Group J Design Brief: PONDER

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1. Innovation

"To provide an affordable, unmanned and versatile system for the quantification of a body of water's quality."

Whilst many developing countries such as India and Brazil continue to urbanize and industrialize rapidly, their effective protection of the environment sadly remains lacking. Poor waste management, heavy manufacturing and increasing weather volatility have inflicted pronounced and widely-recognised damage upon typical water qualities within such countries. The leakage of hazardous materials and pollutants into a drinking water source, combined with inadequate or non-existent water processing are massively detrimental upon public health and the environment as well as the region's economy and reputation.

Research conducted by the United Nations in relation to one of their Sustainable Development Goals (SDGs), Goal 6 (Clean Water and Sanitation), revealed that globally, more than 80 percent of wastewater resulting from human activities is discharged into rivers or sea without any pollution removal.[1] We seek to remedy the problem by allowing our clients to identify the source.

Through monitoring changes in water quality throughout a water network, the root causes of water contamination may be identified. Polluting factories, agricultural run-off, major dumping sites, chemical spillages and more produce sharp changes in the levels of particular contaminants as these substances migrate down-stream which, when combined with knowledge of the river's topography and built-in GPS, will allow for the pin-pointing of pollutant sources. Current methods for monitoring water quality often consist of hand-held meters or bench-top equipment that requires human personnel / boats.[2][3] Current buoys for monitoring water quality are expensive (on the order of hundreds and in some cases thousands of pounds)[4][5] and are usually implemented solo. We wish to create a network of buoys that will allow us to wirelessly monitor several parameters indicative of water quality at numerous points throughout a water network. Our product will be highly cost-effective and robust, packing a lot of functionality for a low price.

2. Technical Outline

Hardware Technical Aspects

The PONDER water sensor will be equipped with four different types of sensors to monitor the water's condition; it will measure the temperature, turbidity, Total Dissolved Solids (TDS) and pH levels. These sensors were chosen as together they give a good indication of water quality at a low cost. We can measure the impact of common concerns such as eutrophication, without the need for more costly sensors, such as for measuring Electrical Conductivity (EC), Oxidation Reduction Potential (ORP), Dissolved Oxygen (DO), etc.

An Arduino Nano microcontroller (chosen due to its small size and low power requirements) will be

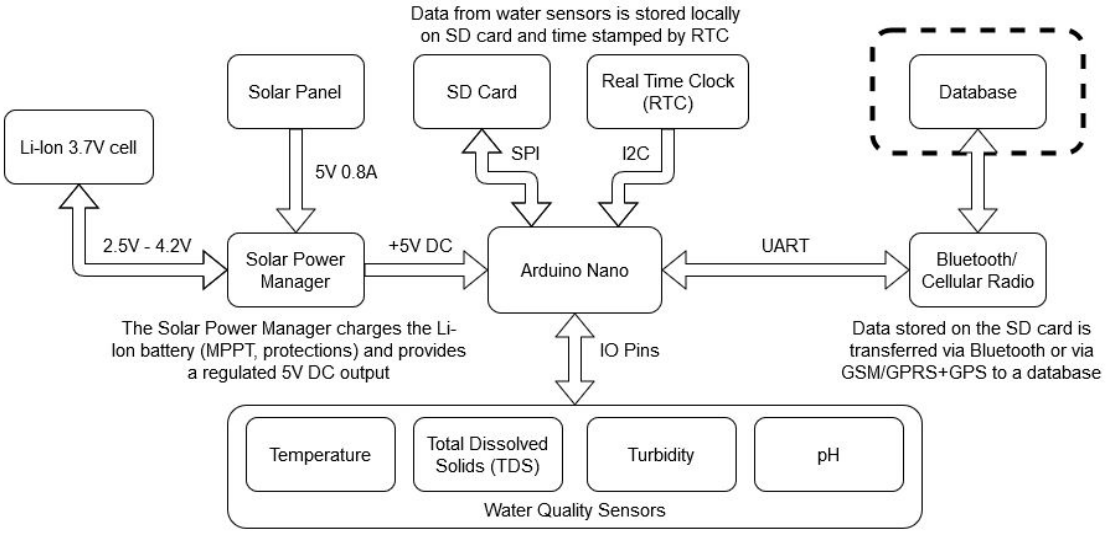

Figure 1: Hardware Diagram

used to poll the sensors at regular intervals and store the sensor data on an SD card as a CSV file. The SD card and Arduino will communicate via SPI. A DS3231 Real Time Clock (RTC) will be connected to the Arduino via the I2C bus. The RTC allows data logs to be time stamped, and also has the function of setting alarms which can be used as interrupts to wake the Arduino from a deep sleep mode, thus saving power when not in use.

