STEM Project Scriptase 1 **Stephen Anderson**

**Step Forward**

**Importance of STEM/Visual Introduction**

Before we get into the details of our project, we feel it necessary to express the importance of STEM and how this project has allowed us to come in contact with its positive effects. Science, Technology, Engineering and Math all carry vital tools and knowledge necessary to better the community. STEM skills are essential to inciting real change in the world, and fostering tangible progress. With that in mind, we entered this project eager to expand our knowledge and above all else, create a device that will bring real change to the community, a goal we believe we have achieved.

To start off the journey of our sign, I’m going to ask you to close your eyes.

Pause

Imagine this scene. It’s snowing. White and grey color the ground, ice and fog hang, suspended in the air. You’re driving your car with your family members seated around you. Their lives are in your hands, they are your responsibility. Squinting to see, you approach an unfamiliar intersection. Advertisements and buildings line the road, their signs vying for your attention. In the midst of the chaos, the snow, the fog and the distractions, you fail to see a lonely stop sign, not just a sign that must be lawfully obeyed, but one that keeps you safe. Unaware, you continue on into the intersection and, all at once, in a sudden blinding jerk, you smash into another car. Metal grinds against metal and your family is no longer safe, their fates uncertain. Can you see it? Can you imagine the fear, your heart pounding, the world stopped for the longest of moments?

Pause.

Now open your eyes. All of that happened because that unassuming stop sign was nearly invisible in the weather and intersection conditions. How can this problem be solved? How can this tragedy and others, which could happen to any of us, to our families and loved ones, be avoided? We believe our sign is the answer.

Angela.

**CUT TO NEW SPEAKER**

**Angela Herb**

**Step Forward**

**Crash Statistics**

Thousands of accidents happen in Pennsylvania each year. As mentioned in the scene Stephen described, even drivers who are being careful can experience the horrors of a car accident. On average, drivers in Pennsylvania lost over $1,000 to traffic accidents in 2012. This number has only slightly decreased since then. Twenty-two percent of accidents in 2012 were a result of a rear-end collision at a stop-sign or traffic light, and over fifty percent of all car accidents occurred during the winter months. In addition to these numbers, more than 20,000 collisions took place at night in areas with no street lights. Looking at these statistics, it is obvious that we need to consider improving our roadways to increase the safety of all drivers in Pennsylvania and their families. It is a concern that needs to be addressed. Matt.

**CUT TO NEW SPEAKER**

**Matt Horger**

**Step Forward**

**Addressing a Real World Problem/Community Needs**

Stop signs are imperfect regulators of traffic. Drivers sometimes trivialize the signs. We took the specific problem of stop sign inadequacy and devised a solution:a folding, solar powered, LED sign. The LED’s increase visibility, especially at night or in bad weather conditions. Powered by the sun, these lights are a clean, sustainable energy source. The folding capability provides a potential solution at intersections where traffic lights are situated. When the power goes out, rendering traffic lights useless, these lit stop signs can be opened and would provide a substantial amount of light for drivers to see as well as safely regulating the flow of traffic.

The potential benefits of such signs is obvious. First and foremost, these stops signs would significantly reduce crash possibilities at intersections. Reducing crash possibilities in turn reduces damage to personal property and the vehicles of drivers. Every year (stare at judges), an almost $8.2 billion dollar loss is a byproduct from car crashes and compensation of drivers. Above all, these stops signs would have the potential to save the lives of drivers and the pedestrian population. In total, more than 1,000 innocent Pennsylvanian lives were taken as a result of a car crash in 2012. Putting a stop to such tragedies is a duty we hope to fulfill.

Andrew.

**CUT TO NEW SPEAKER**

**Andrew Johnson**

**Step Forward**

**Light on Brain/Solar Power**

Thanks Matt. Low amounts of light have certain effects on the human body. Studies have shown that dark, stormy weather can affect a person’s mood and alertness, possibly hindering driving ability. Distracting advertisements and buildings draw attention away from stop signs. To draw much-needed attention to the stop sign and provide cognitive stimulation necessary to counter weather and distractions, our sign is equipped with 88 LED lights. The issue of powering LED’s is solved by the sun. On our sign, mounted solar panels use the photons of sunlight to create an electrical current. This current is led into batteries, which charge and are used to light the sign in inclement weather or darkness. In summary, the LED lights on the stop sign are efficiently and cleanly powered attention beacons that help people in bad weather and darkness to notice and follow the rules of the road.

