E1.05 – Heat Island Mapping

Product Specification

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Revision History			
Version	**Date**	**Description**	**Author**
0.1	10/19/20	Section authors assigned	Jose Silva
0.3	10/31/20	Majority of sections filled out	Jose Silva
0.5	11/02/20	Revision of some sections including 2.8	Jose Silva
0.7	11/08/20	Revision after D2's review of spec	Jose Silva
1.0	11/23/20	Revision after IDR, changes to sections 2.4 and 2.7	Jose Silva

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1 Introduction

The Introduction section was written by Jose Silva

Our product is a device used to measure the heat island effect of cities by recording the temperature and humidity of an area. The device will store the data collected locally and send a backup to a cloud storage. The data stored on the cloud storage will then be used to show the recorded temperatures on a map overlay through a web application. The product's intent is to demonstrate capabilities to our sponsor and employers; in addition, it gives the team members experience in cloud management and system integration. To build the device, parts will be bought off-the-shelf and implemented with each other, including sensors, a display, and a microprocessor. Figure 1 shows a high-level overview of the system with a block diagram.

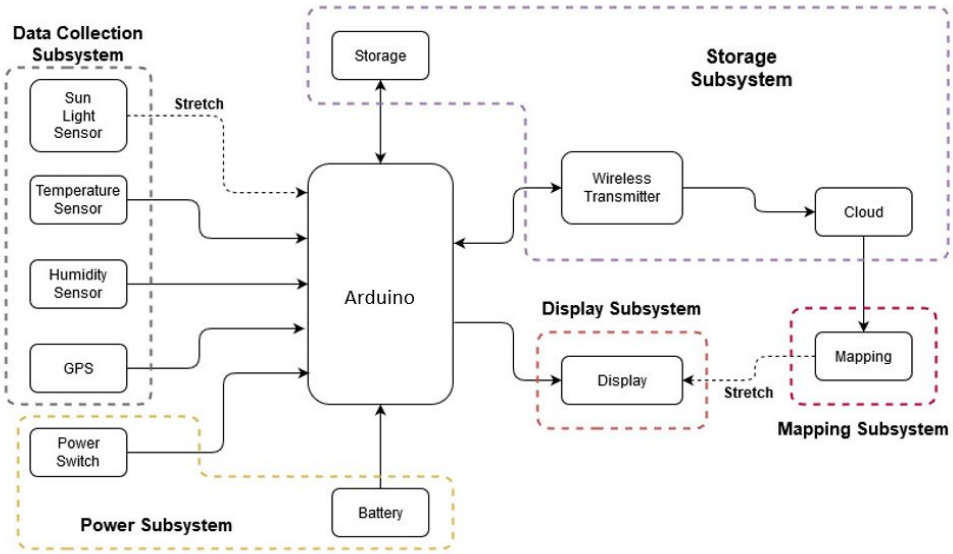


Figure 1: High Level Block Diagram

1.1 Sponsor Requirements

This Section is written by Cameron Muir

The functional requirements given by the sponsor are the following:

- Data Collection Requirements

    - Sample Frequency of 1 minute.
    - Record ambient temperature from -23 to 120 degrees Fahrenheit. Precision to the nearest tenth of a degree.
    - Records humidity
    - Records location with a tolerance of +/- 1 meter.
    - Records a timestamp (time and date) to the nearest second.
    - Data can be exported in a .csv/.txt. format.
    - Can store one month of data locally with 4 hours of daily collection.
    - Data can be exported to a cloud service in less than 5 minutes. It must take fewer than 3 button presses.
    - Data will be visually shown on a map with location and color-coded markers to represent temperature.
- Device Requirements
    - Must be portable, handheld and weigh no more than 5.1 lbs.
    - Must contain an on-board indicator to represent current readings as well as the battery percentage.
    - A minimum battery life of 4 hours, active recording time.
    - A charging time of 4 hours or less for a rechargeable battery or a replaceable battery that can be charged within 24 hours.
    - Must be rain and water resistant
    - Must be able to withstand a 3 foot drop without loss in functionality.
    - Must cost less than $100 to make

1.2 Existing System

The Introduction section was written by Gabriel Montero

This device is meant to be replacing heat mapping satellite technology from companies like NASA. Temperature measured from satellites in orbit tends to be inaccurate across urban environments because of obstacles such as buildings and terrain. Our product is a handheld device that is meant to fix this issue. The handheld device allows the user to measure temperature in areas that the satellite cannot, or at least accurately measure. This device also has the ability to map out the path that was used to take the reading. This allows for a more accurate reading of an urban environment, but will also allow for an interactive map that the user can use to map the path taken. The biggest constraint about our product is that the device only records data in a localized area. Whereas a NASA satellite is capable of recording data from a much greater distance. Our device, if used in conjunction with the NASA satellite, would provide a much greater detail to the data collected.

