**Prototype II for the “Hot Car Emergency”**

**Deliverable G**

**Project Group B2**

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# 1.0 Introduction

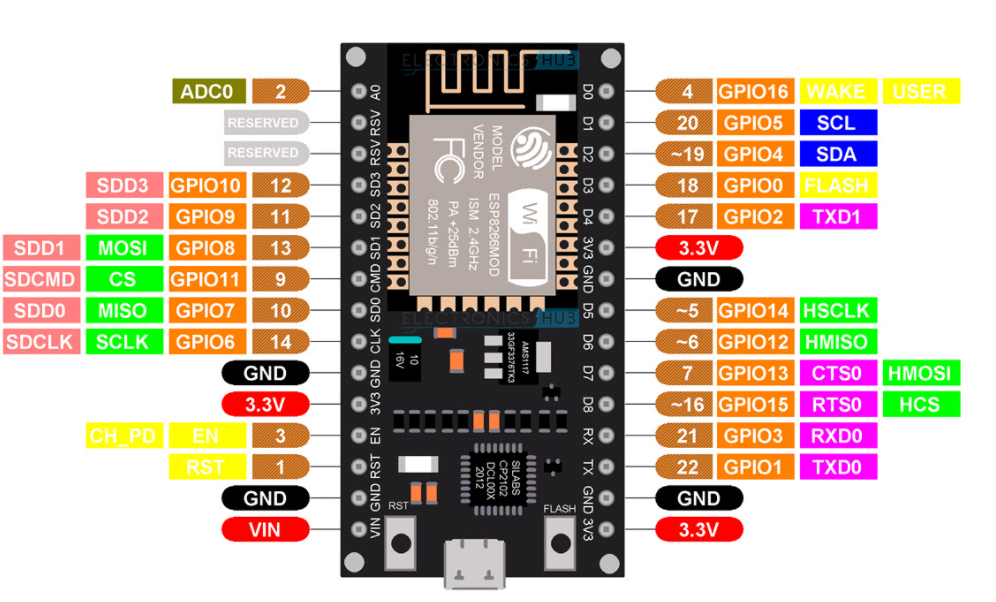
In the previous section, an initial prototype was developed in a simulated environment as a proof-of-concept for our codebase, sensor array configuration, and circuit layout. This proof-of-concept was met with positive feedback from both prospective users and the client, and was a success. Unfortunately, some unforeseen issues have arisen concerning our ability to source parts for a physical prototype. Therefore, in following with the iterative prototyping process, this section will focus on the adaptation of our first prototype’s design and concept to the parts chosen for our final prototype - notably the ESP8266 combined wifi module and control board, which is written in a language distinct from Arduino C/C++. This section will outline the differences between the arduino and the ESP’s codebases and pin layouts, provide additional details and technical information regarding the use of Pushbullet for mobile connectivity, and present a physical reconstruction of the proposed device case with details of it’s fit and position inside the vehicle. Additionally, this report will present the adjustments made to the prototyping and test plan to account for the change in the prototyping process, as well as all wrike and CEED task tracking documentation.

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# 2.0 Prototype and Explanation

**2.1.1 NodeMCU ESP8266 ESP-12E Combined control board Hardware**

Our chosen control board is the NodeMCU ESP8266 ESP-12E combined module. The NodeMCU ESP board is an open-source development kit based on the ESP8266 chip, which uses the Lua programming language - a development environment for applications that provide fast and effective Wi-Fi connectivity. In addition to using a different development environment than the Arduino platform, the NodeMCU board has a distinct pin layout, as described in Figure 1.

