Team 312 Final Detailed Design Report

I. Introduction

Problem Statement/Motivation:

Given the frequency of accidents due to drowsy driving, how can we alert drivers when they get too drowsy and improve upon current autonomous safety features to prevent further accidents?

Driving, a necessity for many, can be very dangerous on any given day. It does not matter how careful one is driving, another person on the road may not be. This is also exacerbated by the toll of day-to-day responsibilities. This is significant because driving drowsy will statistically lead to more accidents, and thus, more deaths. To address this issue, there should be a way to detect drowsiness in a driver and allow their vehicle's autonomous safety features to take over if they are getting too drowsy to drive.

Project Description:

Develop a drowsiness-sensing rear view mirror that observes the driver and tracks their drowsiness levels to facilitate autonomous driving. Included in the system is a microcontroller with a built-in mmWave radar and a radio frequency transceiver to be encased in a compact custom rearview mirror.

Requirements:

The design has to detect drowsiness but it also has to work as a rearview mirror. Furthermore, the design would have to meet the following requirements:

- The device shall affect the Vehicle's overall power consumption by an insignificant margin.
- The device shall function without the need for manual user input and work passively.
- Housing for the microcontroller and radar shall fit the majority of average-sized vehicles without hindering the driver's overall visibility.
- The system shall notify the user once the device determines that drowsiness has been detected.
- The device shall communicate the driver's drowsiness levels with the vehicle's autonomous system.
- The project shall be created with a reasonable cost of materials to develop the device.
- The device shall use a microprocessor for its drowsiness detection algorithm.
- The device shall be powered through an external power source.
- The device shall contain a radar to propagate waves for eye/face detection.

- The device shall comply with the Federal Motor Vehicle Safety Standard (FMVSS)

II. Selected Concept

The selected design was chosen after a brainstorm of every possible solution discussing and breaking down everything from material design, coding, detection methods, and best methods of verifying success. After conceptualizing the many possible solution cases for this project, the following were selected as the final concepts to realize this design. 3D printing filament was chosen as the mirror casing material due to its accessibility and cheap cost to produce. A simple LED will be used to indicate the driver's drowsiness to the autonomous system of the vehicle. An RGB LED in addition to a single-tone buzzer will notify the driver of their drowsiness and that some assistive autonomous driving feature will take over. These are both cheap and effective options to meet their respective customer needs. To detect drowsiness, the device will be closely monitoring the heart, lungs, eyes, and head. The lungs and heart will be the primary body parts for detecting drowsiness due to their size and constant visibility while the eyes and head will be secondary to increase detection accuracy.

For collecting and processing the required physical data, the POSITION2GO board will be employed. With its mmWave Radar sensor, analog body data can be recorded and converted to usable digital data. From there, MATLAB will be used to clean the data and implement it into a drowsiness-detection algorithm. The MATLAB environment was chosen due to its familiarity among the team and the board's ability to run MATLAB code. The drowsiness-detection algorithm will detect the beat frequency of the heart as well as the respiration frequency of the lungs and compare that data with its training data to determine if the driver is drowsy. Machine learning may be used for more accurate application of the training data. After assembly of the prototype, the experimental tests will be performed in a stationary, turned-off car to mirror the real-world scenario. Lastly, the testing method will involve testing team members and other participants at different points throughout the day to observe their drowsiness levels. To collect more data, participants will attempt to mimic drowsiness to test the accuracy.

