Prospectus

Short-Range FM Radio Transmitter
(Technical Topic)

Impact of LEED Requirements on the Construction Industry
(STS Topic)

By

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October 30th, 2019

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Older and more recent car models do not contain auxiliary jacks that allow users to connect their handheld devices to the vehicle to play music, audiobooks, and podcasts. Many newer car models solve this problem through the use of Bluetooth, however, complications can arise with this wireless technology. Bluetooth can be hacked into, it has connectivity issues, and can make handheld devices prone to viruses. Distracted driving is another issue that has grown in intensity and has created the need for technologies that can help reduce cell phone usage. Mobile phones have caused "drivers to take their eyes off the road, their hands off the steering wheel, and their minds off the road and the surrounding situation" (World Health Organization, p6). The cell phone is considered to be a cognitive distraction and can result in shorter following distances, inability to stay in the correct lance, longer reaction times and road traffic crashes and injuries. Connectivity issues within vehicles and the potential for loss of life due to distracted driving has motivated engineers to develop a technology that allows drivers to operate a device with minimal distraction and can reduce the risk of safety concerns.

These concerns are considered to be the foundation for the design and development of the short-range FM transmitter. The primary goal is to produce a functional device that can receive audio from a cell phone through an auxiliary jack, find an open and secure frequency modulation (FM) band, and transmit the audio signals onto the car radio for playback. Through a simple auxiliary connection between the handheld device and short-range FM transmitter, the multiple steps to set up a Bluetooth connection are eliminated. This device will allow minimal user operation, which will in turn minimize driving distraction.

Technical Project

The technology that the short-range FM transmitter most strongly relates to is software defined radios (SDR). This device is a wireless radio communication system "in which some or all of the physical-layer functions are software defined" (National Instruments, 2019). This means that rather than relying on the traditional hardware to design radios, embedded computing and digital signal processing is used for data communication and transfer to transmit audio signals from a source to its destination. The automotive industry recognized the usefulness of SRDs and implemented this technology due to its low cost and performance. The SDR is the best approach to supporting the simultaneous reception of a large number of broadcast channels, and to complying with the upcoming digital standards within the United States, Europe, India and China (Carbone, 2018). To accomplish this, engineering companies such as NXP semiconductors have used state-of-the-art embedded digital-signal-processing cores to the present set of radio standards in automotive applications to support AM/FM reception (Key, 2008). Background knowledge on the SDR encouraged the development of a similar portable device that operates on the FM band to transmit audio signals from a user's handheld device to the car stereo. This device will be utilized to increase compatibility with all car models, reduce driver distraction, and Bluetooth connectivity issues.

The first step to approaching the design of the FM transmitter is to develop the power circuit for the subcomponents to function properly. The entire device will be connected to a car power supply, which will be rated at 12 volts. To protect the device's subcomponents from failure due to high voltages, two voltage regulators will be used to drop the supply voltage down to 5 volts and 3.3 volts. The resulting 5-volt output will power the LED display and low noise amplifier, and the 3.3-volt output will power the MSP430 microcontroller, SI4713 chip, and

crystal oscillator. The power supply tree shown in figure one below gives a summarization of all the subcomponents that are connected to each regulator.

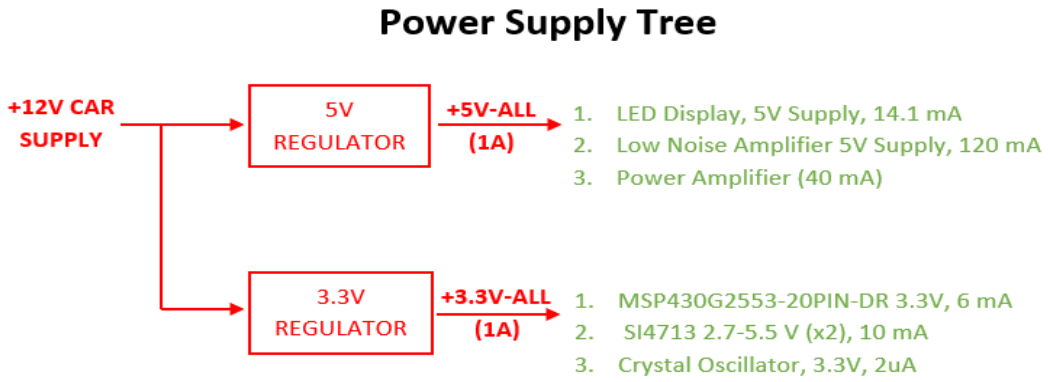

Figure 1. Main subcomponents of the power supply tree that are connected to the 5V regulator or 3.3V regulator output. Both of these regulators' inputs connect to the 12V car power supply (Created by Traynor, 2019).