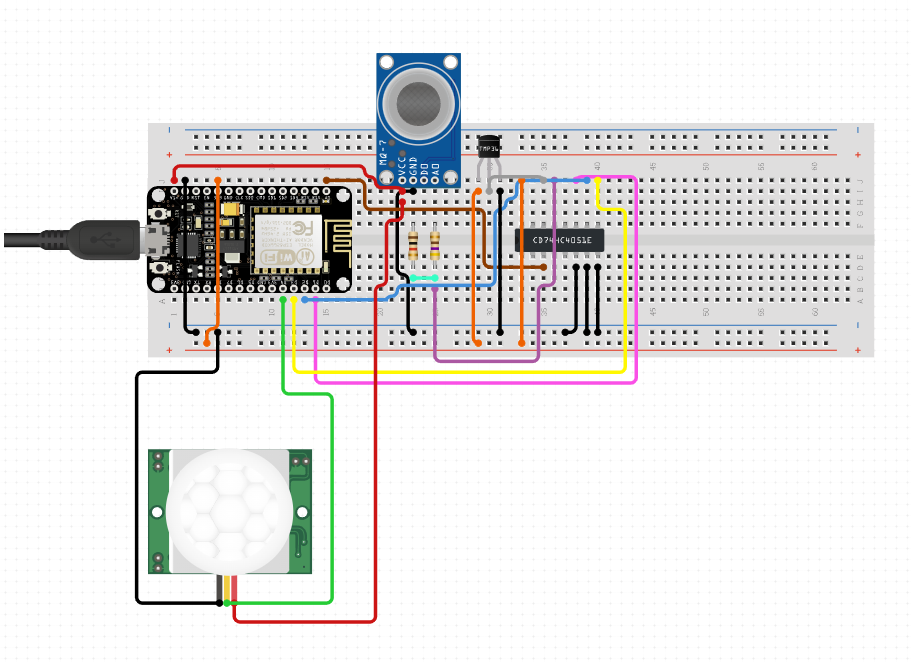


*Figure 1: NodeMCU ESP board Pin diagram[[1]](#footnote-0)*

| **Pin** | **Description** | **Functions** | **Default value** | **Arduino Pin equivalent number** |
| --- | --- | --- | --- | --- |
| ADC0 | Analog input | Input voltage from sensors | ADC0 | Pin D0,  analog\_ip |
| Reserved | Reserved pins, with no functions as Input or Output | Reserved pins are used to connect flash memory chips, they cannot be used as IOs | N/A | N/A |
| Reserved |
| SDD3 | Secure digital Input-Output (SDIO) Data 3 | Interface for input/output devices. Alternate: GPIO10 | SDD3 | N/A |
| SDD2 | Secure digital Input-Output (SDIO) Data 2 | Interface for input/output devices. Alternate: GPIO9 | SDD2 | N/A |
| SDD1 | Secure digital Input-Output (SDIO) Data 1 | Interface for input/output devices. Alternate: GPIO8 | SDD1 | N/A |
| SDDCMD | Secure digital Input-Output (SDIO) command | Bidirectional pin for communication between the microcontroller and the wifi module - used for commands and information.  Alternate: GPIO11 | SDDCMD | N/A |
| SDD0 | Secure digital Input-Output (SDIO) Data 0 | Interface for input/output devices. Alternate: GPIO7 | SDD0 | N/A |
| SDCLK | Secure digital Input-Output (SDIO) clock pin | A clock signal is sent by the microcontroller to the wifi module through this pin.  Alternate: GPIO6 | SDCLK | N/A |
| GND | Ground pin | Ground, to complete circuit | N/A | GND |
| 3.3V | 3.3V output | 3.3v board output signal | N/A | VOUT |
| EN | Chip enable / Chip select pin.  Active setting: HIGH | Command pin which connects I/O pins to internal circuitry | N/A | N/A |
| RST | Pin capable of resetting the board | Board resets when RST pin is set to LOW | N/A | N/A |
| GND | Ground pin | Ground, to complete circuit | N/A | GND |
| VIN | 5v input to onboard 3.3v regulator | Power supply input, to power board | N/A | VIN |
| 3.3V | 3.3V output | 3.3v board output signal | N/A | VOUT |
| GND | Ground pin | Ground, to complete circuit | N/A | GND |
| TXD0 | Universal Asynchronous Receiver/Transmitter (UART) 0 - transmitter | Pin for transmitting UART serial communication protocol, allowing data to be transmitted without need for a clock signal.  Alternate: GPIO1 | TDX0 | Pin 1, Alias D10 |
| RXD0 | Universal Asynchronous Receiver/Transmitter (UART) 0 - receiver | Pin for receiving UART serial communication protocol, allowing data to be transmitted without need for a clock signal.  Alternate: GPIO3 | RXD0 | Pin 3, alias D9 |
| GPIO15 | General-purpose input/output pin 15 | Digital pin input/output. | GPIO15 | N/A |
| GPIO13 | General-purpose input/output pin 13 | Digital pin input/output. | GPIO13 | Pin 13, alias D7 |
| GPIO12 | General-purpose input/output pin 12 | Digital pin input/output. | GPIO12 | Pin 12, alias D6 |
| GPIO14 | General-purpose input/output pin 14 | Digital pin input/output. | GPIO14 | Pin 14, alias D5 |
| GND | Ground pin | Ground, to complete circuit | N/A | GND |
| GPIO2 | General-purpose input/output pin 2 | Digital pin input/output. | GPIO2 | Pin 2, alias D4 |
| Flash | Pin used for Boot sequence. | Board is put into bootloader mode when Flash pin is set to LOW.  Alternate: GPIO0 | Flash | Pin 0, alias D3 |
| GPIO4 | General-purpose input/output pin 4 | Digital pin input/output. | GPIO4 | Pin 4, alias D2 |
| GPIO5 | General-purpose input/output pin 5 | Digital pin input/output. | GPIO5 | Pin 5, alias D1 |
| GPIO16 | General-purpose input/output pin 15 | Digital pin input/output.  Alternate: Wake control board from deep sleep | GPIO16 | Pin 15, alias D0  LED\_BUILTIN |