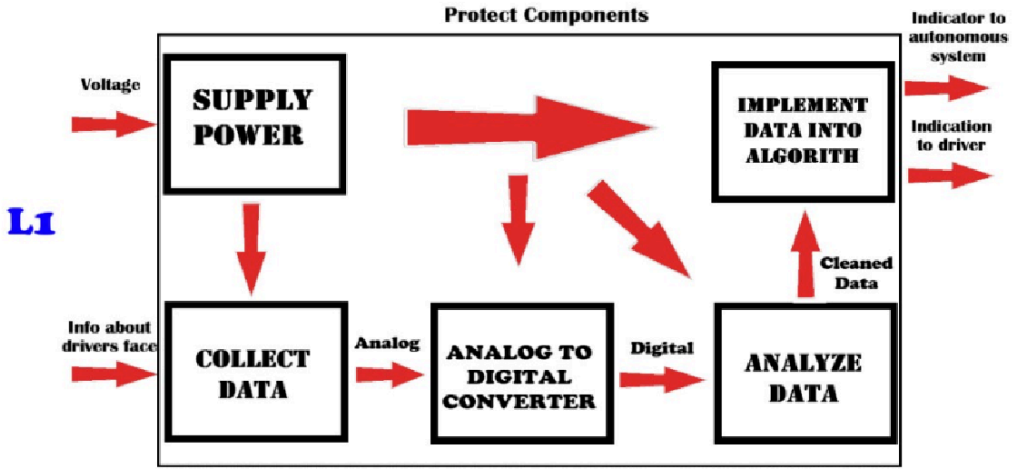
III. Preliminary Design

The mirror housing will be designed in 3D modeling software and 3D printed at FSU's Innovation Hub using their selection of filament types. The casing will have an area to securely hold the POSITION2GO board inside. The placement will include space for connections to the board, such as the cable to upload the code and the wires for the audio/visual indicators. The case will have a split open design to allow for quick adjustments for testing and simplicity for monitoring connection.

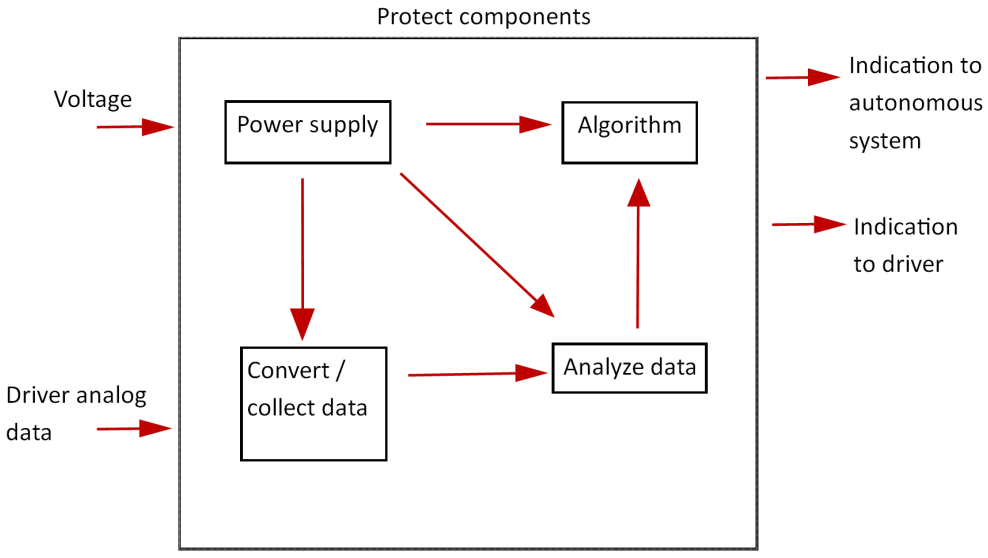
Below are the previous and current iterations of the device's functional decomposition. The updated model removes the ADC block as the built-in microprocessor and radar will automatically do these processes and will not need to be implemented manually. Overall most of

the functional decomposition has stayed the same. Additionally, a high-level breakdown of the selected components to realize the design is shown below the functional decompositions.

