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Atlanta Emission Reduction
Final Paper

How Might We Statement
How might we reduce harmful emissions caused by transportation in the Atlanta Metro Area?

Problem Statement and Significance
Currently, one of the most well-known problems we face is air emissions and their impact on our environment and health. Our problem is focused on exhaust emissions from transportation vehicles.

These vehicular emissions are a worsening problem because they have been on the rise over the past five years. Transit vehicles are a significant source of such air emissions. Such vehicles are the second-largest producer of carbon dioxide (CO2), a component in these emissions in the US. This represents 32% of all CO2 emissions in the US, falling only behind the CO2 generated from producing electricity; transportation also holds second place behind electricity for greenhouse gases produced in general, at 28% [1].

Though these emissions can negatively affect nearly anyone anywhere, their impact is most severe in developed cities with high vehicle usage. Vehicular emissions include major air pollutants such as nitrogen oxides, carbon monoxide, and the aforementioned carbon dioxide. If left unchecked, these pollutants can increase the likelihood of cardiovascular and respiratory disease [2], especially in urban environments [3].

Context of the Problem
Previous attempts at solving this issue include improving vehicle design and components, using alternative fuels, and reducing the amount of vehicles being used. Other attempts include creating high occupancy vehicle (HOV) lanes to encourage carpooling, implementing more public transit options, and tightening emissions standards [4]. However, these solutions have downsides, including but not limited to the extreme difficulty of measuring their effectiveness as well as the cost and time incurred to implement or use them. Additionally, influencing a change in one's behavior - such as using a carpool - can be very difficult to accomplish [5]. In a time where we thrive on instant-gratification, a more immediate yet still effective solution is desirable.

Goal
Scope
Our goal is to reduce the emissions in the Atlanta Metro area by improving driver acceleration behavior.
Rationale
Periods of high engine load, which is caused mainly by hard acceleration, have shown to cause increases in emissions by several orders of magnitude [6]. Causing someone to drive in a more relaxed manner can reduce the amount of times the engine is put under high load. We believe that this mild change can be more efficacious as it is easier to coerce consumers to try,

where drastic changes such as transit habits or vehicles are large and daunting to consumers or otherwise too costly in terms of money or time [5].

Impact

In addition to the potential fuel savings a driver may experience, improved driver behavior has the potential to reduce vehicular emissions for relatively little cost. (Compare this to using an alternative fuel, buying components, or giving up individual freedom to carpool, for example). These savings are significant for their very low cost. A single day class on eco-friendly driving habits can cause an seven percent improvement in fuel economy [7]. To put this in perspective, CO2 emissions in the US have increased by about 5% between 1990 and 2012 [1].

Solution Description

We aim to promote better driving habits through the use of a small, cheap, and easy-to-use device that the user will attach to their dashboard. The device will provide real-time feedback on the user's driving habits using an indicator light. The light will fade from red to green depending on how the user is currently driving. The device will utilize a three-axis accelerometer to perform its analysis using models provided by Dr. Guensler. Additionally, the data will be constantly logged to an SD card for further analysis by a computer application. The device will run on three triple-A batteries and attempt to preserve energy by only lighting when the car is being driven. These batteries should only need to be changed as frequently as the oil in the car. A device similar to this (the "ECO light", etc.) is present in some vehicles, such as select Ford and Honda models, and has experienced success, however this device aims to replicate the effect for vehicles that do not have this feature in a cost-effective manner.

Objectives and status update

Objective 1: Refocus approach to problem solution

Because of numerous factors including feedback from Wes, Rob, and Terrell as well as our own analysis, a re-evaluation of whether or not our original solution is still feasible was required.

Plan:

1. Decide if our current solution should be continued or if we should redirect the current solution.
   ✓ The team has decided to attempt to create an alternative solution to our problem.
2. Brainstorm new approaches to problem solution.
   ✓ We have considered many alternative solutions and chosen one we wish to implement.
3. Determine feasibility of new solution.
   ✓ The team has conducted preliminary research that shows similar solutions in the same problem space are effective; it has also received recommendations and feedback from Terrell and Dr. Guenseler.

Criteria: This objective will be complete once we have decided whether or not our original solution is feasible or once a new solution is formed and determined to be feasible.

Status: We have determined that modifying long-term user behavior through the original app would not be reasonable. We have succeeded in coming up with an alternate solution. Instead of the app, we plan to pursue a more 'instant gratification' style solution, as described previously. There is nothing else more to be done.

Objective 2: Plan Device Specifications and Usage Cases

The first step in getting the device to work is planning what it will do and what effects it will have. This is a vital next step because the device's capabilities and ultimately whether or not a user will actually use it depends on its components, structure, cost, and usability.