*Table 1: Pin descriptions for NodeMCU ESP, with reference to equivalent pins on Arduino boards*

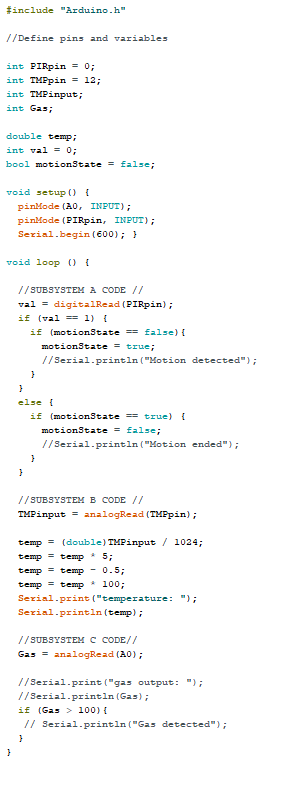
Taking this revised Pin layout into account, the circuit diagram for the sensor array becomes;



*Figure 2: revised sensor array circuit, note the Multiplexer / Demultiplexer*

There is one notable discrepancy between the simulated circuit of Figure 2 and the circuit that is going to be utilized in our device - the use of a Multiplexer module. As opposed to the Arduino uno board, which features 6 analog input/output pins, the NodeMCU ESP8226 combined control board only had one analog pin. This is notable because the MQ7 and the TMP36 in the configuration shown are both outputting to the single ESP analog pin. The shown circuit allows for the dual input to the analog pin with the use of the Texas Instruments CD74HC4051E analog multiplexer and demultiplexer. Our circuit will differ in that we will make use of the MQ7’s digital output signal, which we will map to one of our GPIO pins. The simulation software was chosen to represent our circuit despite this discrepancy, because it was one of the only easily-accessible circuit simulation programs with the NodeMCU combined board available.

**2.1.2 NodeMCU ESP8266 ESP-12E combined control board Software**

The NodeMCU board uses the Lua development environment to facilitate its wifi connectivity features. It is possible, however, to use the Arduino IDE to develop software commands which are supported on the NodeMCU board - but certain considerations must be taken into account. First, because the NodeMCU board is not an arduino platform, the “arduino.h” library must be imported. The pin layouts must also be defined according to their respective default values, which differ from those of an Arduino board. With these considerations implemented, the code for the sensors becomes: 

*Figure 3 : Sample code for NodeMCU board control*

**2.2 Mobile Connectivity**

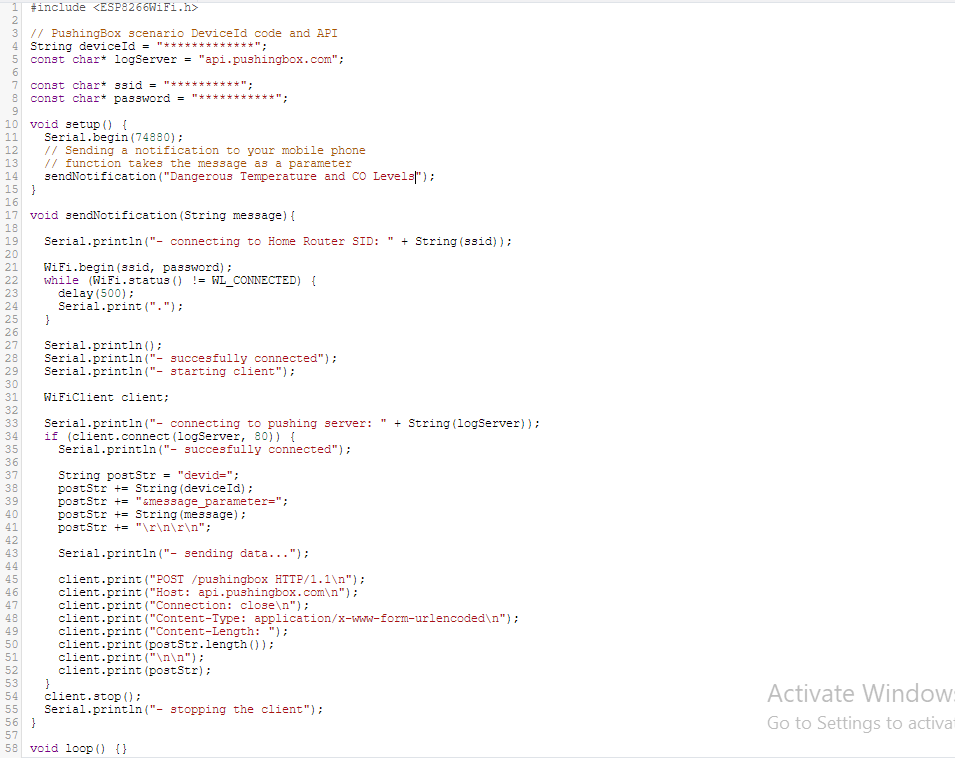
After researching many different Mobile Connectivity options and modules, we decided to use the Pushing-Box services and the PushBullet Application. One of the main reasons we chose to use their services is that they are free and straightforward. Pushbullet is one of the quickest and easiest ways to send notifications from your desktop computer to your mobile device (Android or IOS). However, since PushBullet does not directly connect to our ESP8266, a service called Pushing-Box will be used to connect our device to PushBullet. PushingBox is a cloud that can send notifications based on API calls. Since our control board features a wifi module built into it, we can easily connect our prototype to the PushingBox Cloud.

