Concept of Operations

(CONOPS v1.0)

For

"Hack That Flood" Capstone Device

University of Rhode Island

Department of Computer, Electrical and Biomedical Engineering

Submitted by: Habib Lawal, Andrew Osmanski, Jordan Peralta, and Rafi Simon

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1. Introduction

1.1. Project Description

The “Hack That Flood” team was given two tasks to complete. The first goal of the team is to develop a user-friendly smartphone android application that will be able to accurately predict possible flooding in high risk areas using live data that is collected. This will take data from stormwater runoff using integrating real time weather, and a Geodatabase. The application will display the results into a map interface. This will allow the user to see if the directions intersect with any possibly flooded areas. The second portion of the project is to develop a remote floating sensor platform that collects water depth, wave, and GPS coordinates data. This data will then be transferred through a cellular network to the smartphone application. The end result is the user being able to obtain the information, help them to avoid flooded roads, and obtain knowledge about the current conditions of the area the floatation device is located.

1.1.1. Background

The motivation for this project stemmed from a newspaper article from August of 2014. The article addressed the consistency of the flooded streets of Rhode Island. There was no way of seeing which roads were unsafe to travel on, making a commuter’s normal route treacherous to travel. The newly developed application would allow a user to see where flooding is most probable. With this data it could easily provide a safer route, avoiding the roads that may see flooding.

The “Hack That Flood” device’s motivation stemmed from this original idea. Mr. Rick Davids wanted to be able to explore the conditions of the bay area during these flood causing storms. The device would collect data from the bay and send it to the application. Rainstorms cause runoff, and contamination to the bay and the flotation device would be able to measure these types of contaminants. A final product would be able to measure the ocean’s swell, depth, and GPS coordinates. The Product can be use in different scenarios such as measuring rain flood depth in any street.

1.1.2. Assumptions & Constraints

Due to the nature of the project, there was a limited budget when it came to time and money. It prevented multiple servers working in parallel, and a map engine on each server to reduce the server overload on one server and prevent single point of failure. With the budget provided the hardware team was frugal when purchasing equipment. It caused for not only double checks, but triple as well to ensure a properly functioning product.

The time constraint put pressure on the team to drop certain proposals. A contaminant sensor was in the works of being developed, but the remainder of the project forced it to be put on the back burner. The initial assumption about the amount and complexity of coding was very slim compared with the amount the team spent to get the hardware calculating GPS coordinates, water depth and the phone application. The timing was not very efficiently estimated due to lack of experience.

Another major constraint was the length of intervals for collecting data. Due to the constant draw of power, the entire device would only be powered for 5-7 days. This cause for several devices to maintain longer intervals so as to maximize the time the device could stay in the water.

Data Sources:

- DOT flood data
    - Digitized data: A layer added as a filters to the base map
- FloodPlain Data: FEMA
    - Flood Hazard Zones Layer added to the base map
- USGS Stream Gauges
    - Stream Gauges Above Normal layer added to the base map
        - Shows bubbles on the map in water depth above normal areas.
- Sensor Platform Date
    - Data added as a dots on the base map
- National weather service
    - Data used as a weighted input for flood probability estimation

1.2. Document Overview

1.2.1. Overview

This Concept of Operations (CONOPS) establishes the high level functional architecture, organization, roles, responsibilities, processes, metrics, and strategic plan for the "Hack That Flood" device. The CONOPS will define and describe the device including its hardware and software elements.

1.2.2. Scope

This CONOPS is acknowledged as a living document that documents the concepts and processes by which the "Hack That Flood" device will perform. It describes the desired characteristics of the system from the user's point of view. The sections below identify the proposed "Hack That Flood" device's system, provide a document overview and the approach used to generate the document, and provide a brief overview of the system.

1.3. Glossary & Acronyms

AVL	Automatic Vehicle Location
baud	unit for symbol rate or modulation rate in symbols per second or pulses per second
DC	Direct Current
DSP	Digital Signal Processing
EEPROM	Electrically Erasable Programmable Read-Only Memory
FEMA	Federal Emergency Management Association
GIO	Geographic Information Officer
GIS	Geographic Information System

GND	Ground
GPS	Global Positioning System
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HTTP	Hypertext Transfer Protocol
ICSP	In-Circuit Serial Programming
IP	Internet Protocol
IDE	integrated development environment
LCD	Liquid Crystal Display
LED	light-emitting diode
MSC	Maps Service Center
mm	millimeter
NFIP	National Flood Insurance Program
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOR	Net Operating Result
OS	Operating System
Oscillator	a circuit that produces an alternating output current of a certain frequency determined by the characteristics of the circuit components.
OTP	one time programmable
PVC	polyvinyl chloride
RAM	Random-Access Memory
RIDOT	Rhode Island Department of Transportation
ROM	Read-only memory
RMS	root mean square

RSS	Radio Service Software
SIM	Subscriber Identity Module
SMS	Short Message Service
SONAR	Sound Navigation and Ranging
SPI	Serial Peripheral Interface Bus
SRAM	Static Random-Access Memory
TCP	Transmission Control Protocol
Transducer	a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
USGS	United States Geological Survey

Table 1: Glossary and Acronyms

2. Goals and Objectives for the New System

2.1. Goals and Objectives

2.1.1. Phone Application

The application is design to allow anyone with access to an Android-enabled mobile device to download the app, and use the information display in the map to know areas or streets that are flooded. The app serves as end-point flood warnings communication system.

2.1.2. "Hack That Flood" Device

The "Hack That Flood" device is going to be placed in a body of water. Its goal is to act as a data collector. The device will measure water depth, acceleration, and GPS location The device is designed to act as a resource on the conditions of the local body of water. The information will serve as a resource not only for the conditions, but the possible flooded areas in residential neighborhoods.