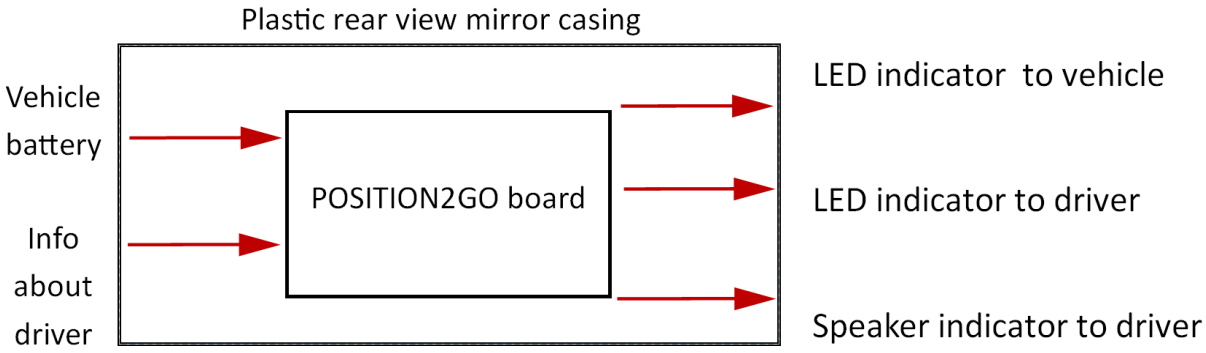
1st Functional Decomposition



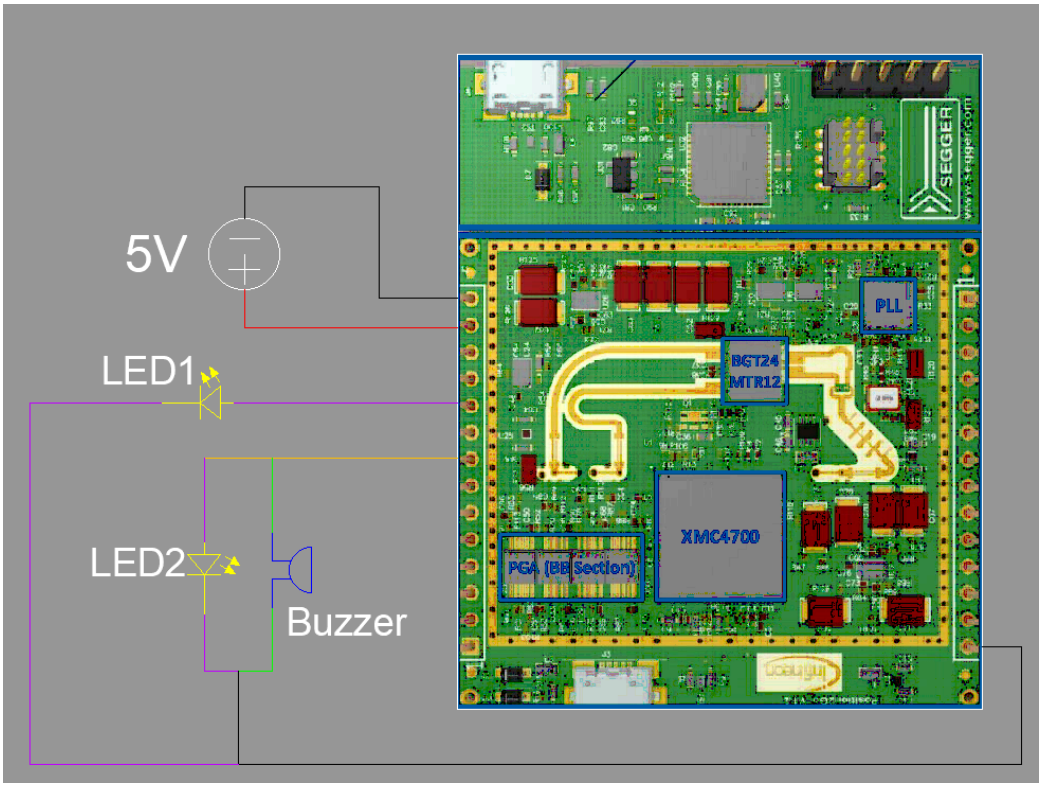
2nd Functional Decomposition