PushingBox has the feature of creating different scenarios and how each of them will cause different actions. We will have different alerts for different hazards based on the output the cloud receives from the device. The device will provide all the data and information needed (Temperature, CO, and Motion Results).

We will be creating three scenarios on Pushing-Box:

1. Motion is detected and dangerous conditions ( CO or Temperature)
2. Dangerous Temperature and Motion not detected
3. Dangerous CO levels and Motion not detected

If any of these conditions are met, the user/customer will receive a mobile notification on the PushBullet application to alert the parent/guardian.

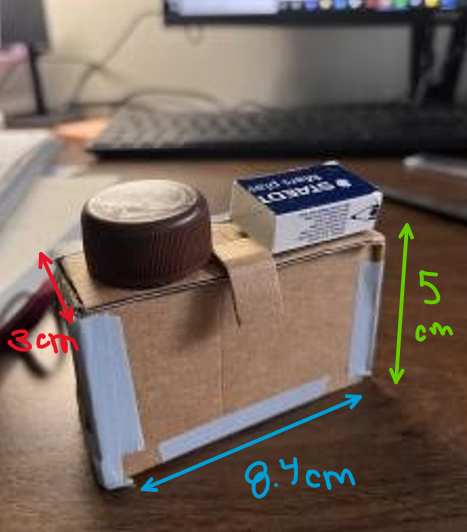


*Figure 4: Sample Arduino Code For Mobile Connection*

## 

**2.3.1 Case concept**

Below is a photo of a physical concept. We have not received any parts yet, so this is to accurately identify the most optimal configuration of the physical components within their case. The dimensions have been chosen based on the size of the circuitry components and the batteries. The box is made out of cardboard, but will instead be made out of a 3D printed ABS thermoplastic for prototype III. The bottle cap and eraser packaging are in lieu of the cutouts for the physical sensors. More information on this part of the prototype is in test 2.1 below.



*Figure 5: Cardboard physical concept prototype*

## 2.3.2 Component layout

## A mathematical analysis has been completed to determine the ideal configuration for the parts within the case, to both maximize part protection and minimize overall device volume. As per it’s design, the NodeMCU board will be placed on top of, and soldered to, the protoboard. The sensor array will then be soldered to the protoboard, with the TMP36 temperature sensor and the PIR motion sensor being placed directly on top of board, and the MQ7 being connected via soldered wires. The figures below further outline this configuration.