1.3 Terminology

This section was written by Andrew Flores

Term	*Description*
I2C	*Inter-IC*
LCD	*Liquid Crystal Display*
Li-Po	*Lithium Polymer*
H.I.M	*Heat Island Mapping*

MCU	*Microcontroller Unit*
AWS	*Amazon Web Service*
GPS	*Global Positioning System*

2 Functional Description

2.1 User Attributes and Use Cases

The User Attributes and Use Cases section was written by Jose Silva

The product is designed to be used by any researcher or environmentalist. No special skills are needed for operation.

Step 1: The user pushes the “ON/OFF” button to power on the device. The LCD screen turns on and begins to record data.

Step 2: The user will walk around with the device in hand, while it automatically records data and stores into the local storage.

- The data recorded will be stored on the cloud service automatically when connected to WIFI.

Step 3: The user finishes data collecting and turns off the device by pressing and holding the “ON/OFF” button.

Step 4: The user uses the Mapbox URL to view a visual map of the data record.

- User can zoom and scroll through the web application.
- Recorded data will be represented as a circle with a color gradient indicating the temperature recorded at point.
- A Legend will be included for understanding the color gradient.

Step 5: The user will access the URL provided to view the cloud storage and the data collected.

2.2 Administration Functions

The Introduction section was written by Gabriel Montero

The data this device collects will be accessible for everyone. Because the data collected is not sensitive or unique, there is no need for an encryption on the data. The user would be able to push a button for the device to record a reading or wait for the device to take a reading from an internal clock. The device would transmit data to a cloud. In the cloud, the user would have access to read the data but not have permission to edit or rename any files

2.3 Error Handling

This section is written by Cameron Muir

A list of potential errors and how they will be handled are provided below:

- Low Battery Level - When the battery reaches a capacity of 20% or lower the battery indicator on the screen will change from a color green to red. As well as a warning message will be displayed for a few seconds letting the user know to find a power source soon.
- Unable to connect to Wifi - This error occurs when the arduino's on board wifi module cannot make connection to a wifi router when requested by the user. A message will be displayed on screen letting the user know that a connection could not be established and to please try again in a few minutes.
- SD Card Storage Full - This error occurs when a reading is made and it cannot be stored onto the SD card as it has no more room. An error message will come up on screen asking the user to place in a new SD card or backup the data to another device and clear the sd card.
- SD Card Not Found - This error occurs if the SD card is not seated properly into the card reader or there isn't a card present. A warning message will be displayed letting the user know to open the device and insert an SD card into the slot properly.
- Sensor Read Error - This error will occur if the value of any of the sensors on the device are above or below the limits given in the datasheet. This error will display a message saying to restart the device and try again.

2.4 Safety and Security

The Safety and Security was written by Jose Silva

The device only records nonsensitive information, thus no encryption or security is needed. The only information being stored is the ambient temperature of the surrounding area and will not need any protection to access interfaces and storage.

The device and its battery should only be used in environments outlined, avoiding things such as:

- throwing the device in fire, or heat
- short-circuit the battery terminals
- disassembling the battery
- immersing the device in water or seawater

2.5 Help and User Documentation

The Help and User Documentation was written by Andrew Flores

This device will be used to record climate related data. Although the device will be able to record the data on its own, the user will need to manually use a touchscreen interface display to perform basic functions such as powering the device on and off. Due to the interface application there there will be a short manual provided with the device to provide instruction on how to power on and off the device. Moreover, the manual will include a description of what is being displayed on the display panel. The

manual will also include directions on the desired traveling speed in order for the device to record data properly for the most accurate data collection.

2.6 Interfaces

2.6.1 User

The User Interface section was written by Jose Silva

The user will power on the device by pressing on the power button and can verify it's status once the display turns on. The device will also send a notification when it has reached low battery or when the device is charging.

The device will display when data is being recorded and when it is being uploaded to the cloud storage via symbols to notify the user.