The microcontroller will be powered by a single rechargeable Li-Ion cell linked with a solar panel to extend runtime. We calculated our solar panel and battery requirements by considering the worst case scenario, during the month of December when solar irradiation is at its lowest. Using a 3.7V 3000mAh cell, the PONDER will be able to run for an estimated 5 days without being recharged by the solar panels in the event of bad weather. We may be able to extend this time even further by decreasing power consumption by using interrupts from the DS3231 RTC, by setting the ATmega328P microcontroller's clock prescale register to decrease the system clock frequency, and by using NPN transistors to stop other components from drawing current.

Data stored on the SD card will be transmitted wirelessly and viewable on a companion mobile application. Data transmission will be performed either via Bluetooth, or using a GSM/GPRS+GPS module which would allow for completely remote operation and the use of GPS to monitor that the device remains in its intended position.

Sustainability Implications

The primary sustainability concern for the PONDER device is the impact of its enclosure within the water body. We must ensure that it does not endanger wildlife, nor do its materials degrade and pollute the water. Biofouling is also a concern, and so our design will consider it. Furthermore, the use of GPS monitoring allows the device to be retrieved, should it become untethered, to avoid being lost and becoming litter. The device will be fully self-sufficient thanks to its solar panel, and thus have no carbon footprint once in operation.

Specifications

The device will satisfy the requirements set out by the client in the initial meeting (EEE3017 Session 1 - Introduction and Overview), given that it will include an aspect of hardware, software, timed data transmission, data display, etc). In addition, we have set out our own set of specifications relating to PONDER's functions. These encompass its self-sufficiency, buoyancy, and waterproofing, among others.

Software Technical Aspects

The software will consist of three main tasks: An app, a database, and communication between the app and hardware.

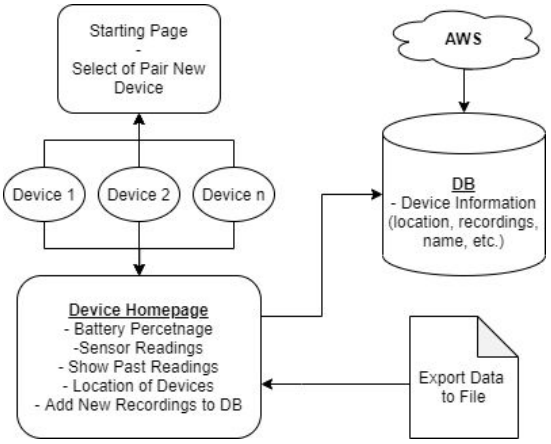

Figure 2: Software Diagram

The app will be an Android app written in Java using Android studio. The UI of the app will be made using the "design" feature in Android studio, which can also be configured using XML files for the UI. The app will display the different qualities that affect water quality, as well as the GPS data to track the device, should it be dislodged from its designated position.

The data we collect from the sensors will be stored in a database server hosted on AWS (Amazon Web Services). The backend of the app will consist of Java code written to execute SQL queries to CRUD (create, read, update, delete) data. Returned objects from SQL queries will be passed to the app's interface.

Device communication between the app and the device will be done using Bluetooth or GSM/GPRS. Further research will be done in order to decide which is the most feasible option.

The GSM option will require the Arduino to connect to the DB server and execute queries to add or update readings. The app will check in the background for any changes in the DB and update the interface accordingly.

In terms of security, the arduino bluetooth module has a feature where if a device wants to connect it must enter the correct passcode to connect to the device. This therefore ensures only authenticated devices can connect to the module. Connection to the database from the app or module will be made using SSL to ensure data transmission is encrypted.

3. Project Management

A key aspect of our project management is the use of a Gantt chart showing an estimated timescale for each task. Figure 3 shows an abridged version of our Gantt chart, up to December.

Each task has one or more designated owners, which were assigned in such a way as to take advantage of people's strengths. The hardware development of the project will be primarily undertaken by Mark, Kieran, and Lawrie, whilst Robby will develop the mobile application, and Pranay and Priyam will implement the database and data communications. All members contribute to creating and maintaining documentation.

Risk Assessment

We identified the key risks and mitigation measures for each task. We assessed the risk occurrence likelihood and potential severity of outcome, and used a typical risk matrix to obtain an overall risk level (Low/Medium/High). For the sake of brevity, only the overall risk level for each task is illustrated in Figure 3.

