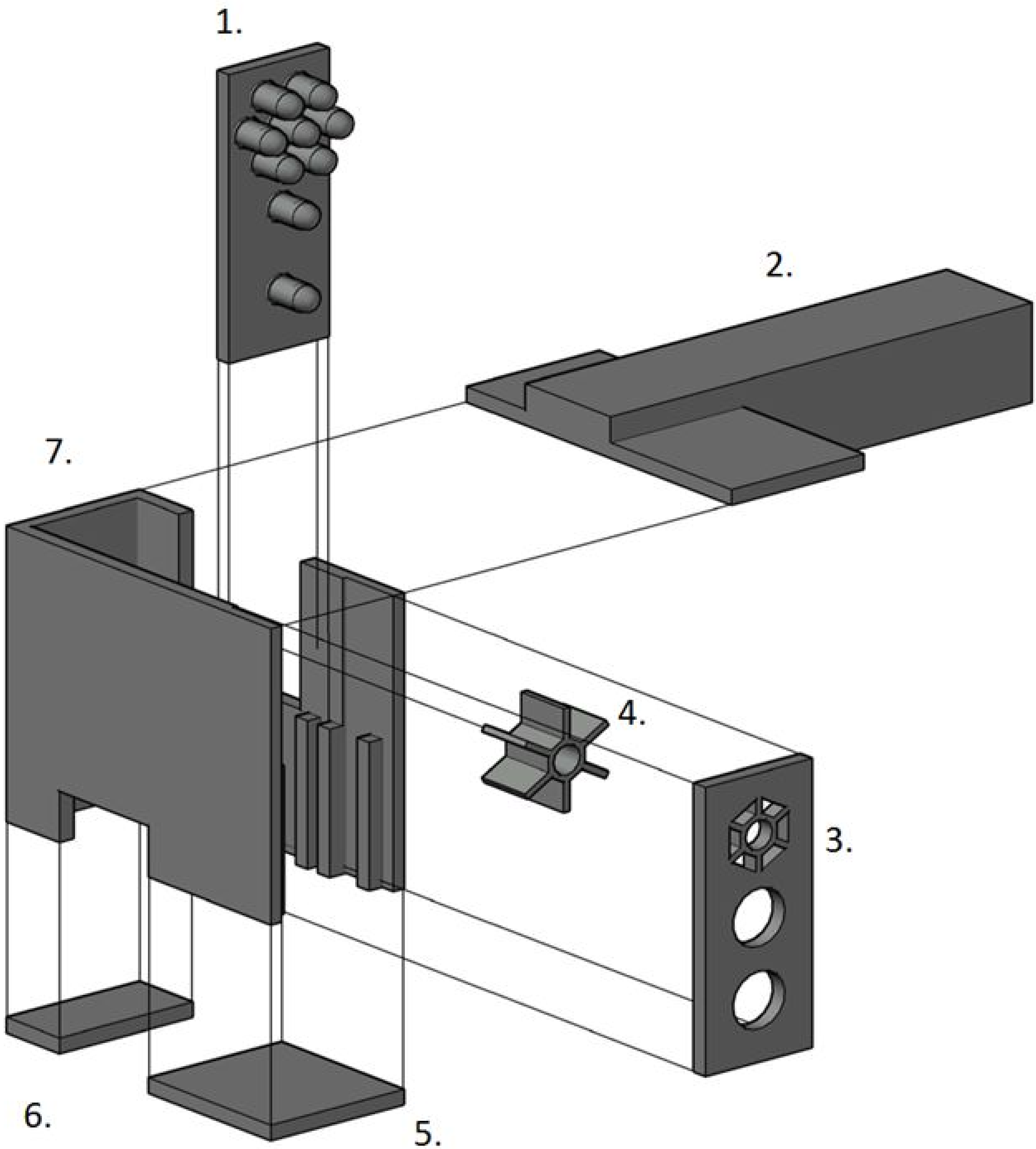


Figure 8-5: Model Design Schematic