2.2. Rationale for the New System

2.2.1. "Hack That Flood" Device

The device that was developed will be implemented in the observations of a water source. These water sources can include bays, rivers, lakes, estuaries, ponds, and even oceans. While in the area the device will be collecting data in regards to depth, wave motion, and GPS location. This information can be used to develop an observational study on the conditions of the water source in regards to flooding in residential areas. The device will be able to transmit the data to a cellular device via an application. The "Hack That Flood" device will serve as a resource to the conditions that are present during flooding. Residential areas can be adversely affected due to heavy rainfall. The apparatus will be able to work with the phone application in order to notify customers of potentially flooded areas.

3. Major Parts & Systems

3.1. Phone Application

Real Time GIS: Real-time GIS analyzes sensor data and other live feeds, and then puts it on interactive maps for real-time decision-making.

ArcGIS Desktop: Professional GIS software for creating maps, conducting spatial analysis and sharing intelligent visualizations for better decision making.
The ArcGIS software is capable of:

- Integrating real-time streaming data into ArcGIS;
- Performing continuous processing and real-time analytics;
- Sending updates and alerts to user at different locations using live data;

Using Real time map, the locations of all the devices in the field will be available. The sensors transmit their locations using GPS and water depth about the current location.

GeoEvent Extension: Serves as a server used to connect any type of streaming data feed and transform GIS applications into frontline decision applications. An analysis is going to be performed using the live data. There will be alerts set up to display red dots on the map, indicating that the sensors are floating. These red dots will be imported to the GeoEvent Extension inputs. The application is going to receive RSS feed, NMEA 0183 which is standard GPS data format. The data will be sent from the sensors using HTTP Protocols, which will write the received data to a shared google doc using google app engine. The GIO event Processor will be reading the data from the same file, do the analysis, and perform actions accordingly. Each data received from the sensors will have time stamps to indicate recent data.

GeoEvent Services: GeoEvent Services allows for the definition and application of the real-time filtering and processing of GeoEvents as they flow from input to output in the GeoEvent Extension. A service designer defines the flow of event data by adding filter and processor elements to the canvas and then connecting these elements to inputs and outputs to create a GeoEvent Service. The final step is to publish the GeoEvent Service; this starts the service and the real-time processing of the event data.

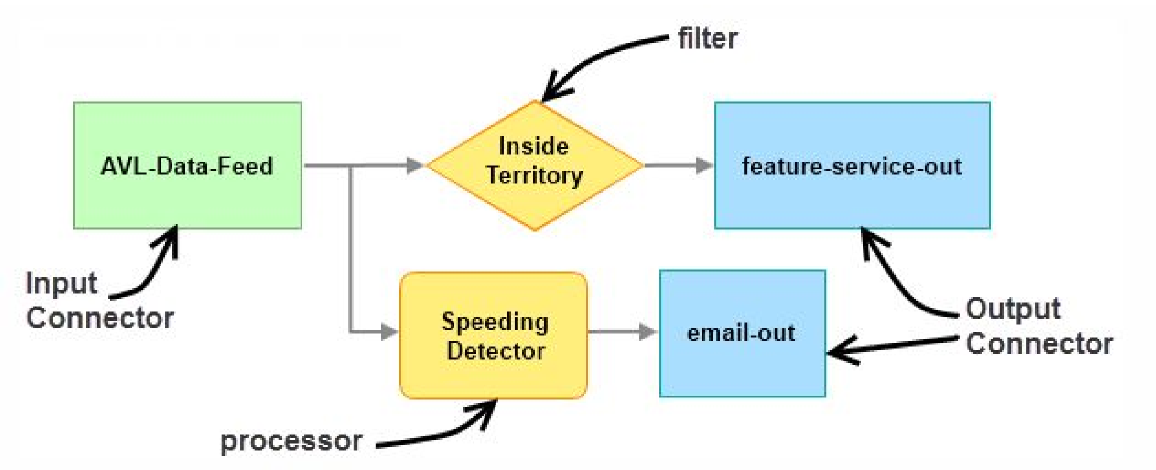


Figure 1: GeoEvent Service diagram

<u>GeoEvent Processing</u>: Processors are components of GeoEvent Service that perform specific actions on the GeoEvents, such as identification or enrichment as GeoEvents are routed from inputs to outputs used to perform continuous analytics on GeoEvents.

<u>Android Studio</u>: This is an integrated development environment that enables Android developers to write, test, and deploy their applications to the Google Play store.