We identified two key tasks as having a 'High' level of risk; both are related to data transmission using a GSM/GPRS+GPS module. We assessed the risk occurrence likelihood as 'Probable (61-80%)', and the impact of having no working form of data transmission as 'Very High', giving an overall risk of 'High'. Thus, we chose to mitigate this risk by developing both Bluetooth and GSM/GPRS transmission in tandem, such that Bluetooth may be used in the event that GSM/GPRS cannot be successfully implemented.

In order to reduce risk on the software side, data security is applied when dealing with data transmission. To prevent data loss, regular backups of the DB will be taken on AWS. Since GSM is our preferred method of data transmission, the chosen GSM provider will be of the highest reliability.

Costs

We have identified all necessary components and their costs, illustrated in Figure 4. The project is within the £100 budget. All components have now been ordered.

Category	Part	Part Description	Unit Price
Sensors	Temperature	Waterproof DS18B20 Sensor Kit	£ 5.76
	TDS Sensor	Analog TDS Sensor/Meter for Arduino	£ 9.06
	Turbidity Sensor	Analog Turbidity Sensor For Arduino	£ 7.60
	pH Sensor	Analog pH Sensor For Arduino	£ 22.66
Arduino	Arduino Nano	MakerHawk Nano Microcontroller	£ 4.33
	Real Time Clock	DS3231 RTC I2C with Alarm	£ 3.24
	SD Card Reader	Micro SD Card Reader Module	£ 1.74
Power	Solar Panel	4W 5V 0.8A Solar Panel 175x172mm	£ 7.34
	Power Manager	Solar Power Manager 5V	£ 6.07
	Li-Ion Battery	Samsung 30Q 3.7V 3000mAh Li-Ion	£ 4.69
	Battery Holder	18650 Li-Ion Battery Holder (1 Battery)	£ 1.80
Comms	Bluetooth	HC-05 Android Bluetooth Transciever	£ 4.60
	GSM/GPRS+GPS	A9G GSM/GPRS+GPS Module	£ 8.83
Other	PCB Cost	JLCPCB 100x100mm 2 layer 5pcs	£ 0.31
	Enclosure Cost	TBD	£ 11.97
Total			**£ 100.00**

Figure 4: Cost Breakdown

Ethics/EIA/DMP

An ethical review, an Equality Impact Assessment (EIA), and a Data Management Plan are included as appendices. They do not raise any concerns.

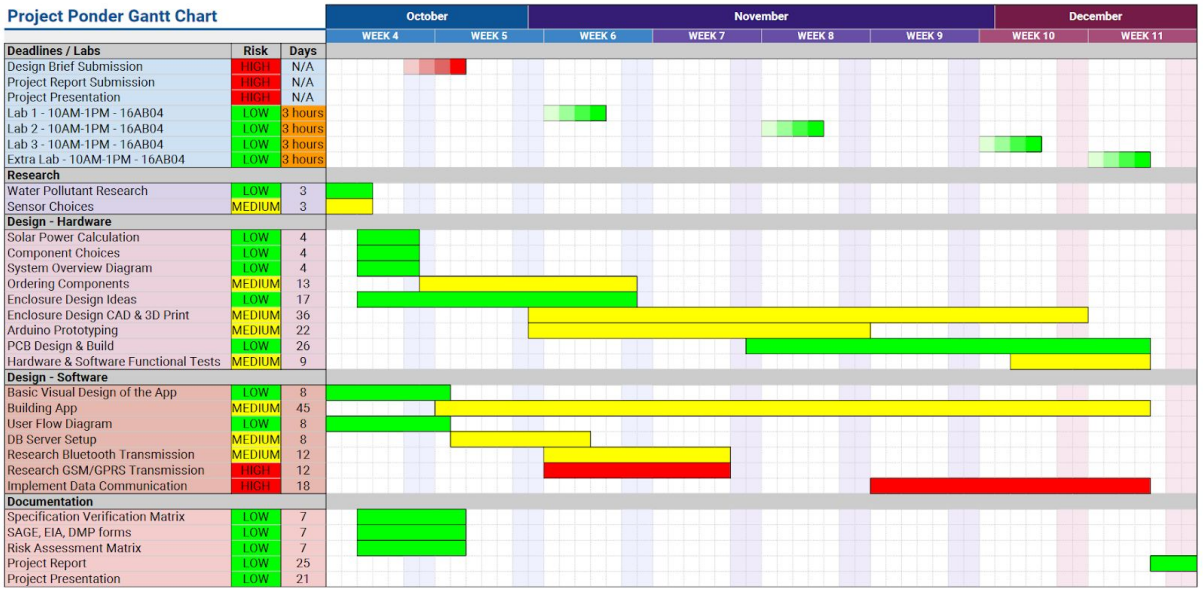

Figure 3: Gantt Chart

Appendix 1: Ethical Considerations

SAGE-HDR

Response ID	Completion date
640816-640807-66800695	26 Oct 2020, 11:46 (GMT)