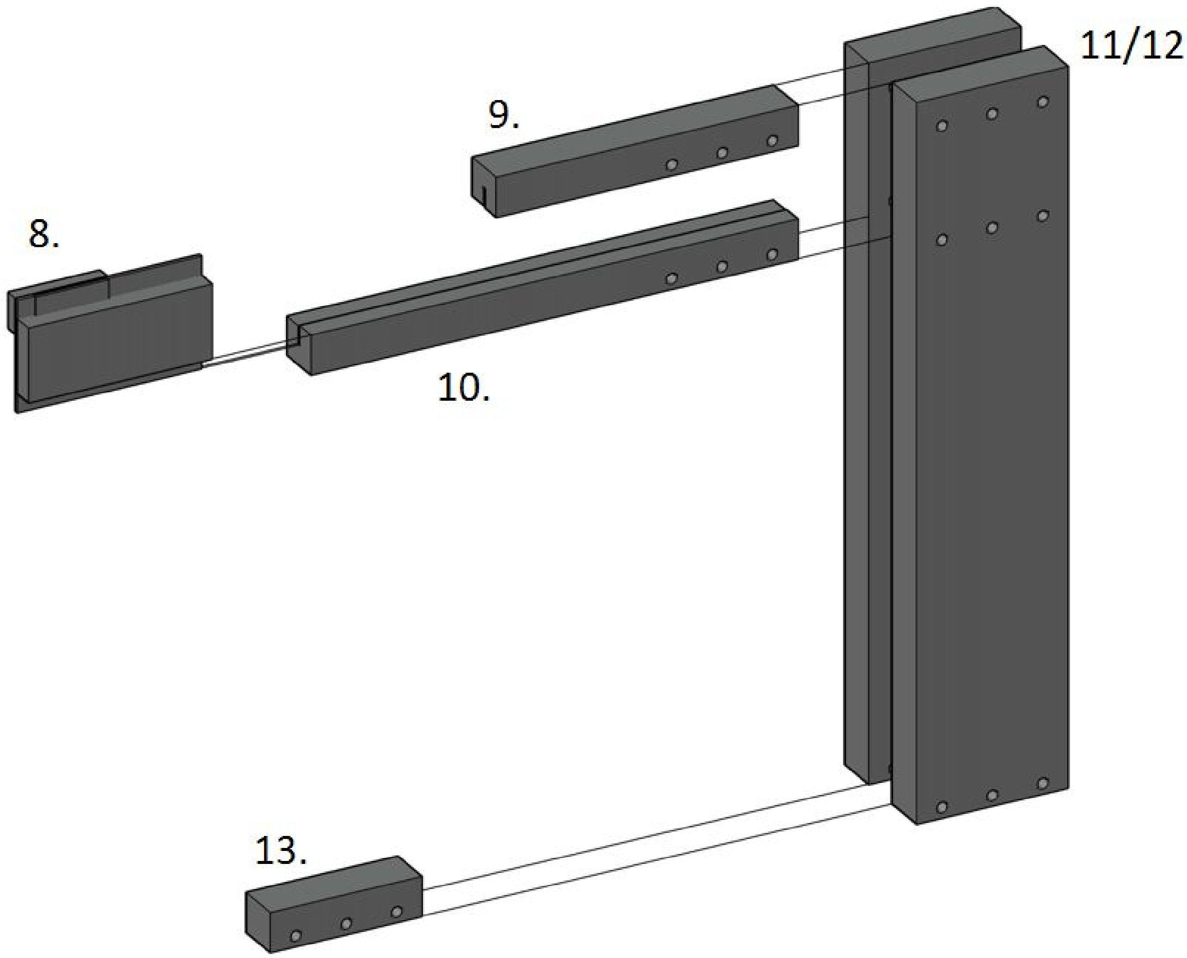


Figure 8-6: Model Design Schematic

14.