**CUT TO NEW SPEAKER**

**Conor Waldt**

**Step Forward**

**Precedent**

Our research led us to find that signs such as the one that we had in mind, with lights and solar power, do exist and do provide a practical benefit. Studies regarding such signs show that, by increasing visibility, safety and reaction rates for drivers are greatly increased, meaning the chance of an accident is reduced. Overall, the signs already in use provide a positive uplift to driver alertness and encourage lawful and cautious behavior. Yet, the cost of such signs is a detraction from their value. The current signs therefore are impractical for widespread use by townships. As a result, these signs are rarely used, meaning their benefits are not being realized. Our mission then was to create a sign with a positive application in society that could be more easily produced and less costly.

Caln Township is where we got the idea for the use of folding stop signs. Driving through the area, we noticed many folding stop signs at traffic light intersections. They are used all over Pennsylvania, but are rarely opened because of the manual labor involved. Seeing this commonly unrealized benefit, we set out to make our roadways safer by automating our signs, so they will be opened more often.

**CUT TO NEW SPEAKER**

**Stephen Anderson**

**Step Forward**

**Version 1.0**

Our regional competition device was the first tangible step to creating what we have today. The core of the design consisted of a 30” H x 30” W High Intensity Sheet Metal **Vertically** Folding Stop Sign. The folding aspect of the sign was vital to its practical use as well as to our future vision. Next, 108 solar powered LED’s provided a substantial amount of light. A 6ft signage post held the sign upright. Finally, nuts, bolts, and duct tape were used to bring all the parts together on the sign. Daylight sensor solar panels made the sign applicable in nighttime, as well as harsh winter storm conditions.

Building the first version of the sign was a rather crude process in retrospect. With our limited resources, we had to punch and drill each of the holes manually, which lacked precision and efficiency. The lights were held in the sign with a combination of hot glue and duct tape. Both of the solar panels were facing the same direction, a fact we came to see limited their sun exposure greatly. Perhaps most notable of all was the fact that it opened and closed only manually.

Still, the first sign had merit. It was bright and able to capture attention. It was solar powered and therefore energy efficient. It opened and closed effectively and above all, it offered a practical solution to a real problem.

**CUT TO NEW SPEAKER**

**Angela Herb**

**Step Forward**

**Vision for Improvement**

Beyond the regional level, our plan was to implement a mechanism that would open and close the sign at the push of a button. The most realistic option we envisioned was a simple device activated from a car that would open the sign from a reasonable distance, eliminating the need for drivers to leave the vehicle. A bluetooth and phone connection we decided would be best for such a system.

In addition to mechanical improvements, we also knew we needed to make our device sturdier and more precise professional device so mass production would be more easily achieved. In all, the device needed to be motorized, had to be stronger, more durable, more precise and of better quality materials.

**CUT TO NEW SPEAKER**

**Andrew Johnson**

**Step Forward**

**The New and Improved (Design)**

Creating an improved model of our sign first meant planning the new design. The core of the design would remain the same. The type of folding sign, solar power and basic light layout remained constant. From there, we began to make vast improvements.

First, we implemented a pair of new 12v solar panels, double the power of the previous panels. To address the problem of the first design in how it limited sun exposure, we fashioned a mount for the panels that extends from the top of the pole. This allows for much greater sun exposure and therefore greater energy production.

Our previous design lacked precision and durability. To solve this dilemma, we created a polycarbonate backing and casing for the sign. The backing provides a layer of protection for the sign and adds security to the lighting system, holding the lights in place. The polycarbonate material itself is unaffected by UV rays and is durable so it is capable of facing any weather conditions. Our previous design was secured by duct tape, but our new casing provides much greater protection and lends itself to mass production.

Our first model was hand-produced. Thanks to our partners at CTDI who allowed us access to their building spaces, we were able to upload specific CREO drawings into an advanced Haas drilling machine. This machine followed our design and drilled the holes to within an accuracy of 1/1000 of an inch. Each hole is now exactly 1.1018 inches apart and the sign is completely symmetrical, making mass production a much more feasible possibility.