2.6.2 Software

The Software section was written by Cameron Muir
We will be using quite a few software interfaces and programs to make our project function, these include:

- Arduino IDE
    - This will be used to program the microprocessor board and tell the board "what to do." We will be using the most current released version at the time this document is written.
- AWS Cloud Service
    - The AWS cloud service will be used to store data that has been collected at any given point. This will serve as not only storage of data, but also a middle man between the device and the mapping service.
- Mapbox Mapping Service[2]
    - This service will be used to take that raw data from the cloud service and generate an interactive map that is able to be used on the web or a mobile device. This is done using javascript and a number of custom Mapbox created APIs.

2.6.3 Hardware

The Introduction section was written by Gabriel Montero

Display:

- TFT LCD with Touchscreen Breakout Board with MicroSD Socket - ILI9341 [1]
    - This 2.8in display will be used to display the recorded data for the user to see.
    - This display also features a resistive touchscreen for the user to interact with.

Microprocessor:

- Arduino MKR Wifi 1010
    - This board will read data from the sensors, store them in a microSD card on board using a microSD card module.

Sensors:
- AM2302 (wired DHT22) temperature-humidity sensor
    - This sensor is both a temperature sensor as well as a humidity sensor.
    - The data recorded from this will be sent to the arduino to be stored in the microSD card and transmitted to the cloud service.
- NEO-6M GPS
    - This GPS module will be used simultaneously with the temperature and humidity sensor to record where the reading occurred.

Storage:
- Micro SD TF Card Memory Shield Module
    - This module will be used to allow onboard storage for the arduino.

Power:
- Lithium Ion Polymer Battery - 2500mAh
    - This battery will power the device for at least four hours recording time.

2.6.4 Mechanical

The Mechanical Interface section was written by Andrew Flores

The only mechanical function of this device is the powering on and off of the device which will be performed by the user. Once the device is turned on, it will record data automatically and the data will then be processed using software.

2.7 Boundary Conditions and Constraints

The Introduction section was written by Gabriel Montero

Component	**Constraint**	**Bound**
Cost	Budget	$100
Chassis	Design	5” x 5” x 5”
Weight	Design	3 lb
Battery	Duration 3.7V Nominal Voltage 2500mAh Current	4 hours a day 3.3V Voltage 2500mAh Current
Sensor	-40 to 172℉ Temperature range 0 to 100.0% Humidity 3.3V to 5V Voltage 2.5mA Current draw	40 to 120 ℉ Temperature range 0 to 100.0% Humidity 3.3V Voltage 2.5mA Current draw

Arduino	-40 to 185℉ Operating Temperature 3.3V to 5V Voltage 7mA Current per I/O pin 1/2/3 Mbps Data Transfer Speed	40 to 120℉ Operating Temperature 3.3V Voltage 7mA Current per I/O pin 1/2/3 Mbps Data Transfer Speed
LCD Display	Resolution 3.3V to 5V Voltage 150mA Current draw	240 x 320 pixels 3.3V Voltage 150mA Current draw
MicroSD	Capacity	8 GB
Completion	Working Product	D2 Senior Design Day

2.8 Performance

The performance table is owned by Andrew Flores

Hardware Performance Parameters					
Parameter	***Test Conditions***	***Min***	***Max***	***Units***	***How Tested***
Battery Life	100% Capacity	4	N/A	Hours	Constant run time for the device without a charge
Input Power Supply Voltage	Vin=5V	3.7	5	Volts	Measure the power supply voltage with DMM

Software Performance Parameters		
Function	***Description***	***How Tested***
Data Collection	When the device is turned on, the sensor and GPS will begin to run and collect respected data. This data will be stored on board first, and then transmitted to a cloud storage for use of the map overlay.	Record data using the Arduino board and export data to test that data is being collected and ready to send to the map overlay.
Map Platforms	*The map will be able to be viewed on the following platforms: (a). Web (b). Mobile (includes IOS and Android).*	*When publishing the map, one will use the link given and test it on multiple web browsers and platforms to ensure compatibility*
Map Refresh Rate	*The map will be refreshed with any new data every hour*	*To test this one would create a test .csv file and upload it. Then check if it updates the map every hour. making changes between each hour to see any new data changes.*

2.9 Software Platforms

The Software Platforms section was written by Jose Silva

The operating system for the Arduino MKR WIFI 1010 will be using Arduino IoT Cloud.