The primary component of the FM transmitter is the SI4713 chip, which is responsible for processing the mixing, digital-signal-processing, and transmission of FM signals. Mixing involves combining and changing the properties of multiple audio input signals. The MSP430 microcontroller will be used to communicate with the chip using the Inter-Integrated Circuit (I^2C) interface. This will allow the microcontroller to command the chip to sweep through the FM band and relay the power frequency spectrum using the serial clock (SDA) and serial data lines (SCL) (Texas Instruments, 2016). The chip will then perform an algorithm to determine an empty frequency at which it should transmit audio signals. The detected frequency will then be displayed on the LED display that is connected to the microcontroller. The set frequency will also allow the chip to receive the analog audio coming from the user's handheld device via a 9mm audio jack. Once the audio is received, the signal will be routed to the SI4713 chip's analog-to-digital receiver and it will digitally mix the signal and frequency to modulate the proper output frequency. The signal will then be relayed through the transmission and receiver

hardware which consists of the low noise amplifier and antenna. The low noise amplifier (LNA) is used to keep the noise floor low, which is essential for amplifying low-power signals without reducing the signal-to-noise ratio. The LNA also enables farther FM signals to be detected by the antenna, thus decreasing the chance that the user will travel into an area where the signal conflicts. If, however, the user does face this problem, the device will feature a tactile switch that allows the device to reset and rescan for an empty FM band. To simplify the process, the overall design for the device, with all of its subcomponents, see figure 2.

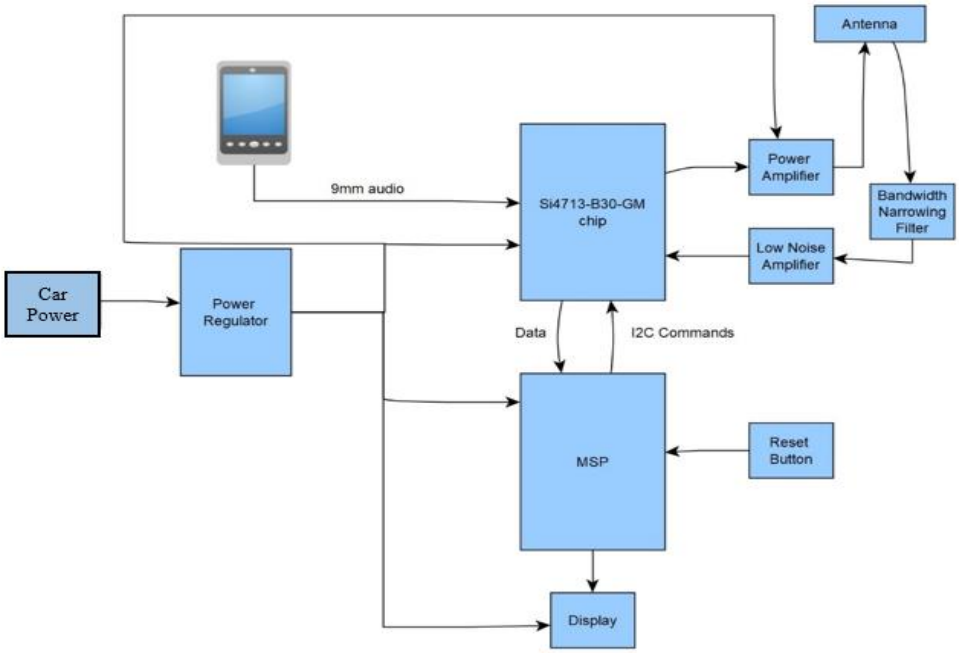

Figure 2. Concept diagram provides a visual representation of the how all the subcomponents interact with each other and shows the pathway beginning with audio signal and power supply. (Created by Traynor, 2019).