**CUT TO NEW SPEAKER**

**Stephen Anderson**

**Step Forward**

**Design (cont.)**

By far the greatest and most difficult improvement we have made is the motorization of the sign’s folding capability. We needed to enable the sign to open and close at the push of a button from a limited range. The base of our electrical circuit and signal processing is the Arduino Uno. This microcontroller requires relatively simple coding, for it is an open-source project, and can work in tandem with a myriad of attachments, including bluetooth modules, a motor and solar power, making it perfect for our needs. Creating a complete and closed electrical circuit and programming the Arduino are two major implementations of STEM skills at a much higher level than those of the previous sign. The task of connecting each component in the system truly tested our abilities to carry out the scientific and engineering processes.

The motor for the sign is a NEMA-17 bipolar stepper motor, powered by 24v solar energy and commanded by the dual H-bridge driver, which is connected to the Arduino unit via 4 I/O pins. This driver also provides 5v power to our Arduino, enough to power the bluetooth module as well as the lights. Initially, we had a smaller motor, but its’ holding torque was three times less powerful. With our addition of the polycarbonate and motor components, the sign proved too much weight so we had to upgrade the motor to compensate.

Turn on sign.

We’d now like to demonstrate for you the actual opening of the sign and its illumination.

**CUT TO NEW SPEAKER**

**Matt Horger**

**Step Forward**

**DEMONSTRATION**

For the sake of this demonstration, we are using a Windows Nokia Lumia 825 phone to remotely communicate with our Bluetooth receiver. However, any mobile device such as Androids and iPhones can communicate with the receiver, as long as they are able to send serial information and are within a range of 500 feet. We set up the program so that sending a ‘1” via terminal connection opens the sign. It is possible to change what the arduino recognizes, so instead of a “1”, you could send it “open” or any other string. (send “1”) By sending a “1”, the 2 I/O pins connected to the lights are enabled and the stepper motor begins to move 1 step at a time at a speed of 1 rpm (rotation per minute). This bi-polar motor consists of four magnetic coils which are connected to 4 I/O pins to receive power. The arduino turns each set of coils on and off to allow the gears inside the motor to move our armature. However, the stepper motor cannot step too fast, or else it will begin to skip steps due to the sheer mass of the sign. The ideal speed for the motor is around 1 - 10 rpm; anything higher than 30 will cause the motor to start skipping. 60 rpm is the maximum limit for the motor. Each step is exactly 1.8 degrees, and to open the sign, the motor needs to step exactly 100 steps, which is half of its total step capacity. To close the sign, we send send a “0”. (send 0). Again, this can be easily changed if desired. The arduino, as you just witnessed, will then shut off the I/O pins connected to the lights and the stepper motor will begin to step negatively, thus closing the sign.

**Future Improvements**

We are pleased with what we have accomplished in this project, but are also looking toward the potential our sign has for the future. To improve communication to the motor, we thought of sending the signal from the headquarters of the township. It would cost approximately $200, and would still require active human effort. The required hardware would be either an Arduino ethernet shield connected to a cat5e cable, which will allow for the arduino to access the internet, or an Arduino SIM card shield with a standalone SIM card to communicate via SMS. The monthly cellular costs to maintain the SIM card would make this option more expensive in the long run. Besides this, we have thought of connecting the sign to the city’s power grid, so that it senses power outages. The sign would automatically turn on, eliminating the need for any human effort, and thus provide an even safer alternative. The required hardware for this improvement would be a 4 channel relay in order for the 5v arduino to connect to the 120v traffic light. To sense the power outage, a wall-brick 9v capacitor circuit hooked up to an analog pin on the arduino is necessary. This would admittedly be difficult for us to achieve; we would need the assistance of professional electrical engineers.

We would also like to expand the lighting system to other signs to increase visibility throughout the roadways. Street signs, speed limit signs, and yield signs are all possible candidates to receive this improvement. Our last idea would be to create a casing to retrofit current stop signs with our lighting system. A pre-built frame would clip to the border of the sign, making application more universal. Saving the township money by not having to buy brand new signs, we believe this option would be more economical for some locations.

Other aspects that could be improved are a mechanism for keeping the sign open and closed, possibly electromagnets, a ventilated self-cooling circuitry container, and a non-transparent backing for security purposes.

**Mass Production**

Looking at what we have accomplished, we have projected a cost of approximately $376.96 per sign for mass production. If four signs were installed in an intersection, they would still cost less combined than one lit stop sign of current retail price.