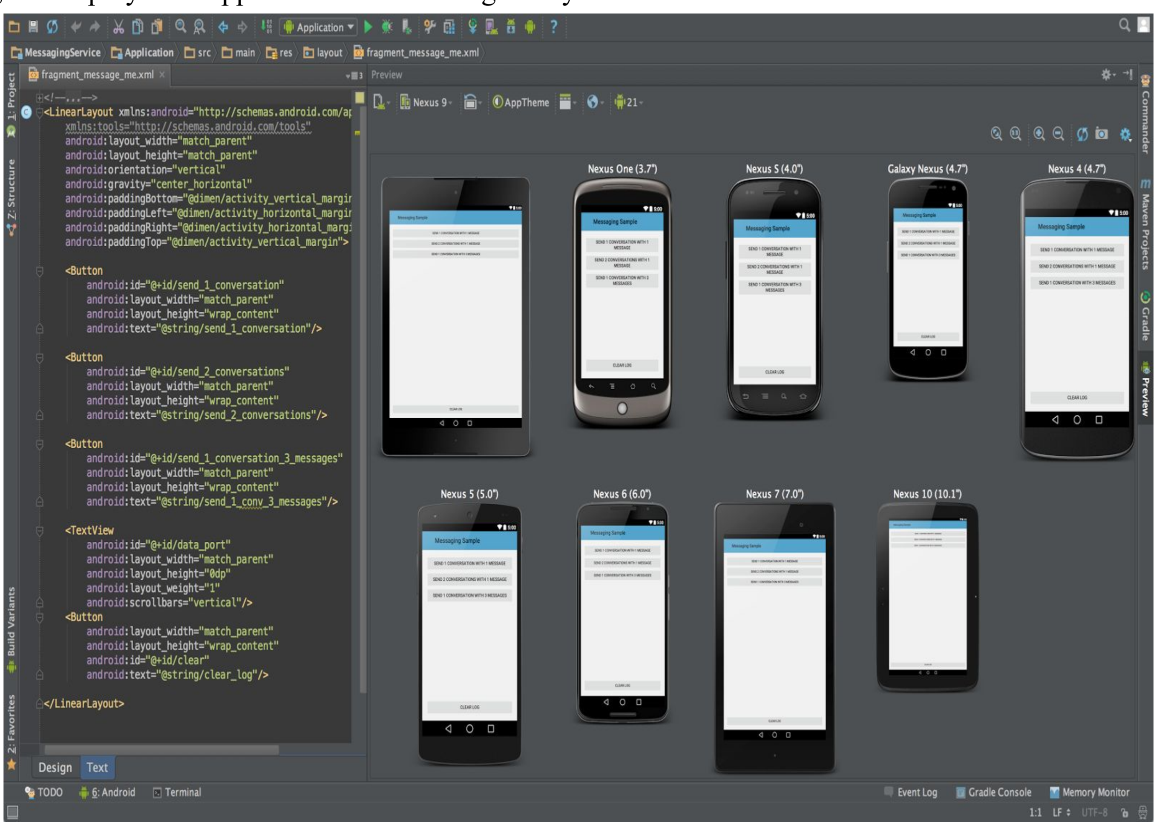


Figure 2: Android Studio Several Phone Testing Display

Emulator: Part of Android Studio, a very powerful tool that enables developers to emulate how apps will perform across different devices and software configurations.

Figure 3: Simple Android Phone

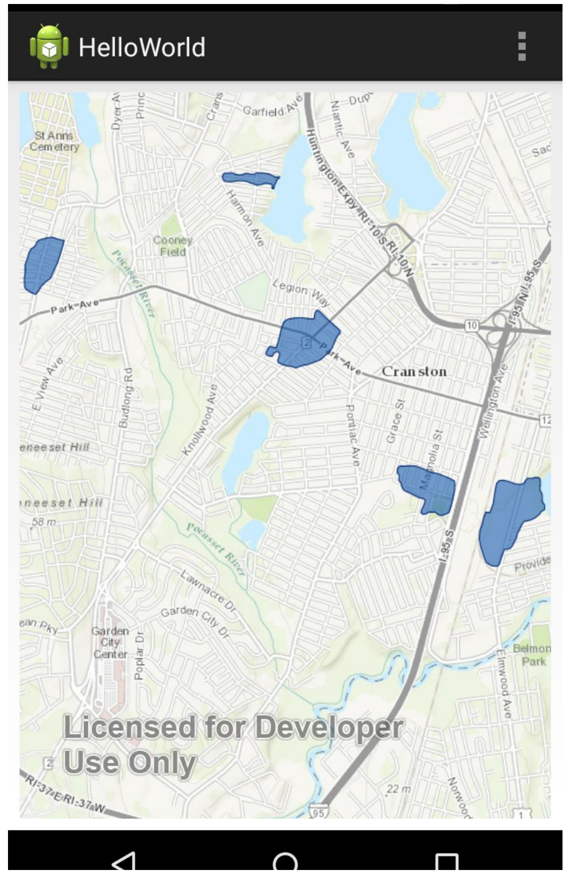


Figure 4: Android Phone Displaying Map

3.2. “Hack That Flood” Device

3.2.1. Arduino Mega 2560

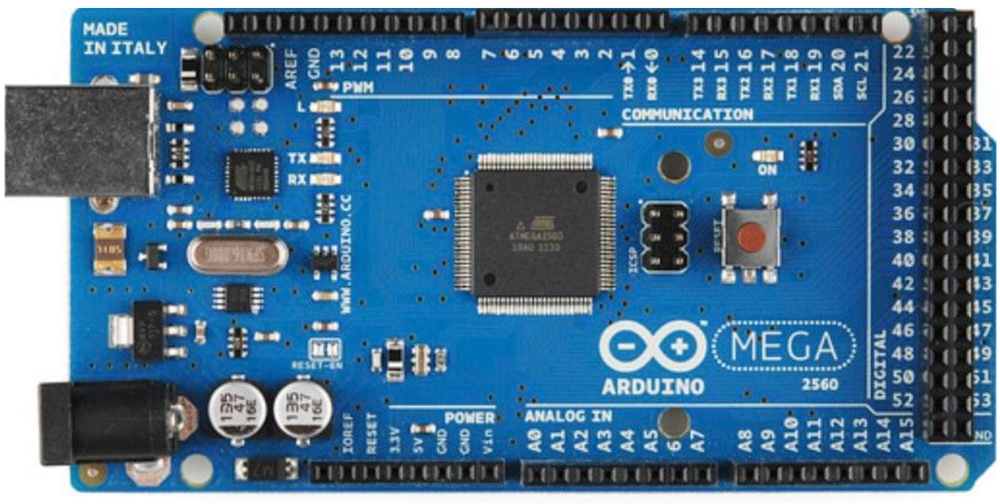


Figure 5: Arduino Mega 2560

The Arduino Mega is a microcontroller device that is used in complex, electronic components. It is based on the ATmega2560, which executes powerful instructions in a single clock cycle. This allows for the device to achieve a balance between consumption of power and processing speed. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is intended for creating and developing interactive projects.

This device has fifty-four digital input/output pins (of which fourteen can be used as pulse width modulation outputs), sixteen analog inputs, four UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The microcontroller in itself contains all elements required to support it. It simply needs to be connect to a power source via a USB cable, or an AC-to-DC adapter or battery.