Plan:

1. Determine the form and functions of the device.

✓ *The team has decided that the device will be small enough to mount on the dashboard of a car, and will alert users through a small light of their driving habits. This will be determined from an accelerometer. More detailed data will be available through the use of an SD card. Dr. Guensler has experience working with larger 'boxes' mounted in vehicles, and states that although they are accurate, they are also expensive, whereas a small device such as our proposed one would be more appealing to the casual users we intend to target.*

2. Determine the most efficient way to implement the device.

✓ *The team has investigated different options for powering the device, and has determined that small solar panels are not sufficient to sustain the battery's charge. We have determined that two easily replaceable AAA batteries will be enough to run the device for more than a year. Discussion with Dr. Guensler has also determined that an alternate solution - using a smartphone's built-in sensors - would not be as appealing due to concerns with battery usage, general usability and safety, and problems with immobilizing the phone while in use. These all cut back on the device's ease of use, which we wish to keep as high as possible in order to appeal to our target audience.*

3. Design the casing and circuitry of the device.

x The team needs to create a hardware prototype, ensure that everything functions correctly, and then create a printed circuit board. The casing of the device needs to be designed in an aesthetic manner and to accommodate the circuitry. A general plan to accomplish this has been formed, and parts have been ordered and assembled into a crude first prototype.

4. Program the device.

x An algorithm needs to be devised such that the habits of the driver can determined from the sensor data in a reliable fashion. A general "model" for each vehicle type - car, truck, van, etc. - can be used with Dr. Guensler's MOVES greenhouse gas emission calculator and the device's accelerometer. This "model mode" shall be easily selectable by the user with a small switch in order to maximize user-friendliness.

Criteria: This objective will be complete once we have a physical, working device in our hands that is able to provide accurate feedback about driving habits through the use of its accelerometer and color LED depending on general vehicle type.

Status: In general, we have identified the pros and cons of each part of the device's make up, including general form, power source, sensors, and means of data recovery, and have gone over most of these aspects with Dr. Guensler as well. Specifics that require more technical work still need to be determined, such as the exact design of the device's casing and layout of its circuitry. Once that is accomplished, we must coordinate with Dr. Guensler to obtain an accurate program that can measure driving habits as they relate to acceleration, vehicle type, and emissions.

Objective 3: Test Device Operation and Effectiveness

The final step is to perform a case test starting with our team to ensure the devices performs as intended, as well as deal with any other issues that may have been encountered and improve on the device itself.

Plan:

1. Ensure the device's software and hardware work reliably and accurately.

    x Driving tests need to be executed to ensure the device can accurately determine if a driver is driving in an efficient manner. This needs to be done for each vehicle type we wish to support.

2. Test device with drivers to determine effectiveness.

    x To determine if the device is effective, a test needs to be created that measures how the user is driving before and after installation or activation of the device, to determine if the device is effective in changing driver habits.

3. Ensure the device is safe.

    x We need to ensure that the device does not cause safety concerns, such as causing a distraction or short-circuiting and causing a fire, for instance.

Criteria: We can use Dr. Guensler's emissions calculations data and possibly his more accurate "box" devices to determine if the device has created a noticeable change in driver behavior and emissions. Similar, built-in devices from Ford and Honda have shown an approximate 4-7% reduction in emissions. We can consider our device to be effective if falls near this range or better.

Status: The device still needs to be prototyped and physically completed before testing can occur.

How has your project changed over time?

Originally, our project was focused on an app centered solution in order to directly modify commuting habits. However, we decided to move to a different direction when we decided that incorporating different modes of transportation into daily commutes is unfeasible, given our current resources and status. Our new projects focus on the driving aspect of transportation. Using our device, we hope to encourage commuters to adopt more fuel efficient driving methods that will cause a reduction in fuel usage, and thus a reduction in emissions. A report by the Ford company who installed similar lights in their vehicles showed that a 4% reduction in emissions is possible.

Future implications and next steps

We're currently collaborating with Dr. Randall Guensler, whose research surrounds vehicle travel patterns and transportation-based emissions. After our first prototype is working correctly, we need to work on product design and engineering. We will look for partners in the school of industrial engineering to determine a design that is pleasing to consumers. We will also need to partner with someone who has experience with manufacturing electronic devices in bulk, as it would be infeasible to sell a large amount of hand-assembled product. Lastly, we need to talk with someone to determine if the device will have to meet quality standards to be sold free of legal liability.

Future versions of the product may include more functionality, such as Bluetooth connectivity to monitor real-time driving habits in a more detailed manner. Though the introductory price point is too high, future versions may have a wired or wireless link with the car's computer port to deliver even more accurate data. We have also been considering a social aspect in which users could "show off" their good driving habits to their friends, which would increase product reach and encourage regular use.

Works Cited

[1] "Carbon Dioxide Emissions." EPA. Environmental Protection Agency, n.d. Web. 20 Apr. 2014.

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[4] "Greenhouse Gas Emissions: Transportation Sector Emissions." EPA. Environmental Protection Agency, n.d. Web. 20 Apr. 2014.

[5] A. Kollmuss and J. Agyeman, "Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?," Environmental Education Research, vol. 8, no. 3, pp. 239-260, 2002.

[6] S. L. Hallmark and R. Guensler, "Comparison of Speed-Acceleration Profiles from Field Data with NETSIM Output for Modal Air Quality Analysis of Signalized Intersections"

[7] "RACQ EcoDrive Research Study," 2012.