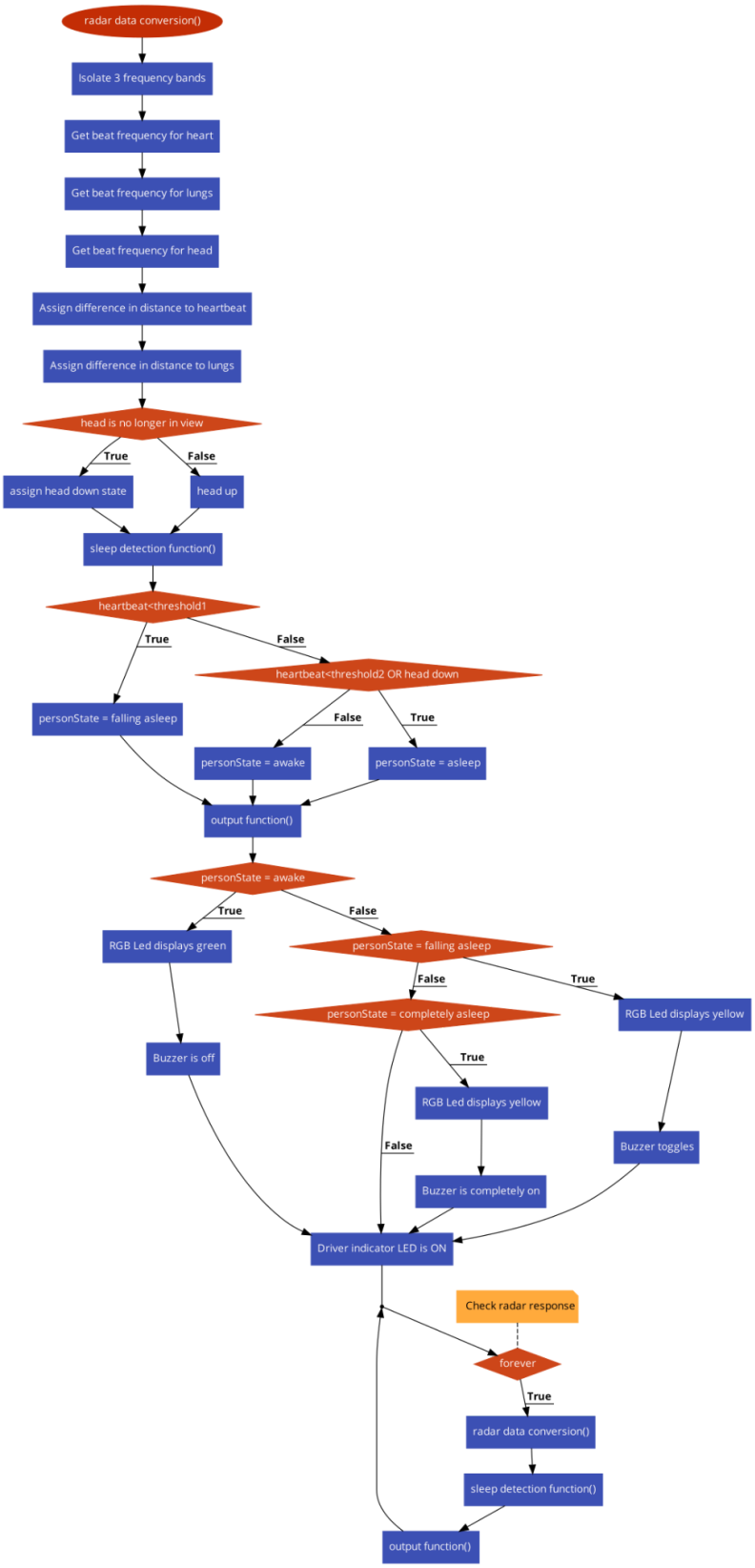
Original Component Breakdown



Wiring Diagram



Initial High-level Code Breakdown:

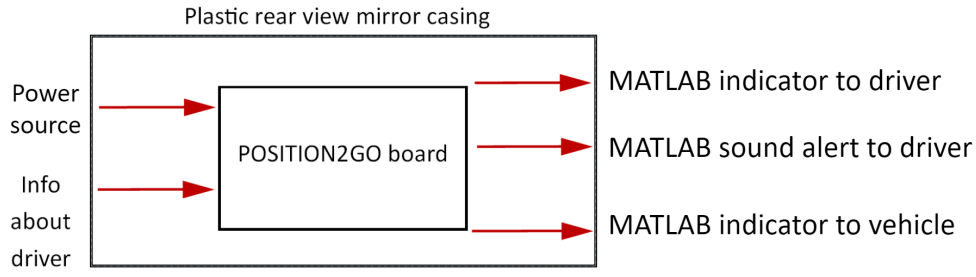


IV. Revisions

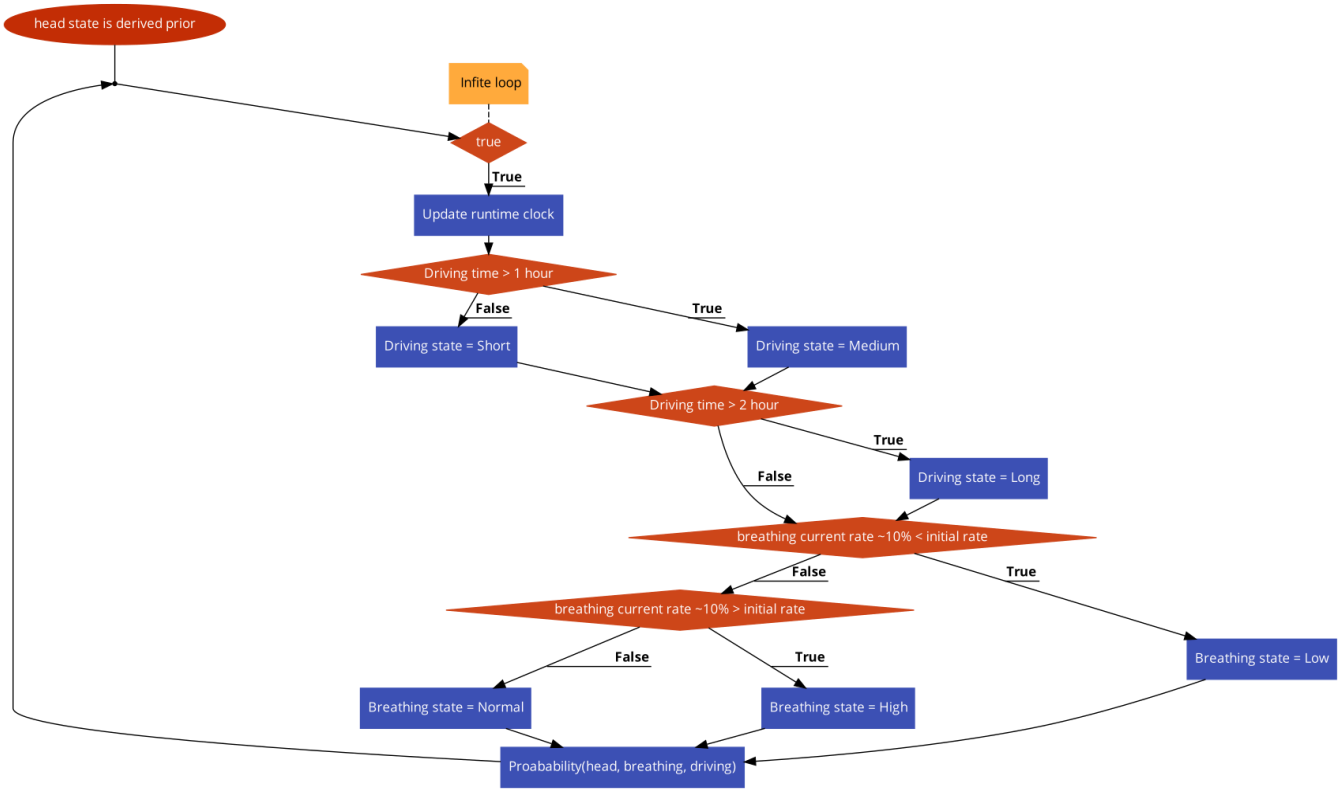
Throughout the duration of this project, several issues were encountered that required various aspects of the project to be redesigned or changed completely. The biggest issue was the delay caused by the signal processing challenges of getting a reliable range measurement and extracting biometric information. The delay forced the design to focus primarily on the driver's head position with a secondary emphasis on the breathing rate. Another significant problem was the inability to interface with the I/O pins on the POSITION2GO board. Manufacturer documentation listed I/O pins on the board and implied they could be used. However, there was no supporting documentation found nor available online resources that explained how to interface with these I/O pins, making the desire to include LEDs and buzzers an apparent impossibility. To make up for this, the declaration of "drowsy" or "not drowsy" will be output to MATLAB's console as well as a notification that the vehicle's system has been alerted.