Arduino Mega Specifications:

- Operating Voltage: 5 volts
- Input Voltage: 7-12 volts
- DC current per I/O: 40 mA
- DC current per 3.3 Volt pin: 50 mA
- 54 pins; power, ground, input, output
- Flash Memory: 256 KB
- SRAM: 8 KB
- EEPROM: 4 KB
- Clock Speed: 16 MHZ
- Size: 101.52 x 53.3 mm

The Arduino company provides the open-source Arduino Software (IDE). The software allows for the user to write and upload code to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and is based on Processing and other open-source software. This software can be used with any Arduino board.

3.2.2. CruzPro "Active" Thru-Hull Transducer ATU120A

A transducer is an electronic device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa. The CruzPro "Active" Thru-Hull Transducer is a device that completes this task with depth. The CruzPro DSP (Digital Signal Processing) active transducer outputs NMEA (National Marine Electronics Association) serial data of depth and water temperature. The current model of the device is the ATU120A. This model does not measure temperature and has a maximum depth measurement of 450 feet. The device is presented with three bare wires extending from a 30-foot cable. The red wire connects to a 12VDC voltage source, the bare wire connects to the shield, or ground, and the green wire is the NMEA output signal.

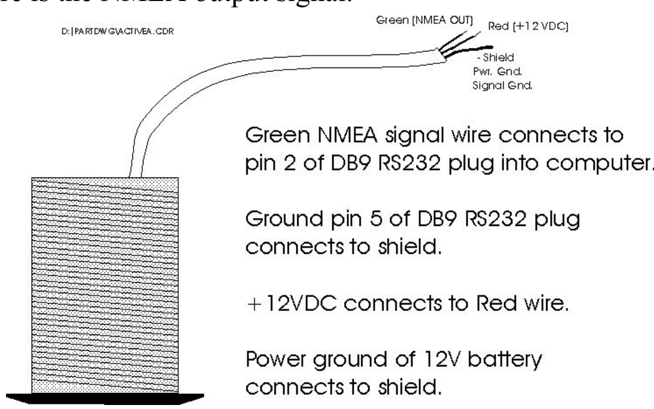


Figure 6: CruzPro 'Active' Thru-Hull Depth Transducer Connection Diagram

Figure 7: CruzPro 'Active' Thru-Hull Depth Transducer

Product Specifications:

- Thru-Hull transducer in plastic
- Max depth of 450 ft
- Operating frequency of 120 kHz
- Connected to a 12 Vdc power supply
- Operating Voltage: 9.5-16.0 VDC
- Output Power - 320 Watts RMS
- Current Drain - 0.035 amps
- Data output - NMEA 0183 serial 4800 BAUD

3.2.3. Adafruit 808 GSM/GPS Shield

The GSM (Global System for Mobile Communication) shield will connect the Arduino Mega to the internet via a cellular system. Along with a SIM card a GSM will connect to the internet via a GPRS network. The GSM shield will be vital in ensuring the communication between the flotation device and the phone application. The GPS (Global Positioning System) will give the current location of the flotation device. These coordinates are going to be sent to the application so the user will be able to see where the measurements that are being collected are coming from. This location will also allow for the administrators of the device. The device that was chosen is the Adafruit FONA 808 Cellular + GPS Shield for Arduino. This one device contains both GPS and GSM devices. It is a great product for the flotation device that is going to be finishing.

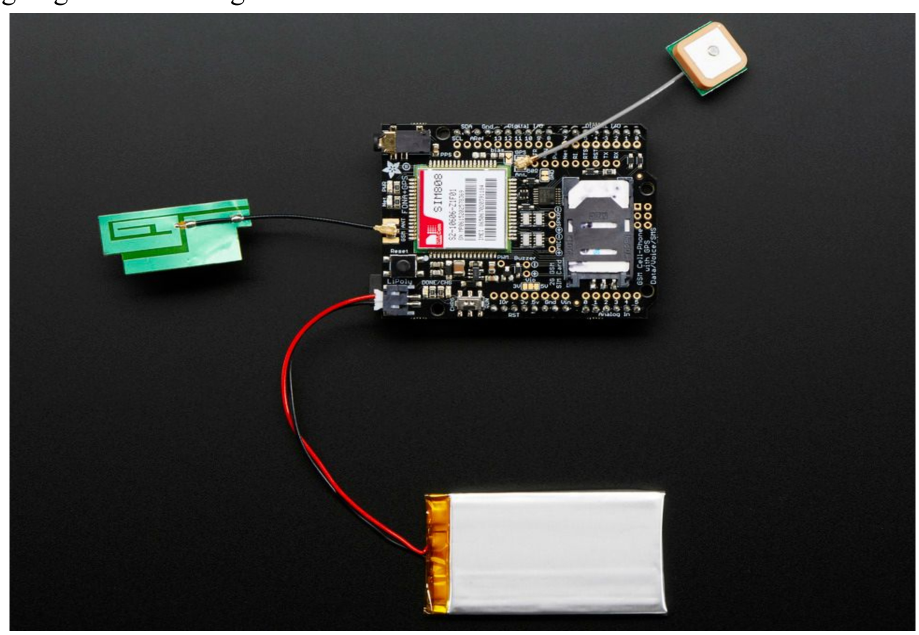


Figure 8: Adafruit FONA 808 Cellular + GPS Shield with 3.7V LiPoly rechargeable battery and Antenna

