**Brain Ballast Sensor: Ideas for different tiers of goals**

(Goals do not have any priority as of now and are meant to be edited and added to by anyone that sees fit)

**I added some text below with suggestions on goal organization and I made a few comments in blue on each of these. I think you are on the right track but I would suggest the following structure**

**Goal 1: Understand the components and overall system incorporated in the BLE sensor and evaluate whether improvements can be made**

Task 1: Determine what components are used in the BLE sensor

Task 2: Survey the market to find out what is the latest tech available and if any would be better than what is used in the BLE sensor

**Goal 2: Improvements to the BLE sensor**

Task 1: Can the housing be reduced (this is your current goal 1 below)

Task 2: Can the signal capabilities be improved (this is your current goal 2 below)

Task 3: Can we transmit and record data without using their proprietary software (this is your task 5, but I would say this is not a critical need if we don’t get to it)

**Goal 3: Convert the wired sensor to wireless capabilities (this is your goal 6)**

Task 1: Determine the best wireless options from Task 2 under Goal 1 and compare it to what is used in the BLE sensor to design the appropriate wireless system

Task 2: Build the wireless system and incorporate with the sensor

Task 3: Build a software interface for recording and downloading files for data

Task 4: Test the sensor

**Goal 4: Create a “Brain Ballast” Prototype (this is the ultimate dream with the idea being that we would build the best options out of all the things you learned in the previous tasks)**

Task 1: Determine the best sensors and wireless options from Task 2 under Goal 1 and design the appropriate system

Task 2: Build the brain ballast prototype and install into a ballast or ballast-like housing

Task 3: Build a software interface for recording and downloading files for data or adapt the software from Goal 3

Task 4: Test the sensor

**Goal 1:**

Find a way to get the housing of the BLE sensor a bit smaller (to match the average size of the ballast rocks) and perform performance testing on the new design to ensure it still works as intended.

* In order to do this will need to conduct some data collection to know how the sensor works already and how it should work in the new housing
* Then design a smaller casing for the BLE sensor and construct a prototype either with 3D printers or another manufacturing process. (Need to ensure that the new prototype has a way for the sensor to get the water sample but also not let any of the unwanted soil particles into the device)
* Perform testing to ensure that the BLE sensor still works properly in the new housing.

**Goal 2:**

Figure out a better way to transmit the data from BLE.

* Currently does not perform the greatest when completely submerged in water and would need to find a way to make it so it does
* To do this we would need to research a way to send a stronger signal with the current device or find a new way of transmitting data
* After the research then implement the best option and perform testing to ensure that it works as intended

**Goal 3: (I think we are okay with the current battery unless we can figure out the piezo power option)**

Find a way to expand the battery life of the current BLE sensor.

* Either by increasing the size of the battery or changing the way the device is powered entirely.
* This may play into the second goal also since changing the signal strength will use more battery when transmitting.
* Also would like to find a way to detect when the train is going over top of the sensor so that the BLE device only collects data when it is needed. This might involve incorporating additional sensors into the device.

**Goal 4: (I think we can let Ben solve this one, no need for you all to bother with the soil side of things)**

Find a way to stop the BLE sensor from getting clogged from material within the ballast.

* This is a maybe since it already has a pretty good pore rock to stop the clogging but may be something to work on. If so it would relate to goal 1 as well.

**Goal 5:**

Find a way to change the software of the BLE sensor transmitter so that it is not reliant on the proprietary software.

* This goal would require a lot of research to be able to figure out how to implement this idea/
* This would most likely be one of the goals further down the line once we have are completed something for the project

**Goal 6:**

Find a way to get the smaller water pressure sensor to work wirelessly

* This would involve finding a way to power it
* Finding a way to store and then transmit the data wirelessly
* And then designing a new housing for it so that it could be tested

**Goal 1 (in my opinion): Determine whether the BLE sensor is as good as we can get or are there other options that will be better?**

**You could do this as a part of the proposal stage and/or as a first couple of tasks**

**Task 1: What components are in the BLE wireless sensor and how does it work?**

* We can take one apart or get the company to help us figure out what is in it (sometimes they don’t like doing this).

**What else is out there and is it better (you could do a neat ranking system for each of these things and help us down select the best components)? Survey microdata acquisition, transmitters, and sensors available on the market. Determine which are the most effective for the application of rail ballast. How do they compare with what is used in the BLE sensor?**

**DAQ options** (Things to consider: what is the size and power requirements of each, how many sensors could it support, does it store or transmit samples, what is the sampling rate, how many samples can it collect???)

* What does the BLE use?
* Raspberry Pi or Arduino?
* Other options (PCB or designed unit)

**Power options** (Things to consider: how much power can it supply, what is the physical size requirement, how long can it hold power, does it need to be charged?)

* Battery (button cell or similar)
* Piezoelectric generators

**Transmitter options** (Things to consider: what is the size and power requirements of each, how many sensors could it support, how fast and how many samples can it transmit, can it transmit through soil and water, does metal interfere???)

* Bluetooth
* RFID
* WiFi
* Other wireless transmitter options?

**Sensors (search MEMS sensors or other micro sensors)**

* Pore Pressure (I think we found everything that makes sense for these and we can share the options with you) I think there are MEMS sensors for tire pressure that might work and even pressure sensors in Apple watches, but we have not looked into these. It might be worth some time googling to see what you can find. We also found these, but did not buy them yet https://www.l-com.com/iot-highly-stable-pressure-sensor-0-35mpa-sealed-gauge-compensated-19mm-diameter?gclid=Cj0KCQjwj5mpBhDJARIsAOVjBdr3Vu1glpQfR1Tww2R88BIkMv3k6yYO8ZAs2rbrJv4ZjGpoGaRibA8aAt4rEALw\_wcB
* Accelerometer
* piezoelectric actuator
* gyroscope

**A few bits of info I found while searching for things:**

**Edge Processing or Edge Computing. (Take a look at this! I think you all could do some really nice CSCE contributions here.)** There are several advantages to having the data processing embedded in the sensor, rather than transmitting raw data to a central processor, perhaps in the cloud. First of all, it takes much more power to transmit large amounts of data, rather than a signal that has already used the data to compute a significant output message. Power can also be reduced if the local processor can aggregate data and just transmit it at fixed intervals rather than continuously. This is especially important for maximizing battery life. And for rapid motions you do not want the latency caused by sending data elsewhere rather than processing it right at the sensor. <https://www.techbriefs.com/component/content/article/tb/supplements/st/features/articles/39241>

(<https://www.semi.org/en/blogs/technology-trends/making-wearables-always-wearable-with-mems-sensor-technology> ) Several techniques are being developed to reduce power consumption. The goal largely is to reduce the power draw of components that are always-on, such as the screen in a smartwatch. In activity trackers, the motion sensor is always on to sense, track, classify and store motion data. Reducing the power needed to operate these features will cut total system power consumption as well. A good example is our [BMA400 accelerometer](https://www.bosch-sensortec.com/bst/products/all_products/bma400_1) that has a current consumption of less than 1 µA in full operation. At the same time, it independently processes sensor data. For example, the device converts the three-axis motion sensor data stream into step counting events. This allows the main (host) microcontroller to remain in the stand-by mode required for activity tracking and to be activated by the accelerometer to deliver full power only, say, every 100 steps. The sensor, rather than the microcontroller, manages the overall duty cycling of the microcontroller to reduce system power and increase overall efficiency.

This and other similar Tech articles seem to have really good info for what we want to consider for sensors and transmitter systems.