**CUT TO NEW SPEAKERConor Waldt**

**Step Forward**

**Business Partnership**

Our business partnerships have proved vital for the vision and production of our device. Our first partnership was formed with Downingtown Engineering Consultants (DEC). Mr. Dave Weightman, a structural engineer, became a mentor to us, helping us visualize our sign’s practical benefits and shortfalls. Mr. Steve Mousley and Mr. Joe Plaza, two DEC team members, working alongside Mr. Weightman, revealed that projects are often outsourced or brought to fruition by multiple specialists working in tandem.

For both phases of our project, we also collaborated with the Burns Group, specifically Mr. Dean Kaiser, a traffic engineer. Mr. Kaiser provided valuable insight into traffic codes and regulations by reviewing with us the Manual on Uniform Traffic Control Devices (MUTCD). With this knowledge, we made vital adjustments to our design so it would be legal yet retain its value.

MENTION EXCERPT

By far the most influential partnership we formed was with Communications Test Design Inc. For our state design, Mr. Leo Parsons linked us with his company through his son Mr. Matthew Parsons, who became a source of incredible knowledge and provided us access to the company’s vast resources and tools. Mr. Parsons and his company’s specialists conversed with us and proved a great center of knowledge and experience. The build for the improved design was largely done at CTDI where we could make our sign as precise and professional as possible. Mr. John Goldman and Mr. Bill Keegan became valuable partners in the build, contributing advice and experience.

In all, our partnerships showed us how much collaboration is a key to success and how different sources of STEM knowledge must be drawn upon to make a vision reality.

**CUT TO NEW SPEAKER**

**Angela Herb**

**Step Forward**

**Team Reflection**

Throughout the course of our project, we implemented a variety of STEM skills. We did a lot of electrical work for powering both the lights and the motor by creating a self-sufficient solar charging circuit. We also implemented programming skills, and wrote the code for the Arduino. Using mechanical skills, we created a device to work with the motor so it could function properly. Lastly, we created representations of our sign using AutoCAD.

In our project, each person brought with them different their skills, and each person had to admit a lack of skill at some point. Andrew Johnson was responsible for keeping the team organized and on task. He was highly involved in the research and application portion of our project and assisted me with building our circuits. I, Angela Herb, was responsible for designing and creating the circuits, serving as our electrical engineer. I also organized our partnership with DEC. Conor Waldt provided us with engineering principles and skills, as well as, detailed calculations and design. He created CAD drawings of our sign, and was responsible for our partnership with the Burns Group. Matt Horger was the leader of our project; he also served as our programmer and worked tirelessly with the arduino and motor. As our leader, he helped us to envision the real world application for our project. Matt was also responsible organizing our partnership with CTDI. Stephen Anderson provided us with vital problem solving skills, working to overcome obstacles. He was instrumental in the design and style of our presentation, making sure we communicated our ideas clearly. Working together, we learned that each component of STEM is useless without the other, and that each skillset is equally valuable for success.

**ENDING COMMENTS**

**Stephen Anderson**

**Step Forward**

I started this presentation by asking you to close your eyes and listen to a story. I don’t ask that of you now, in fact, our mission here today, the purpose of our design, has been to open your eyes, and the eyes of all Pennsylvania drivers. Do you still have the image of the story in your mind? Hold on to that image because it’s real. It’s real for so many people every day. I ask you now to keep your eyes open and to see our sign, just as thousands of drivers would be able to. Our goals in this entire journey were simple, yet vitally important. We wanted to increase visibility, reduce crash probabilities, keep people safe and save lives, all in a cost efficient, effective, and adaptable manner. For the state level we wanted to, to the best of our ability, improve the sign. Keeping the same core ideals in mind, we aimed to make a more precise, more secure, more powerful, and more beneficial sign; making changes that had practical positive impacts. We believe we have achieved these goals, and that with future improvements we can make the roads of Pennsylvania even safer, save more lives. Through this process we’ve learned and implemented STEM skills, researched and understood a problem and its solutions, and witnessed practical applications in real life. I, on behalf of my entire team, thank your for your time and this wonderful opportunity. Finally, we ask again that you remember that story I told and see how our sign can take that pain away, not because we hope to succeed in this competition, but because we believe our mission is one of incredible importance. Thank you again for your time and for this opportunity. It's meant so much to us.