## 

## *Figure 6: Component layout, top view*

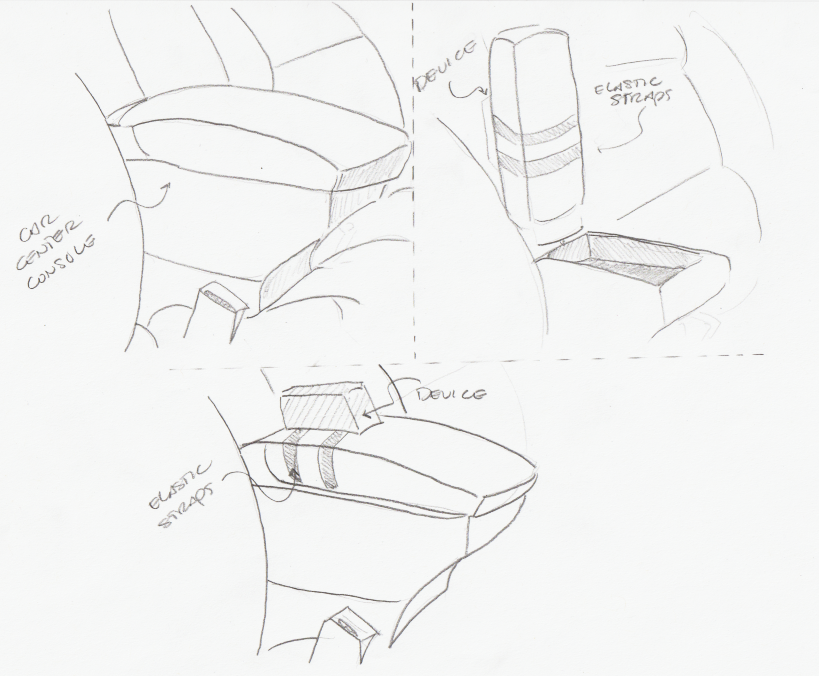
## 

## *Figure 7: Component layout, side view*

## 

## 2.3.3 Device stabilization

To ensure the accuracy of the PIR motion sensor’s readings within the car, and to avoid false-positives caused by shifting of the device inside the vehicle, the device case must be stabilized. Several target specifications were outlined for this stabilization system, notably: ease of use, tool-less installation, and the absence of glues or adhesives which could cause damage to the vehicle upon removal. Several options were considered for this system, but an elastic strap system was deemed the most appropriate for our goals. Two elastic straps, attached to the device via slots designed into the bottom of the case, are looped around the lid of the vehicle’s center console storage cubby. These elastic straps are held in place by their own elasticity and the lid of the center console - which is designed to be closed onto the straps after installation.



*Figure 8: device stabilization*

## 2.4 Analysis of Critical Components and Systems

| **Subsystem** | **Functionality** | **Technical description** |
| --- | --- | --- |
| A | Occupant detection | We’ll determine the presence of occupants by monitoring movement inside the vehicle. If there is continual movement detected, it can be assumed that there is an occupant (human or otherwise). Motion will be detected by the HCSR-501 PIR motion detection module. |
| B | Temperature detection | A thermistor will be used to measure the interior temperature of the vehicle. A danger threshold of 30 degrees celsius will trigger the alarm and message systems. |
| C | CO level detection | The MQ7 Carbon-monoxide deduction module will be used to detect the CO levels within the vehicle. Symptoms of CO poisoning first become apparent at levels of 70ppm, so a danger threshold of 50ppm will trigger the alarm and message systems. |
| D | Batteries & power supply | Two 1.5V AA batteries will be put in series to create adequate voltage for the control board. |
| E | Mobile connectivity | For mobile connectivity, our plan is to use Pushbullet to enable push notifications when CO or temperature levels become too high. Pushbullet is an internet service capable of sending sms messages, notifications and files to mobile devices via an app available on IOS and android. The signal from the sensors will be sent to the arduino, and if the conditions are too high, notifications will be sent to the guardians phone. |
| F | Alarm | The client requested the main focus of the prototype to be on alerting the vehicle owner of the presence of an occupant in the car. As a result, the bystander alarm will be minimalist, taking the form of a simple blinking LED light on the device. This LED will be connected directly to the arduino control board. |

*Table 2: Subsystem descriptions*

| **Part** | **Justification** |
| --- | --- |
| HCSR-501 | This will be the basis for our motion-detection subsystem, which will detect whether there are occupants in the vehicle. |
| NTC | The thermistor will be used to detect the temperature within the vehicle, to determine if conditions are dangerous. |
| MQ7 | This is the gas-sensing module we'll use to determine if the carbon monoxide levels in the car are dangerous |
| ESP8266 module | Our push-notification subsystem will use an open-source sms sending and notification management service called *pushbullet*. The device requires an internet connection for the push notification system to function, and the ESP8226 module will facilitate wifi connectivity as well as having a built-in control board. |
| AA Batteries | According to the Arduino website, the nano can be run on unregulated external power supplies from 6v to 20v without a voltage regulator. Four 1.5 volt AA batteries will be put in series to create the adequate voltage output to power the board. |

*Table 3: Part justifications*

The above have not changed since the last deliverable.

# 3.0 Prototyping Test Plan

Due to the aforementioned issues related to part acquisition, we had to push back some testing as we do not have a working physical prototype this week. Because of the lack of online simulation software capable of recreating the behaviour of the NodeMCU combined control board, testing of the software and hardware configurations beyond the cross-referencing with existing literature has been delayed until the 3rd prototype. Changes made were all the tests in prototype II as well as 3.8 in prototype III as feedback from the client made it clear that we need to put more emphasis on the physical aspect of the device.