A large number of resources have to be used throughout the course of the design and production of the FM transmitter. The power circuit containing the voltage regulator was created using the WEBENCH Design Tool, which is available through Texas Instruments. This tool

allowed simulations and easy selection of passive components. For the majority of subcomponents within the device, Multisim was used to establish the appropriate connections between all of the parts. Once the overall design has been completed, Multisim components can be transferred to Ultiboard so that all the subcomponents could be integrated onto a single printed circuit board (PCB). After the PCB has been produced and parts are ordered for all of the subcomponents, which is funded by the Department of Electrical and Computer Engineering, tests can be run using the Virtual Bench and Code Composer Studio. The Virtual Bench will be used to power and ensure that the correct voltage outputs are occurring. Code Composer Studio will be utilized to make sure that debugging occurs and that proper communication has been established between the microcontroller and chip.

LEED Credits and the Construction Industry

While the technical project focuses on designing a device that transmits audio to a car stereo, additional research will be conducted on how LEED credits concerning energy, atmosphere and indoor air quality impacts the construction industry. Reducing carbon emissions and energy consumption has become a growing concern because the industry has used about "40% of total energy production, 40% of all raw materials, and is responsible for 16% of water consumption and 35% of CO_2 emissions" (Son et al., 2011, p1) across the world. Although LEED credits are aimed to resolve these issues, it has affected worker safety, the health of residents and employees, finances, and business strategies within the industry.

To interpret these standards and their impacts, Elinor Ostrom's (2011) institutional analysis and development (IAD) framework will support the creation of a multi-tier conceptual map that is summarized in figure 3. External variables such as the rules that are used may cause

an action situation to occur. Within the action situation, actors such as construction firms, and individual designers or constructors may have to make "policy decisions within the constraints of a set of collective-choice rules" (Ostrom, 2011, p11). These decisions can result in different potential outcomes that can be evaluated and compared to outcomes that may have been achieved under alternative institutional arrangements. The IAD framework will be used to evaluate LEED's influence on the construction industry and see how it differs from the conventional building approaches that were used.

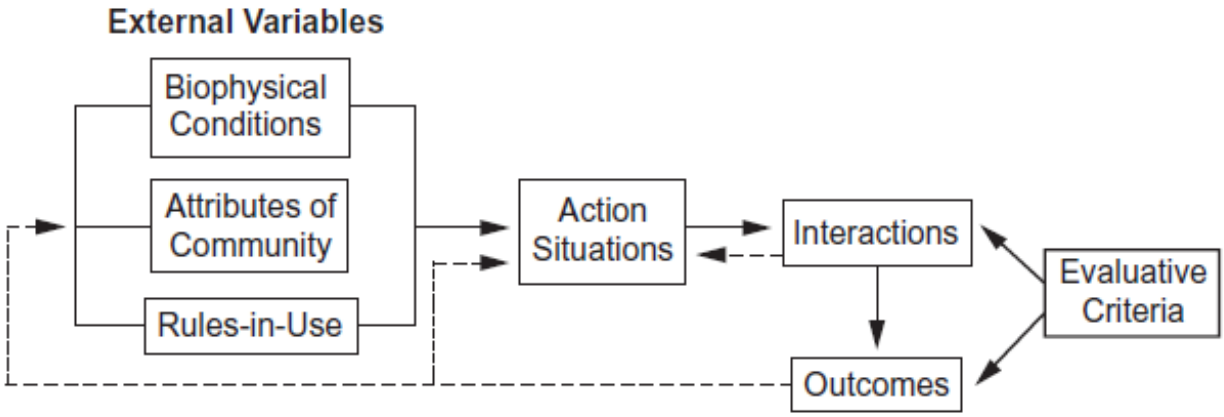

Figure 3. Framework for Institutional analysis containing the external variables that may influence the decisions made by actors within the action situation. Interaction with other actors may occur and can result in outcomes that can be analyzed and evaluated. (Image Source: Ostrom, 2011)

Recent studies have shown that LEED-certified building have accounted for a higher injury rate than traditional non-LEED buildings. Case interviews with actors including LEED designers and their teams were conducted to determine the construction methods chosen to accomplish credits including energy and atmosphere (EA). After completion of the case studies on six different projects, safety risks were determined to come from different EA LEED credits concerning the optimization of energy and performance. New techniques that have been chosen

by designers to increase energy performance include the installation of heavy continuous insulation of building shell and evaporative chillers. These methods require increased duration of construction and lifting heavy materials at height and as a result “there was an observed increase in frequency and severity of falls” (Fortunato, 2012 et al., p5). The report mentions that there are also safety risks that come with that come with building vegetated roofs because it involves inexperienced landscaping contractors who are not familiar with work at height. The authors “found that installing photovoltaic panels and atria increased the duration of work at height and time spent installing electrical systems” (Fortunato et al., 2012, p2). The LEED credits have caused the action situations where sustainable practices are pursued and have resulted in putting worker’s at risk of injury and struck-by hazards.