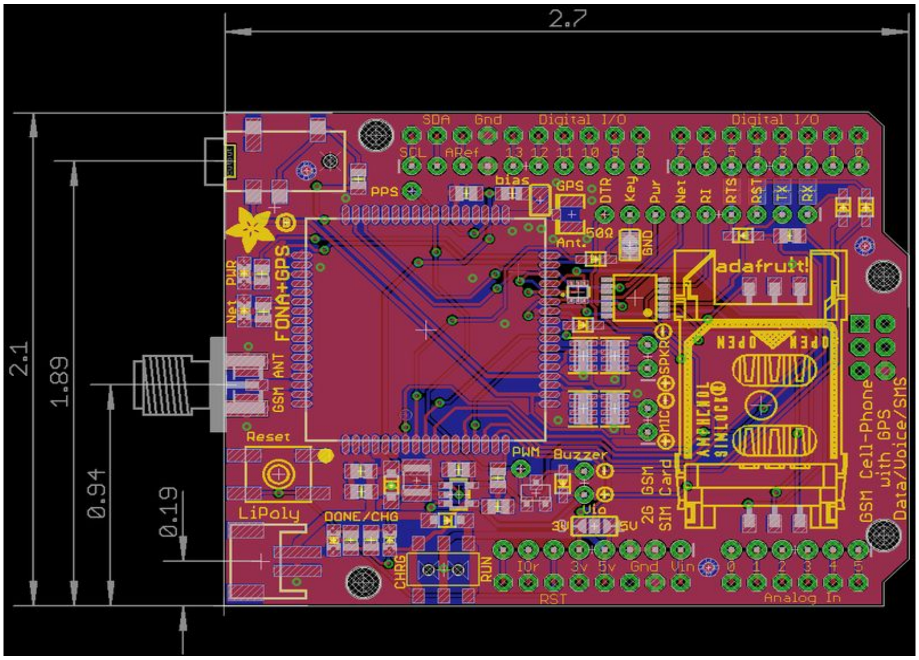


Figure 9: Adafruit FONA 808 Cellular + GPS Shield Schematic

Above is the Adafruit FONA 808 GSM + GPS shield, an all in one cellular phone module with that allows the user to add location-tracking (longitude, latitude and altitude), voice, text, SMS and data to your project, in Arduino shield format for easy use. This shield fits perfectly into the Arduino or compatible. At the heart is a powerful GSM cellular module (using the latest model, SIM808) with integrated GPS. This module can do just about everything

- Quad-band 850/900/1800/1900MHz - connect onto any global GSM network with any 2G SIM;
- Fully-integrated GPS (MT3337 chipset with -165 dBm tracking sensitivity) that can be controlled and query over the same serial port;
- Make and receive voice calls using a headset or an external 32Ω speaker + electret microphone;
- Send and receive SMS messages;
- Send and receive GPRS data (TCP/IP, HTTP, etc.);
- PWM/Buzzer vibration motor control;
- AT command interface with "auto baud" detection;

Adafruit FONA 808 Cellular + GPS Shield to Arduino Mega 2620 Wire Connections	
Adafruit FONA 808 Cellular + GPS Shield	**Arduino Mega 2620**
Vio	5V
GND	GND

Key	Digital 2
TX	10 (9 on Leo/Micro, 3 on Uno)
RST	Digital 4
***Note**: The Adafruit 808 Cellular + GPS Shield will not power on without its own Li-Poly battery*	

Table 2:GPS/GSM Shield Connections

3.2.4. Sparkfun Accelerometer

Accelerometers are used to sense, and measure both static and dynamic acceleration. Because they are affected by the acceleration of gravity, an accelerometer can tell you how it’s oriented with respect to the Earth’s surface. The accelerometer attached to the device being developed will be able to measure the waves of the water where the floatation device is. The one found is the Sparkfun Triple Axis Accelerometer. With the triple axis, the device attached to the Arduino Mega will be able to measure the amplitude of the wave. The Arduino Mega will need to be programmed to power the accelerometer, and collect output information from the device.