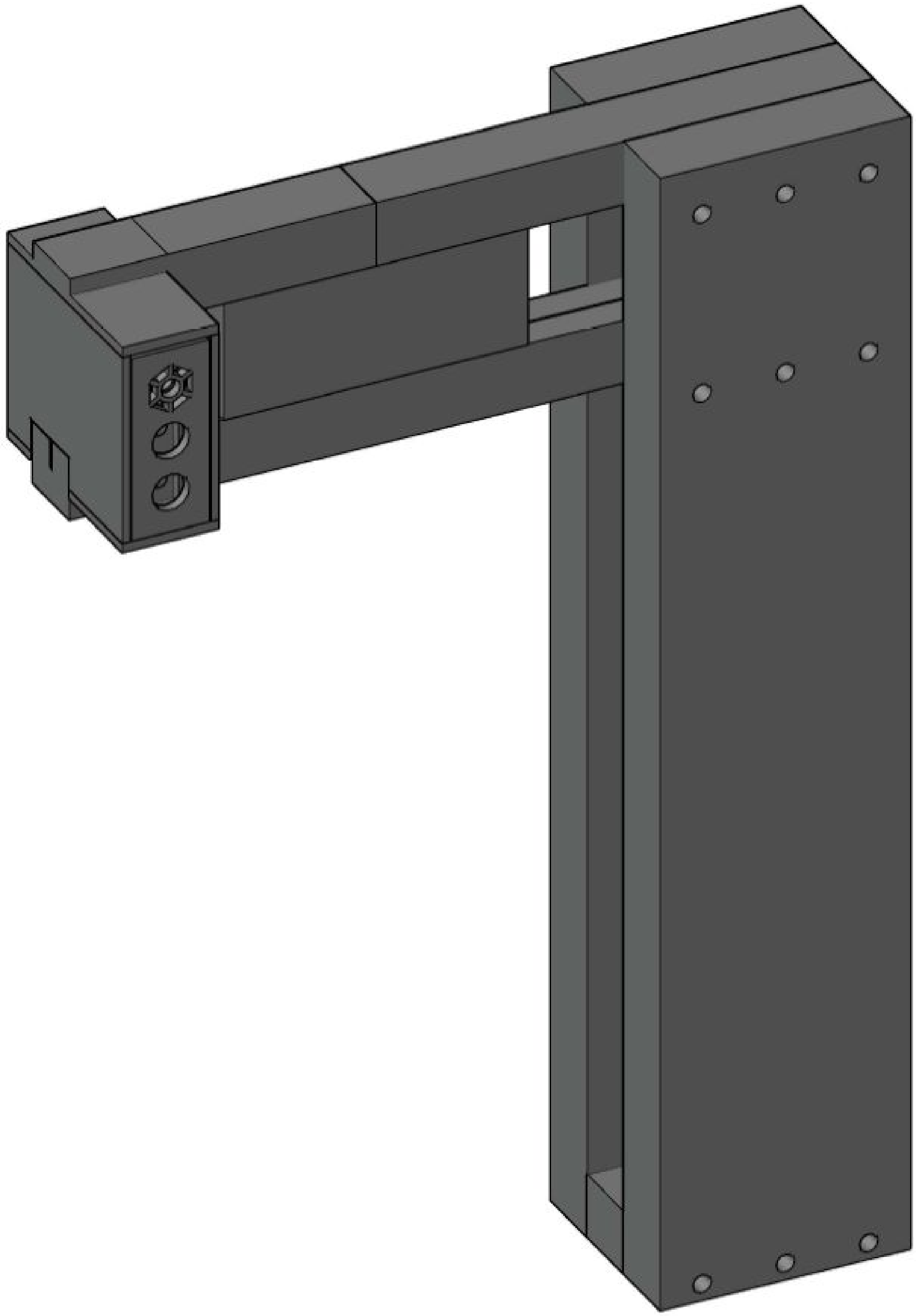


Figure 8-7: Model Design Schematic

1. LED Wire Harness
2. Top and support for Traffic Signal Housing
3. Traffic Signal Face
4. Red LED hood (prevents LEDs from lighting other sections)
5. Bottom of Traffic Signal Housing
6. Bottom of Traffic Signal Housing
7. Traffic Signal Housing
8. LED information display
9. Support Beam
10. Support Beam
11. Wooden Support Post
12. Wooden Support Post
13. Bottom of Support Post
14. Fully assembled

Our model is scaled to about 1/30th full size. At full size, the height between the bottom of the light and the road would be a minimum of 16 feet. This signal is designed for a two lane road. The end of the light would extend 8 feet into the road. The top of the light would be about 20 feet from the ground. These dimensions are consistent with standard US traffic signals.