| **Test** | **Part & Subsystem** | **Objective** | **Test Method** | **How Results will be Recorded** | **Date** |
| --- | --- | --- | --- | --- | --- |
| **~~Prototype I: Analytical Focused on Circuitry Virtual Prototype~~** | | | | | |
| **Prototype II: More Complex Virtual Circuitry and Coding, Physical Concept** | | | | | |
| **2.1** | Car Placement & Functionality | To determine a functioning placement of the device in the car that does not interfere with the driver and properly assesses the conditions in the car in that placement. | Place the cardboard prototype in 3 places in the car, 1 of which being the original idea, and assessing the placement based on the characteristics mentioned in the previous paragraph. | Via a table crafted before the testing takes place. | Nov 12 - Nov 14 |
| **2.2** | PIR motion sensor | To confirm the adequate configuration of the motion sensor’s circuit and codebase | The circuitry and codebase were cross referenced with existing literature | Providing copies of the information consulted | Nov 12 - Nov 14 |
| **2.3** | TMP36 temperature sensor | To confirm the adequate configuration of the temperature sensor’s circuit and codebase | The circuitry and codebase were cross referenced with existing literature | Providing copies of the information consulted | Nov 12 - Nov 14 |
| **2.4** | MQ7 gas sensor | To confirm the adequate configuration of the gas sensor’s circuit and codebase | The circuitry and codebase were cross referenced with existing literature | Providing copies of the information consulted | Nov 12 - Nov 14 |
| **Prototype III: Working Circuitry and Physical Concept** | | | | | |
| **3.1** | Pushbullet device connection  Mobile connectivity | A key portion of this project is notifying a parent/guardian/car owner that a child is present in the vehicle during dangerous conditions. This test will isolate the feasibility of doing so. | Sample information and notifications will be sent to team member’s phones | Screenshots of the shared sample information and notifications will be recorded from the phones | Nov 19 - Nov 22 |
| **3.2** | Pushbullet multiple device connection  Mobile connectivity | One of the feedback given to us, presented in section 5.1, is that the device should push to multiple phones. This test aims to see if that is possible. | Sample information and notification will be sent to several phones simultaneously | Screenshots of the shared sample information and notifications will be recorded from the phones | Nov 19 - Nov 22 |
| **3.3** | PIR Motion Sensor (HCSR-501) Code and Circuit Test (Physical Circuitry)  Occupant detection | To verify the circuit and sensor assembly to ensure adequate function | Objects will be placed in front of the device at ½ meter increments until it’s operating range. These objects will be moved at varying speeds at different times to test the sensor’s speed and accuracy | Sensor response times, object distances and velocities, and sensor outputs will be recorded in a spreadsheet | Nov 17 - Nov 19 |
| **3.4** | Thermistor Sensor (NTC) Code and Circuit Test (Physical Circuitry)  Temperature detection | To verify the circuit and sensor assembly to ensure adequate function | The sensor will be placed in an environment with a controlled temperature. The temperature will then be incrementally increased from 0 degrees celsius until the upper bound of the thermistor’s operating range. | Sensor outputs will be recorded in a spreadsheet and compared with control values. | Nov 17 - Nov 19 |
| **3.5\*** | CO Sensor calibration sequence | To verify the viability of the part, and to ensure proper calibration of the probe. | The sensor calibration procedure, as outlined in the module’s technical documentation, will be completed. CO samples will be measured at different concentrations to verify proper function | Sensor reactant membrane temperature will be plotted against gas concentration, and compared with control values from the technical documentation | Nov 18 - Nov 20 |
| **3.6** | CO Sensor (MQ7 Probe) Code and Circuit Test (Physical Circuitry)  CO level detection | To verify the circuit and sensor assembly to ensure adequate function | Smoke from paper and wood burning will be introduced to the sensor, to test its ability to detect CO in its environment | Sensor output values will be compared with Stoichiometrically determined theoretical CO concentrations | Nov 17 - Nov 19 |
| **3.7** | LED Array or Buzzer System Code and Circuit Test (Physical Circuitry)  Alarm | To verify the circuit and sensor assembly to ensure adequate function | Buzzers will be placed at incremental distances from a microphone to determine their relative power | The volume of each buzzer will be measured in decibels and compared with each other to establish relative usefulness and volume | Nov 19 - Nov 22 |
| **3.8** | Car Placement & Functionality | To determine a functioning placement of the device in the car that does not interfere with the driver and properly assesses the conditions in the car in that placement. This is especially crucial now that the sensors will have been functional | Place the prototype in the car at the chosen spot based on 2.1 and analyze the mechanisms tested in 3.1 to 3.7 in that placement. | A simple yes or no assessment if the sensors worked in that environment. If it ends up being a problem, we have multiple options stemming from 2.1. | Nov 22 - Nov 25 |