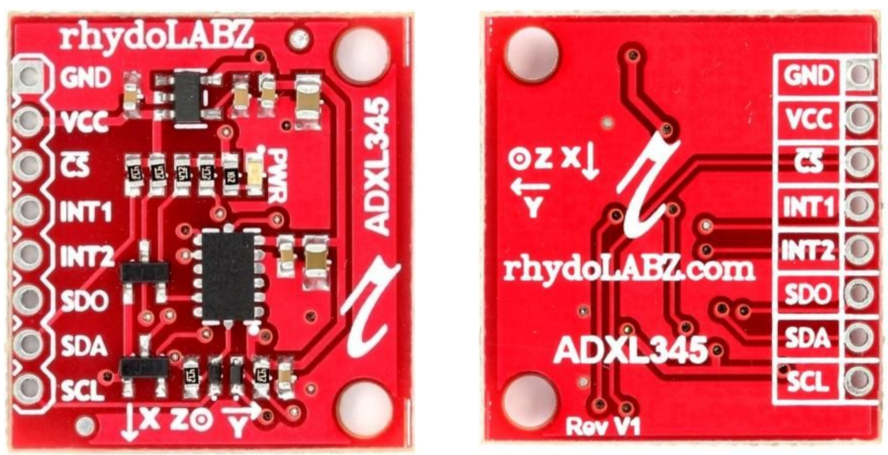


Figure 10: Sparkfun ADXL345 Accelerometer

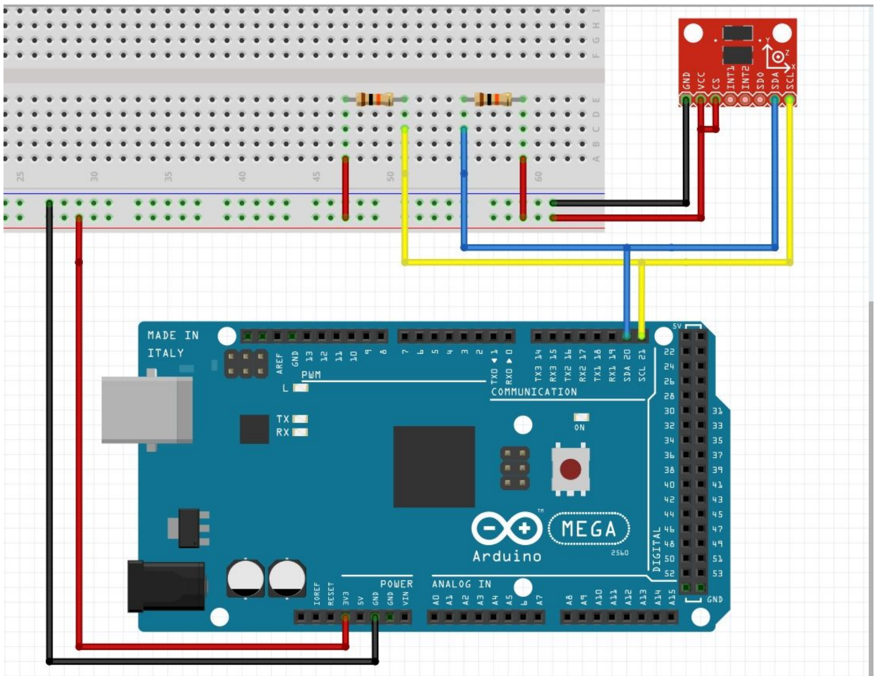


Figure 11: Sparkfun ADXL345 Accelerometer, with 10k resistors and Arduino Mega

The ADXL345 is a small, thin, low power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 g. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface. The ADXL345 is well suited for mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Several special sensing functions are provided. Activity and inactivity sensing detect the presence or lack of motion and if the acceleration on any axis exceeds a user-set level. Tap sensing detects single and double taps. Free-fall sensing detects if the device is falling. These functions can be mapped to one of two interrupt output pins. Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.

3.2.5. 16x2 LCD Screen

Liquid crystal displays (LCDs) are commonly used to display data in devices such as calculators, Arduino and other electronic devices. As shown in the table below, eight of the pins are data lines (pins 7 - 14), two are for power and ground (pins 1 and 16), three are used to control the operation of LCD (pins 4-6), and one is used to adjust the LCD screen brightness (pin 3). The remaining two pins (15 and 16) power the backlight. The details of the LCD terminals are as follows:

Terminal 1	GND
Terminal 2	+5V
Terminal 3	Mid terminal of Potentiometer (for brightness control)
Terminal 4	Resistor Select (RS)

Terminal 5	Read/ Write (RW)
Terminal 6	Enable (EN)
Terminal 7	DBO
Terminal 8	DB1
Terminal 9	DB2
Terminal 10	DB3
Terminal 11	DB4
Terminal 12	DB5
Terminal 13	DB6
Terminal 14	DB7
Terminal 15	+4.2 - 5V
Terminal 16	GND