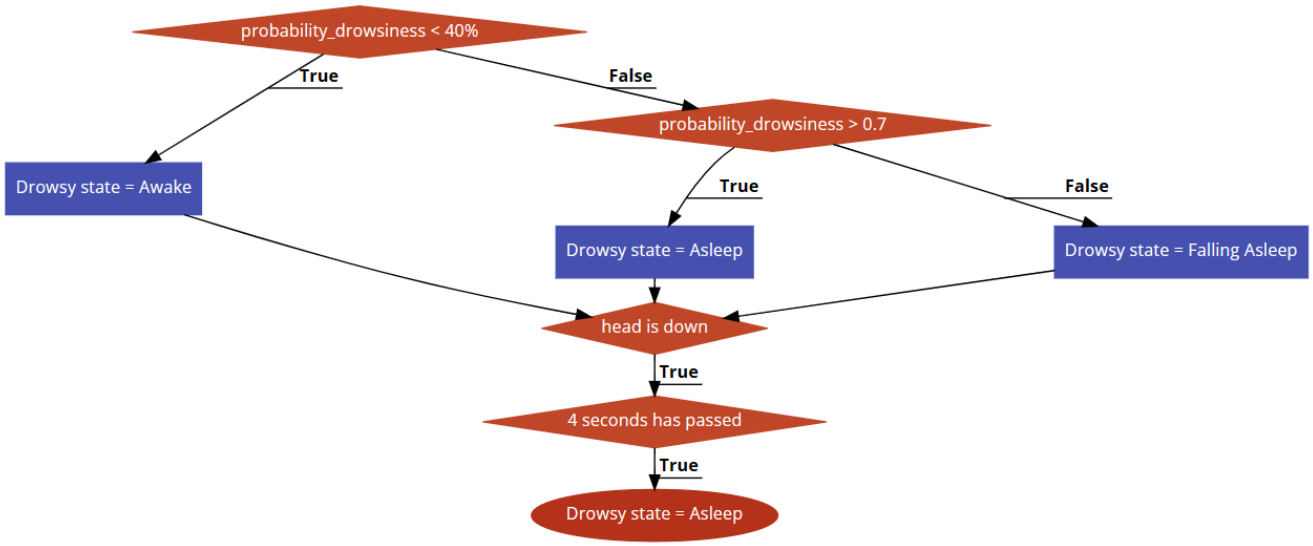
Other issues involving the production of the mirror casing led to several redesigns. Originally, the plan was to create a mirror casing that could be split open from the middle to allow for rapid prototyping and testing, but this proved too difficult to produce. A simpler housing was created where the mirror glass could be slid in and out quite easily to allow for changes to the board. Additionally, the available mirror glass for the design has a metallic backing, meaning it will reflect a portion of the transmitted radar wave back before it reaches the driver. This would create inaccurate readings so a revision was made to keep the part of the mirror containing the radar uncovered by any glass so it can reliably send and receive waves. Lastly, the decision making process was changed from the original plan to instead use a Bayesian Network approach. This approach was deemed more reliable and accurate given that each factor of drowsiness has a respective probability associated with it to give a more precise prediction of drowsiness.

Revised Component Breakdown



Revised pseudocode





V. Final Design + Conclusion

This project aims to address the issue of drowsy driving accidents by creating a drowsiness-sensing rear view mirror. The initial design listed above was modified to address the various issues that arose over the course of the project. The final design concept will still use a compact rear view mirror created with a 3D printing filament. Also, the POSITION2GO Board used to capture the driver's biometrics and determine drowsiness will be housed within the mirror casing. Though, the radar will not be completely covered by the mirror glass to ensure viable operation of the transceiver. The MATLAB environment will be used to process the received radar data to extract information from the driver. Additionally, MATLAB will be used to create the Bayesian network to determine drowsiness and output alerts to the driver via the console and the sound function. The design will be tested in a stationary car to mimic a real-world environment. Furthermore, testing participants will be observed throughout the day to see how their drowsiness levels fluctuate or they will pretend to be drowsy if they can not be observed during their most drowsy time of day. A respiratory belt will be used to collect breathing data while the head position can be easily observed during testing. All in all, the design integrates advanced sensor technology, data processing, and artificial intelligence to create an effective solution for protecting those affected by drowsy driving.

Final Device Rendering