*Table 4: Updated Prototyping Test Plan*

## 3.1 Test Results

Results for Test 2.1[[2]](#footnote-1)

| **Placement** | **Picture(s)** | **Analysis** |
| --- | --- | --- |
| **Near Cigarette Lighter** |  | * Sensors blocked by gear shift. * Takes away some of the car’s storage space. * Individual 4 & 5 suggested that if the device is in a lower area, it is more likely to be in the way. As well as it being more likely to be accidentally tampered with (ie. shoving it on accident). * Good that it is not within the child's reach. |
| **Dashboard** |  | * Dashboard placement can get in the way of the driver's view. * The heat from the sun can damage and skew the results of the temperature sensor. * The PIR sensor will not have an accurate view of the child(ren) in the backseat. * Overall the worst option. |
| **Backseat Cupholders** |  | * This option would include velcro adhesive to the back. * This goes back to the statements of Individual 4 & 5, where if the device is lower, it is more likely to be damaged and has less overall view of the car. |
| **Arm Rest** |  | * The drawings shown is how the device will be attached to the arm rest. This ensures that it is properly attached and can’t be tampered with. * It has a view in the front seats and back seats. * High enough for the sensors to detect vehicle occupancy. |
| As of right now, the best option is the **strapped arm rest location**. Prototype test 3.8 will provide more insight. This will be provided next deliverable. | | |

*Table 5: Test 2.1 and Results*

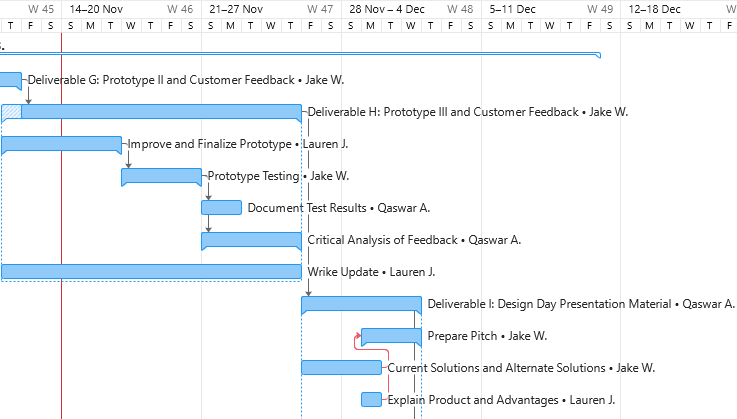
Because of the various delays in the acquisition of our physical parts, and the lack of simulation software capable of accurately representing the behaviour of the ESP line of chips, testing for this deliverable was challenging. The codebase and circuit diagrams, however, were still tested by cross-referencing multitudes of different sources of online literature (from technical documents to internet blogs) in an effort to confirm our circuits and software. The table below features the url’s to the online documents that were consulted, as well as the document’s author and their organization.

| **Part** | **Document type** | **Document usage** | **Reference source** | | |
| --- | --- | --- | --- | --- | --- |
| Author | Organization | Url |
| NodeMCU ESP8266 V1.0 | Technical document | This document was consulted to confirm the pin layout and voltage input/output for the NodeMCU chip | Espressif systems IOT team | Espressit systems | <https://components101.com/sites/default/files/component_datasheet/ESP8266-NodeMCU-Datasheet.pdf> |
| HCSR-501 PIR motion sensor | Blog post / online tutorial | This document was consulted to confirm the codebase for our PIR sensor | Iain Andrew | Wia | <https://community.wia.io/d/56-how-to-connect-a-pir-sensor-to-an-esp8266> |
| TMP36 temperature sensor | Blog post / online tutorial | This document was consulted to confirm the codebase for our TMP36 sensor, and as an additional reference for the pin layout for the NodeMCU board | Aleksandr Cuchriajev et al. | Acoptex | <https://acoptex.com/project/1477/basics-project-070s-esp8266-esp-12e-module-with-tmp36-sensor-at-acoptexcom/> |
| MQ7 carbon monoxide sensor | Blog post / online tutorial | This document was used to confirm the circuitry for the carbon monoxide sensor, as well as an additional reference for the code required for internet connectivity with the ESP8226 chip | Hariharan Vs | Instructables | <https://www.instructables.com/MQ7-POLLUTION-MONITORING-USING-THING-SPEAK-AND-NOD/> |

*Table 6: Technical documentation cross referencing*

**3.2 Wrike Update**

Below is a screenshot of the updated Wrike Gantt Chart for the next 2 weeks. It is crucial to have a solid agenda for the next few weeks with Design Day approaching.