1	**Applicant Name**	Kieran Harrison
1.a	**University of Surrey email address**	kh00646@surrey.ac.uk
1.b	**Level of research**	Undergraduate
1.b.i	**Please enter your University of Surrey supervisor's name. If you have more than one supervisor, enter the details of the individual who will check this submission.**	David Carey
1.b.ii	**Please enter your supervisor's University of Surrey email address. If you have more than one supervisor, enter the details of the supervisor who will check this submission.**	david.carey@surrey.ac.uk
1.c	**School or Department**	Electrical and Electronic Engineering
1.d	**Faculty**	FEPS - Faculty of Engineering and Physical Sciences Sciences

2	**Project title**	PONDER

3	**Please enter a brief summary of your project and its methodology in 250 words. Please include information such as your research method/s, sample, where your research will be conducted and an overview of the aims and objectives of your research.**	A river pollution / water quality sensor that would tackle the Clean Growth grand challenge. The objective of this device, is to allow monitoring of water quality in remote areas with a low-cost and user friendly device. It will be a small bouy like device, which will float on the waters surface and use multiple sensors to measure and record different aspects of water quality (e.g. turbidity, temperature, pH, etc.). This data can then be transmitted to an external device, to be displayed on an app. The device will be developed using a Arduino microcontroller to interface the sensors with the communications (bluetooth / mobile) module within the device, that will allow it to communicate the recorded data to an external device. The device will be powered using a lithium ion battery, with connected solar polars on the top side of the device, which will allow it to operate isolated from a mains power supply for an extended period of time. We will be testing this device within electronics labs, and in local rivers and streams, to ensure accurate operation of the device.

4	**Are you making an amendment to a project with a current University of Surrey favourable ethical opinion in place?**	NO

5	**Does your research involve any animals, animal data or animal derived tissue, including cell lines?**	NO

7	**Does your project involve any of the following: human participants (including human data and/or any human tissue*); engineering and/or the physical sciences?**	NO

23	**Declarations**	• I confirm that I have read the University's Code on Good Research Practice and ethics policy and all relevant professional and regulatory guidelines applicable to my research and that I will conduct my research in accordance with these. • I confirm that I have provided accurate and complete information regarding my research project • I understand that a false declaration or providing misleading information will be considered potential research misconduct resulting in a formal investigation and subsequent disciplinary proceedings liable for reporting to external bodies • I understand that if my answers to this form have indicated that I must submit an ethics and governance application, that I will NOT commence my research until a Favourable Ethical Opinion is

		issued and governance checks are cleared. If I do so, this will be considered research misconduct and result in a formal investigation and subsequent disciplinary proceedings liable for reporting to external bodies. • I understand that if I have selected any options on the higher, medium or lower risk criteria then I MUST submit an ethics and governance application (EGA) for review before conducting any research. If I have NOT selected any of the higher, medium or lower risk criteria, I understand I can proceed with my research without review and acknowledge that my SAGE answers and research project will be subject to audit and inspection by the RIGO team at a later date to check compliance

24	**If I am conducting research as a student:**	• I confirm that I have discussed my responses to the questions on this form with my supervisor to ensure they are correct. • I confirm that if I am handling any information that can identify people, such as names, email addresses or audio/video recordings and images, I will adhere to the security requirements set out in the relevant Data protection Policy

Appendix 2: Equality Impact Assessment (EIA)

EEE3035 Engineering Professional Studies

Semester 1 2020/21 - Year 3 Group Project

Equality Impact Assessment

Please read the guidelines associated with the completion of EIA before you complete this form. You may find the example EIAs on SurreyLearn useful.

Question	Response
1. Name of the project being assessed; include the group letter	PONDER (Group J)
2. Summary of aims and objectives of the project	To provide an affordable, unmanned and versatile system for the quantification of a body of water's quality. This will take the form of buoys with sensors to measure water temperature, TDS, turbidity, and pH. Data will be viewable using an accompanying mobile application.
3. What involvement and consultation has been done in relation to this project? (e.g. with relevant groups and stakeholders)	None
4. Who is affected by the project?	The end user of the PONDER device.
5. What are the arrangements for monitoring and reviewing the actual impact of the project?	No need for monitoring or review, as no known impacts against any protected characteristic group has been identified.