Air pollution, high temperatures, traffic noise, and high energy consumption for heating and cooling purposes each present health and environmental risks, especially in dense, urban settings. However, LEED standards have motivated actors such as firms to solve this problem by designing green walls, which includes the use of vegetation and inorganic matter. These green facades develop oxygen and absorb gaseous pollutants such as nitrogen dioxide, carbon dioxide and ozone compounds that affect air quality. There has been a direct link to the physical and mental health of individuals according to a study done by researchers at Washington State University. Green walls have been able to reduce risks of obesity, asthma and the likelihood of having heart attacks by lowering blood pressure. It has also improved the efficiency of employees within the workplace, speeding up their reaction times by 12% and helping them focus (Wesolowska et al,, 2019). Green wall technology also led to feelings of relaxation and better concentration.

Incorporation of LEED into project design and operations has profoundly yielded significant economic benefits. Although going green may completely reshape a corporation's business strategies and operations, it can benefit construction firms financially in both the short and long term. Shifting to a green construction approach can result in 26% less energy usage, save 13% on maintenance costs, generate 33% less greenhouse gas emissions, and raise return on investment by 6.6% (Lu et al., 2013). An empirical analysis was performed between eleven green and eleven conventional organizations in the construction industry. When short-term performance between these firms were analyzed, the average return on equity for 2007-2009, which measures the profitability of an organization, was calculated to be 17.4% compared to 8.2% for traditional firms (Lu et al., 2013). In fact, green firms performed better with their economic value added, return on capital, and revenue growth. Long term performances show that green corporations are more financially viable too. When it came to measuring the companies' economic profit in excess of all required equity and debt, there was a positive economic profit for green firms, and an economic loss for conventional firms (35.1% compared to -1.74%) (Lu et al., 2013). Changing business structures within the construction industry in accordance with LEED has proven to have economically beneficial outcomes.

Implementation of LEED and demand for sustainable buildings in the United States has caused the construction industry to expand their performance goals in low energy consumption and reduced air emissions. These goals have led to research that determines how project delivery methods and levels of team integration have an impact on the outcomes in sustainable projects. Integration generally states that participants become involved in the project at the correct time and coordinates with other team members. Studies were conducted on eleven projects that determined the relationship between the level of integration and sustainability goals (Mollaoglu-

Korkmaz et al., 2013). By the conclusion of these studies, it was observed that if there is a higher level of integration between actors, higher levels of sustainability can be achieved. The second part of this study concerned which project delivery methods should be used to achieve higher levels of sustainability. By the study's completion, it was concluded that design-build and construction management at-risk methods for completing a project results in better achievability of sustainability goals.

Research Question and Methods

This research will address the question: Have LEED certification credits concerning energy, atmosphere and air quality impacted sustainable engineering practices and the construction industry and if so, how? To collect evidence for this question, methods similar to Ostrom's in *Background on the Institutional Analysis and Development Framework*, will be employed. Within her paper, she emphasized that the IAD framework may aid on "the accumulation of knowledge from empirical studies and in the assessment of past efforts at reforms" (Ostrom, 2011, p9). Empirical studies would involve the process of quantitative and qualitative analysis to determine if there are direct relationships between the LEED credits and its influence on new technologies or the construction industry. These studies can provide supporting evidence on how the industry's finances, safety, and business structures have changed since the incorporation of LEED.

Empirical studies and comparisons can also be conducted to see how the reorganization of business environments within the construction industry has led to better financial opportunities. I will be reviewing firms' annual reports to determine if their finances and activities have been affected by the accreditation of LEED. Sustainability reports will also be

analyzed to observe if there have been improvements in energy performance, carbon emissions, and air quality resulting from the implementation of sustainable practices. Primary sources will be used to gather information about people's perspectives on how LEED standards may have impacted worker safety, business structures, and engineering practices and approaches. I plan to conduct a series of interviews and surveys that are targeted towards individuals who have roles within the construction industry. The results from empirical studies, interviews, and surveys can be used to see if LEED requirements have impacted the construction industry.