C) Project Schedule:

This design can be installed anytime over the course of a week at most. However, due to construction purposes it is recommended to install some time in the summer to insure quick undelayed construction. Also, as Table 8-1 shows, this design requires time to be tested in the US in order to show the true effectiveness of the timers in this country. Study time should be 1-2 years for an effective research study to be conducted.

	Estimate: Production Time (days)	Best Start Date
Screen	25	April 1
Timer	10	April 1
Traffic Light update	7	May- August
Study Time Required	360-720	Non-Applicable
Installation for specific lights	14	Non-Applicable

Table 8-1: Project Schedule Estimate

As shown in Table 8-1, all traffic lights are not constructed exactly the same. Therefore, for each addition light purposed for his installation the initial design must be altered slightly in order for the screens and timers to fit the light proportionally.

D) Permit Requirements:

Currently the United States Federal Government has outlawed all timers on lights though the reason why seems to be impossible to find. In order for this project to work we need those laws taken away are at least altered. The regulation is Section 4D.06 of the DOE's Manual on Uniform Traffic Control Devices.
https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part4.pdf

E) Sustainability Considerations

Water and Energy Efficiency: The additions required to run the light is virtually nothing, any additional energy would have to be considered through the screen which can be programmed to turn on and off at certain times. Therefore, turning the screen off at 9pm when most people are off the road and turning back on at 6am would eliminate most of the additional electrical cost.

Green Infrastructure: This designs whole purpose is to be green. By increasing smooth traffic flow getting cars to their destination faster allows less carbon to be emitted into the atmosphere. Also, studies in other nations have shown that red light timers decrease collisions happening in intersections. By decreasing car accidents we decrease the money spent on repairs, those repairs require time and energy and usually further carbon emission into the atmosphere. This designs purpose is to make a greener world.

Other: The screen on the design showing traffic information further reduces time cars spend on the road since drivers will know the best roads to take home.

F) Total Project Cost Estimate

Part	Cost	Initial Cost	Total Expenses Yearly
Weatherproof Screen	$6000		
Installation	$5000		
Service (yearly)	$5000		
Maintenance (yearly)	$8000		
		$24,000	$13,000

Table 8-2: Traffic Light Timer Installation Cost Estimates

Table 8-2 shows the cost estimates for one traffic light

G) Annual Operating Budget

Income: This project saves $236700-$289300 over the course of 5 years, it does not produce income.

Annual O&M Costs: When the update is first installed onto a traffic light the cost will run about $17,000 and then an additional early cost of $5,000.

Part IX: Conclusion

We have concluded that Alternative I is by far the best selection to solving our initial problem. Even though our initial problem was energy and the environment, our recommended alternative makes sense with both life cycle cost analysis and with the monetary cost analysis. However, Alternative one is most effective in areas of medium to high traffic and would not affect areas have low traffic very much, therefore it would be unbeneficial to install and pay an additional $5,000 a year to to have minimum benefit. Therefore, roundabouts are most impactful with areas of low traffic due to their safety and constant stream of cars but traffic lights work like facets, when turned out they allow a large flow of cars through allowing them to get far more cars through an intersection.

Alternative I needs to be studied first before implemented in areas of extreme traffic. However, the potential for this design for outways the costs of its construction and maintenance. Traffic lights have always been a section of conflict, stressful for the drivers, time consuming, and environmentally destructive. Our design reduces all of those factors and allows for a more steady stressless traffic flow.

Part X: References

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