*Figure 9: Wrike Gantt Chart for Deliverables H & I with Dependencies*

# 4.0 Updated BOM and Target Specifications

Changes to the BOM had to be made due to low MakerLab availability. The text highlighted in yellow is what has changed.

| **Part** | **Description** | **Price** | **Store** | **Url** |
| --- | --- | --- | --- | --- |
| HSCR-501 | PIR motion detecting module | $3.95 | Pishop | <https://www.pishop.ca/product/hc-sr501-pyroelectric-infrared-pir-motion-sensor-detector-module/> |
| TMP36 | Temperature sensor | $3.45 | Pishop | <https://www.pishop.ca/product/octopus-temperature-sensor-brick-tmp36-analog-for-microbit/> |
| MQ7 module | CO gas sensing module | $9.95 | Pishop | <https://www.pishop.ca/product/carbon-monoxide-gas-sensor-mq-7/> |
| AA Batteries | Standard AA batteries for power supply | $2.85 | Pishop | <https://www.pishop.ca/product/aa-battery/> |
| Battery holder | Case to house the AA batteries | $1.00 | Makerspace | <https://edu-makerlab2021.odoo.com/shop/product/aa-battery-holder-48#attr=47> |
| ESP8266 ESP-12E v1.0 | Combined control board and wifi module to control modules and send push notifications | $9.95 | Pishop | <https://www.pishop.ca/product/esp8266-esp-12e-v1-0-wifi-cp2102-iot-lua-267-for-nodemcu/> |
| Protoboard | Board to solder circuits | $0.50 | Makerspace | <https://edu-makerlab2021.odoo.com/shop/product/protoboard-51?search=board#attr=53> |
| Resistors  (220Ω,4.7kΩ) | Resistors for the LEDs and the MQ7 module | $0.02  (1¢ \*2) | Makerspace | <https://edu-makerlab2021.odoo.com/shop/product/resistor-6?search=resistor#attr=9> |
| Connection wires | Wires for connecting the various components | $2.50 | Makerspace | <https://edu-makerlab2021.odoo.com/shop/product/wire-5ft-45?search=wire#attr=213,217> |
| **Total:** | **$38.10 After tax, $45.60 After shipping** | | | |

*Table 7: Update BOM*

The target specifications have not changed since the last deliverable, thus it would not only be redundant to show them again, but it would also clutter the important new information presented in this deliverable.

# 5.0 Feedback and Comments

## 5.1 Client Feedback

We have had two meetings with the client so far. The first was a success. He was very happy with the direction we were going in, and no new information was given with the exception of an action to lower the temperature. As amazing as that would be to increase the functionality of the device, it is not within the scope of our budget and our abilities to implement such a subsystem. The client had more feedback during the second meeting. He emphasized the element of an alarm to notify bystanders, as well as the adhesive mechanism to the car. These elements are both currently a work in progress. We have established two ideas for the alarm (LED array or buzzer) but both of which would not be significantly noticeable, and would drain the arduino faster. Overall, the mechanisms of which we can implement would not meet the clients standards as of now. The second feedback, regarding the adhesive mechanism, was addressed in this deliverable in test 2.1.

## 5.2 Individual 3 (again): Civil Engineer, licensed driver, parent

* *Overall the prototype concept is good and would work if the plan is followed. Since there is no physical example, it will be harder for the team to account for unexpected problems.*
* *From the current position, there is a possibility that it can be tampered with or moved by a child or dog.*

## 5.3 Individual 4: Part-time worker, licensed driver[[3]](#footnote-2)

* *I think in the long run, even though it doesn’t seem like it’s within the scope of your project or abilities I guess, this would only be beneficial and bought by customers if it had a way of keeping the child safe, like tripping the ventilation system.*

## 5.4 Individual 5: Electricians apprentice, licensed driver

* *Current placement seems like it would get in the way. Because this has sensors you’d think the best location would be on the roof or maybe above the rearview mirror. It should see over seats.*

## 5.5 Individual 6: Parent, licensed driver

* *I think that if the device was going to alert me of a problem, that it would be better if it did something to solve the problem, because if you were far from your car then it would be stressful getting back to your car.*
* *As for the location of the device, I think that it needs to withstand being touched/played because it will likely be disturbed by children.*

This feedback will be considered when making changes for prototype III -and its respective components.

# 6.0 Conclusion

In this deliverable, we enhanced our simulated prototype, as well as provided a solid physical concept of the device. We provided detailed information on our code and circuitry to compensate for the delayed parts shipment. Our prototyping test plan was adjusted accordingly, and is planned to be followed exactly for the next deliverable. An updated BOM, as well as detailed customer and client feedback was provided to critically analyze our designs. Most importantly, we conducted tests on various subsystems of our prototype to ensure their functionality. With our constraints in mind, this deliverable provides an excellent outline of our prototype, and detailed tests and feedback to justify the decisions we have made.

1. Pin layout courtesy of ElectronicsHub.org, <https://www.electronicshub.org/nodemcu-pinout-esp-12e-pinout/> [↑](#footnote-ref-0)
2. Results are coming from two interviews (individual 4 & 5). Results are also based on assumed affect on sensors. [↑](#footnote-ref-1)
3. Individuals 4 and 5 were interviewed at the same time. They agreed on both things they said. [↑](#footnote-ref-2)