Table 3: LCD Screen Pin Specifications

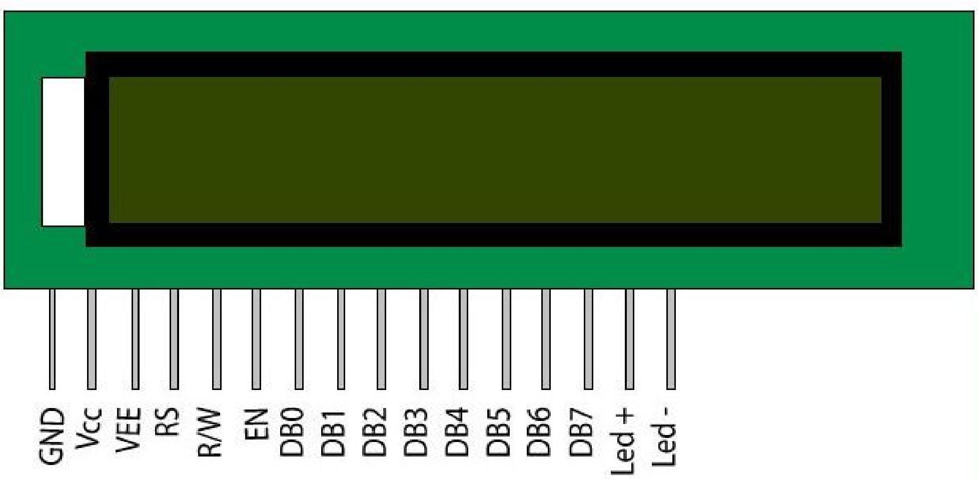


Figure 12: 16x2 LCD Screen

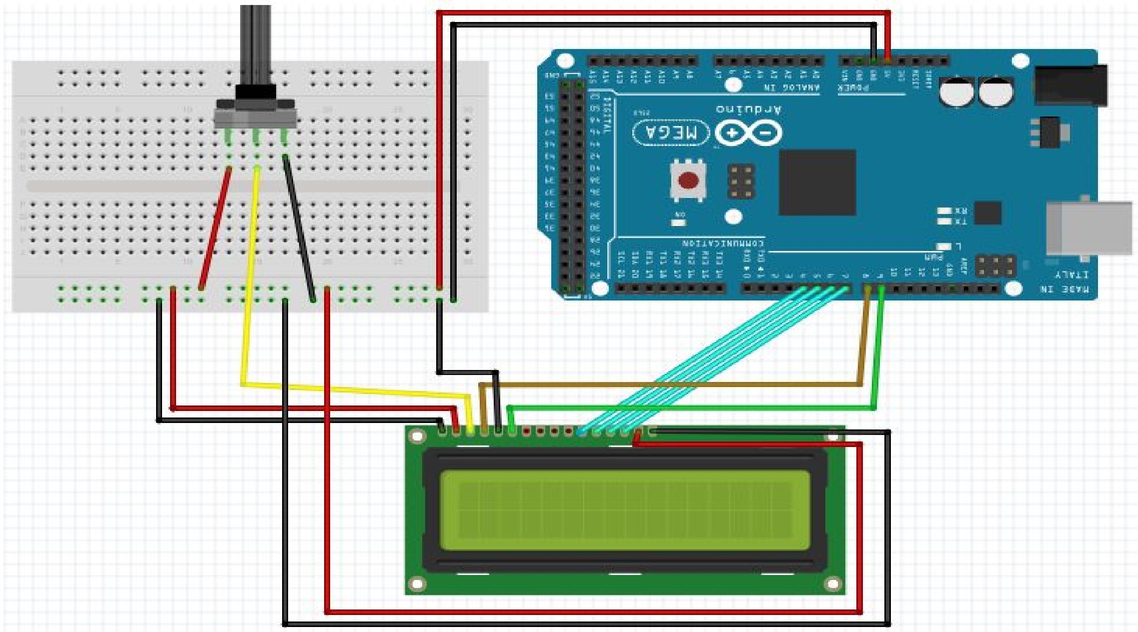


Figure 13: 16x2 LCD Screen Connected to the Arduino Mega and the Potentiometer

3.2.6. “Hack That Flood” Device Housing

The housing of the “Hack That Flood” device is designed and implemented in a way so as to ensure the safety, compactness, and protection of the overall system. Since the product would remain in an aquatic atmosphere for an extended amount of time, the housing would need to be able to withstand long periods of exposure to water, and be completely waterproof. The ideal material is PVC (polyvinyl chloride) piping, which is used in a variety of ways, but known for its uses in plumbing.

In order to place all of the devices and elements within the housing, a large diameter pipe is needed. Currently a PVC pipe with a 6-inch diameter is being used. The pipe is two feet in length, allow for a large amount of space for the devices to sit. This pipe is then covered by two 6-inch PVC pipe caps. The caps fit snugly over the ends of the pipe, and when completely attached form a seal to protect from any water damage.

Since the CruzPro “Active” Thru-Hull Transducer must be submerged in the water, a small hole at the bottom of the housing will be drilled. This will then need to be adjusted and fixed so as to ensure that no water may enter the PVC pipe and saturating the electronic equipment meant to be kept dry.