Protected Characteristic Group	Is there a potential for positive or negative impact?	Please explain and give examples of any evidence/data used	Action to address negative impact (e.g. adjustment to the project)
Disability	No known impacts		
Gender reassignment	No known impacts		
Marriage or civil partnership	No known impacts		
Pregnancy and maternity	No known impacts		
Race	No known impacts		
Religion or belief	No known impacts		
Sexual orientation	No known impacts		
Sex (gender)	No known impacts		
Age	No known impacts		

Evaluation: On the basis of your responses above, please complete the table below with one member of the group signing off the form.

Question	**Explanation / justification**	
Is it possible the proposed project could discriminate or unfairly disadvantage people?	We have not identified any means by which the project could discriminate or unfairly disadvantage people. The PONDER device and accompanying mobile application can be used equally by anyone, regardless of protected characteristics.	
Final Decision	**Tick the relevant box**	**Include any explanation / justification required**
1. No barriers identified, therefore project will proceed.	Tick	No known barriers or impacts were identified. The project can proceed without any changes.
2. You can decide to stop the project because the data shows bias towards one or more groups.		
3. You can adapt or change the project in a way which you think will eliminate the bias.		
4. Barriers and impact identified, however having considered all the available options carefully, there appears to be no other proportionate ways to achieve the aim of the project. Therefore, proceed with caution with the activity knowing the it may favour some people less than others, providing justification for this decision.		

Confirm that this EIA will be included in the project report.	Yes
Date Completed	26 October 2020
Review date (before the final project report)	

Appendix 3: Data Management Plan (DMP)

DMP Title:

Project Name: PONDER
Description: This research project aims to analyse the concentration of pollutants in a given water body.
Institution: University of Surrey
Group Name & Letter: J

What data will you collect or create?
We will collect the concentration values for each specific chemical identified by our device.
We will also collect the date and time that each reading was obtained.
The received data will be presented in chronological order on our database with the date and time that these results were measured.
The size of the data collected will most likely be in the range of X KB – Y MB.
Location of the device.

How will the data be collected or created?
The concentration values will be collected by our water quality sensors on our device and displayed on the database system provided in our mobile application.
The date and time will be collected using a real time clock.
This data will be transferred over from the project device to the mobile application via bluetooth or mobile network data.
The GPS data can be collected by making a GET request to one of Google's location APIs.

Documentation and Metadata
What documentation and metadata will accompany the data?

1. Readings within our mobile application that has the UK water quality standards to compare our collected data to.
2. A HELP section of our mobile application detailing how to connect to our project device and transfer information.

Databases will be named according to a pre-agreed convention.
Should the mobile application run into any errors, a README text file would be present to advise you on how to retrieve the data locally stored on our project device.

Ethics and Legal Compliance
How will you manage any ethical issues?
There are no ethical issues in the generation of our results from our device. No personal information or other information apart from the analysis of pollutant concentration within a water body will be collected.

How will you manage copyright and Intellectual Property Rights (IPR) issues?
We do not intend to patent any hardware or software materials we produce during this project. We do not intend to use any product we produce for any monetary gain.

Storage and Backup
How will the data be stored and backed up during the research?

The data collected will be stored locally on an SD card within the device. Transferred data from the project device to a mobile device will be stored within the database on AWS that connects to the mobile application.

How will you manage access and security?
Our mobile application will only ask for permission to access bluetooth, mobile data and the internal storage of a mobile device. All data transmissions from the device to the phone will be secure.

Selection and Preservation
Which data are of long-term value and should be retained, shared, and/or preserved?
Any data obtained during this research may be considered to be of long-term use should another related study require our findings to be helpful.

State the format of the final dataset
Images will be stored as .png
Measured data will be stored in a database system (SQL)
Data in text files will be stored as .txt

Data Sharing
How will you share the data?
The data from the app can be shared to other users as a plaintext via email or any other communication apps i.e. SMS.
Long term, the data can be fetched from the DB using our APIs.

Are any restrictions on data sharing required?
No restrictions are applicable.

Responsibilities and Resources
Who will be responsible for data management?
The software team on this project will be responsible initially, if the device is by any parties interested, they will be responsible for maintaining the DB server, data maintenance etc.

What resources will you require to deliver your plan?
Credit for AWS to host a database server will be required which can be given free of charge to students. SD card for local storage on the device.