Conclusion

To reduce cellphone usage by drivers and the risks of traffic hazards due to distracted driving, our team is designing a device that can receive audio signals from a handheld device and transmit the signal to a car stereo. The Gantt chart shown in figure 4, shows the expected timeline for the technical project with expected completion by the final demonstration of our device on December 11th, 2019. Expected outcomes include:

- A device that can scan and locate an open FM band
- An LED display that shows the correct FM frequency that was found
- The audio from smartphone is broadcasted through the car stereo
- The FM Transmitter is powered by a 12V DC/DC connection from the car adapter
- A reset button that rescans for an open FM band
- The PCB is placed within a metal enclosure

As for the STS research, interviews, surveys, and empirical studies will be used to determine if LEED credits on energy, atmosphere and air quality have impacted engineering practices and the construction industry. These will be conducted in the first couple of months of 2020 and I

plan to conclude my research by the end of March. It was not expected that LEED puts constructors at risk of injury and other hazards. However, as anticipated, these requirements have led to financial improvements, sustainable-driven business structures and approaches, and reduced health risks.

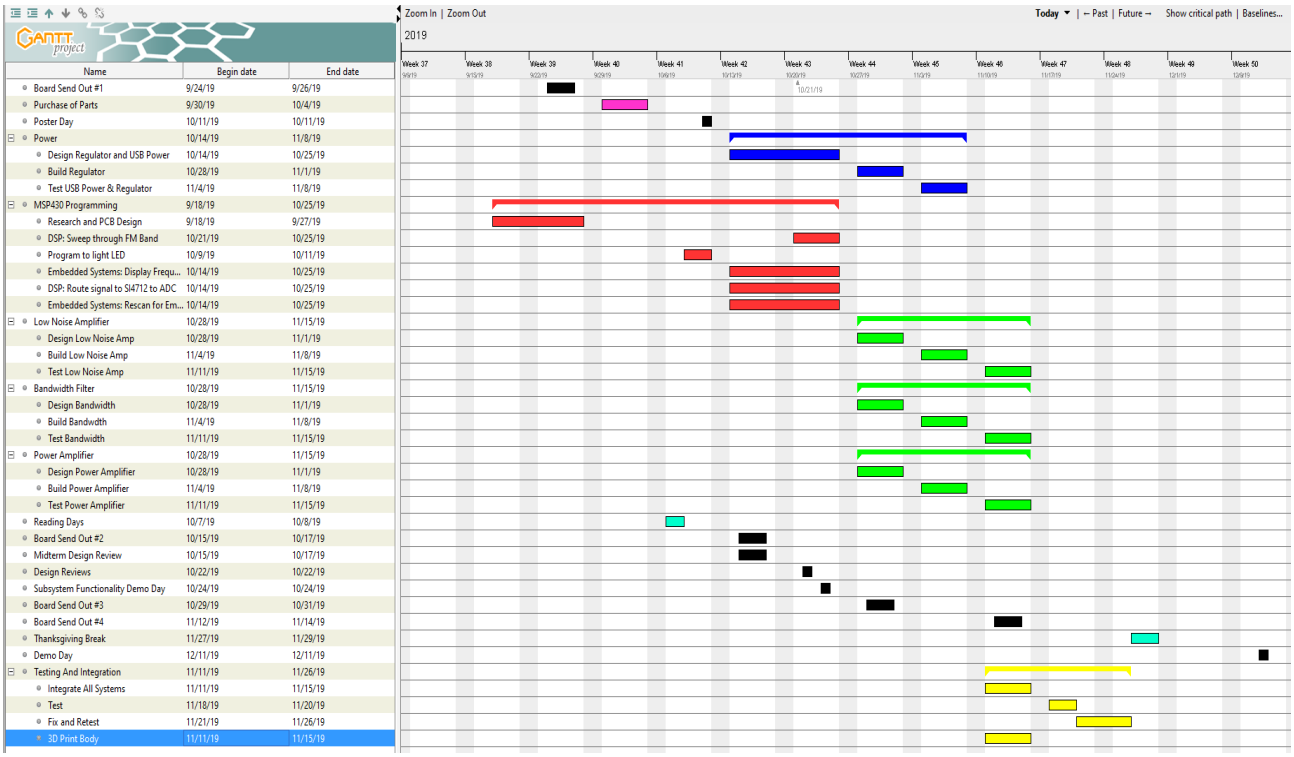

Figure 4. Timetable for the technical project which indicates when designing, building, and testing will be done on the device's subcomponents. (Created by Traynor, 2019)

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