The TFT LCD display will be using Adafruit GFX library for Arduino.

The mapping software Mapbox[2] will be used to create the calculations of the data. The software is based in Javascript.

The cloud storage software is using Amazon Web Service which will provide a URL compatible with web browsers including: Chrome, Safari, Bing, and Firefox.

2.10 Service, Support, & Maintenance

This section was written by Cameron Muir

This device will come with a few built in service/support features to help the user with any errors they might encounter during use.

- The device will have a built in display. This display will normally act as an interface to view the current/most recent reading the device has taken. However, it will also be used to display any error messages or warnings to the user such as a low battery indicator, unable to connect to wifi, storage is full, etc.
- The device needs to be water resistant. This means the device will have a couple of measures to make sure it can be used in a light drizzle. Even with these measures the device should come apart with relative ease. This allows the user to easily access and replace the battery or make any change of modifications that they see fit.

2.11 Expandability or Customization

The Introduction section was written by Gabriel Montero

The device limited customization and expandability for the user. The customization the device would offer would be changing the color of the chassis. The capacity of the microSD card could be expanded to provide greater onboard storage. For the cloud storage, there would be no customization but the user could expand the storage capacity because the device uses a third-party cloud storage solution.

Expand mapping by allowing the cloud to accept data from multiple

3 Project Alignment Matrix

The Project Alignment Matrix was written by Andrew Flores

TABLE 1: Knowledge Alignment Matrix

Course No.	Core knowledge	Specific knowledge incorporated by team
EE 3350 (Electronics I)	Design and analysis of active devices and equivalent circuits	Understand the electronic elements on the device and how to manage the power supply based on the elements used in the design.
EE 3370 (Signals and Systems)	Frequency domain representation of signals and frequency response, transfer functions	There is no external communication for the device. Data relay is wired/I2C.
EE 3420 (Microprocessors)	Principles of operation and applications of microprocessors	Using an Arduino board for communication between devices and software. We will control the functions of the device using the board.
EE 4352 (Introduction to VLSI Design)	Analysis and design of CMOS integrated circuits	We will not be designing an integrated circuit at the CMOS level.
EE 4370 (Communications Systems)	Transmission of signals through linear systems, analog, and digital modulation, and noise	The board will be communicating with the other electronic devices through a linear system.

TABLE 2: Constraint Alignment Matrix (and applicable standards)

ABET Criterion 3 (c): "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability."

Constraint Type	Specific Project Constraint
Economic	Given a spending budget of $100
Environmental	Performance is heavily based on environmental conditions. Device must withstand non-ideal conditions.
Health and safety	Device cannot overheat.
Social/Ethical	Must be able to demonstrate the ethics and skills of Engineering.
Applicable Standards	The device needs to run for the desired amount of time and collect data over the 1 month period established in the requirements.

4 References

[1] TFT LCD Display with Touchscreen Breakout Board with MicroSD Socket Datasheet https://cdn-shop.adafruit.com/datasheets/MI0283QT-11+V1.1.PDF

[2] Mapbox Documentation. https://docs.mapbox.com/

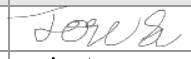
[3] AM2302 Humidity and Temperature Sensor Datasheet https://cdn-shop.adafruit.com/datasheets/Digital+humidity+and+temperature+sensor+AM2302.pdf

[4] LIPO785060 2500mAh 3.7V Li-Polymer Battery Datasheet https://cdn-shop.adafruit.com/product-files/328/LP785060+2500mAh+3.7V+20190510.pdf

[5] NEO-6 GPS Datasheet https://www.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_%28GPS.G6-HW-09005%29.pdf

5 Approvals

The signatures of the people below indicate an understanding in the purpose and content of this document by those signing it. By signing this document, you indicate that you approve of the proposed project outlined in this Functional Specification and that the next steps may be taken to proceed with the project.

Approver Name	Title	Signature	Date
Jose Silva	Project Manager		11/23/20
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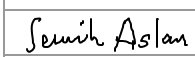
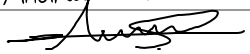
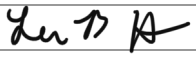
	Faculty Advisor		11/24/20
	Sponsor		12/1/20
	Instructor		

Author	Word Count
Jose Silva	463
Cameron Muir	759
Andrew Flores	648
Gabriel Montero-Sierra	458