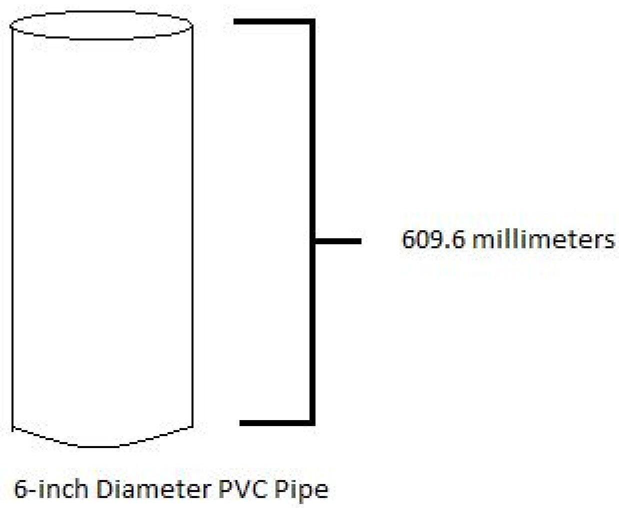


Figure 14: PVC Pipe Side View Diagram

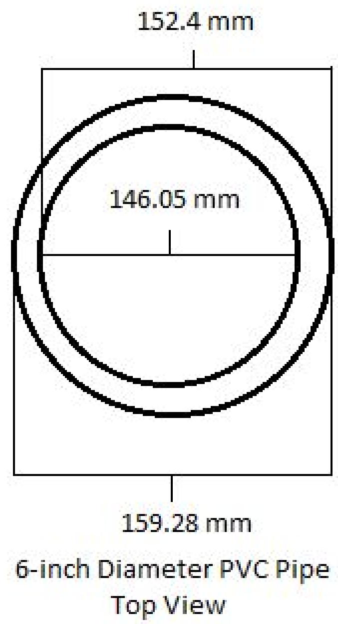


Figure 15: PVC Pipe Top View Diagram

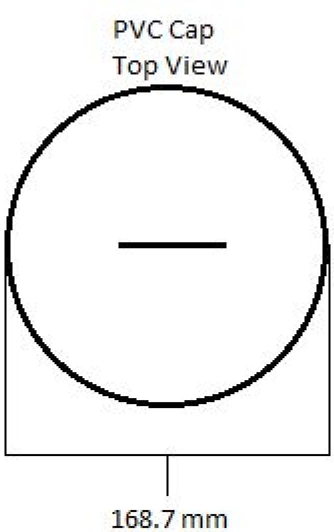


Figure 15: PVC Cap Top View

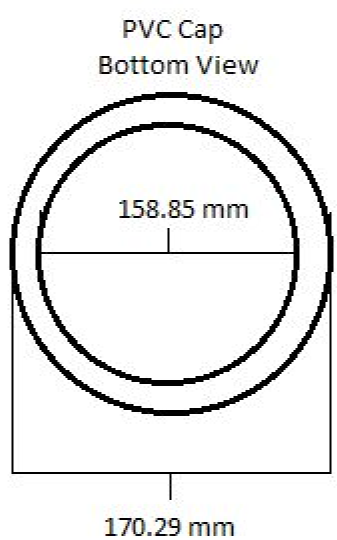


Figure 16: PVC Cap Bottom View

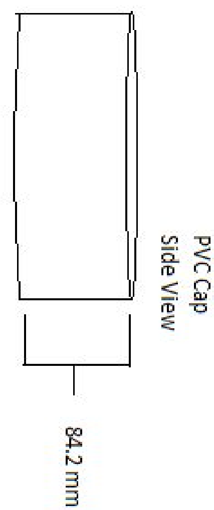


Figure 17: PVC Cap Side View

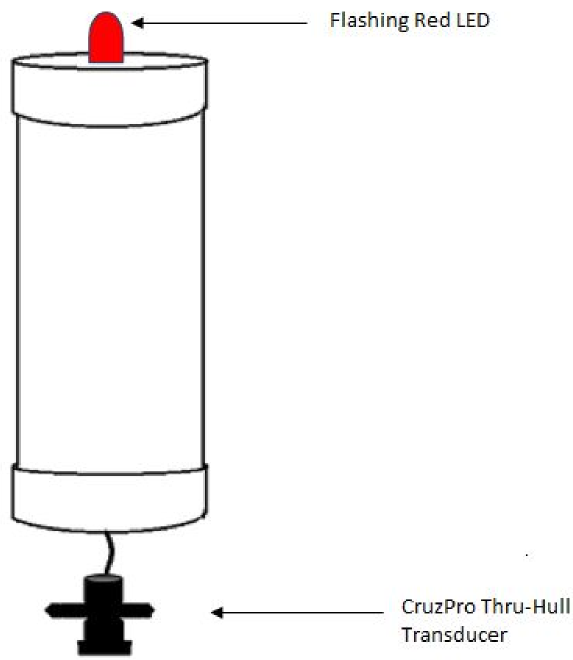


Figure 18: Final "Hack That Flood" Housing

4. Work Processes to be Automated and Supported

4.1. Major Processes & Functions

4.1.1. Phone Application

Attribute	Functionality
FEMA Flood Hazard Zones	Primary
USGS Stream Gauges Above Normal	Primary
Base Map	Primary
Excel Data Sheet	Primary
National Weather Service	Secondary

Table 4: Phone Application Major Processes and Functions

4.1.1.1. FEMA Flood Hazard Zones

The FEMA Flood Map Service Center (MSC) is the official public source for flood hazard information produced in support of the National Flood Insurance Program (NFIP). They provide a map with Historical Flood data.

The orange color is the Feed data from FEMA over 100y Extent Zone

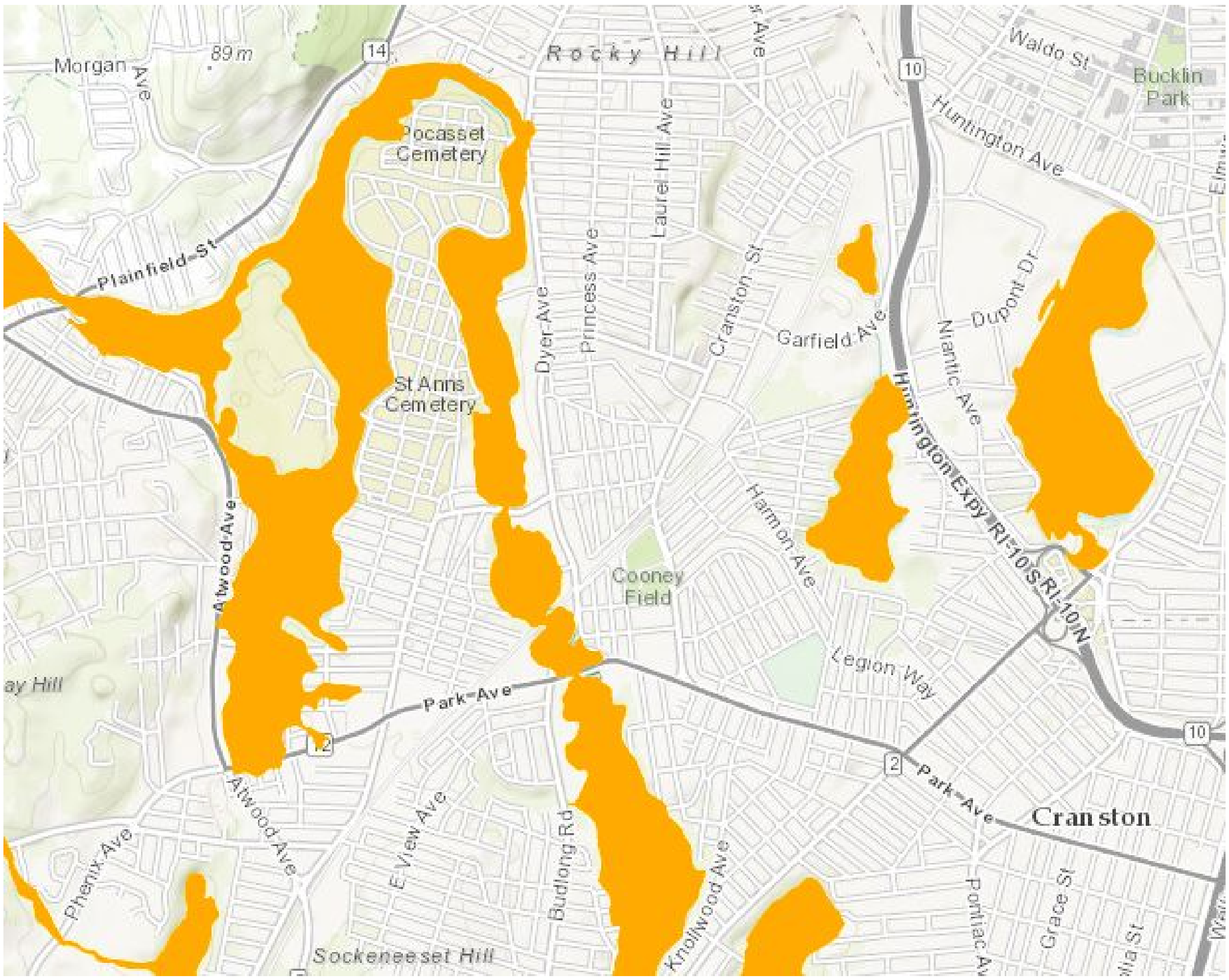
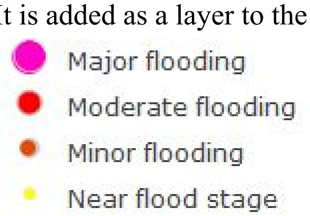


Figure 19: FEMA Zone Data

4.1.1.2. USGS Stream Gauges Above Normal

Stream Gauge is a product of National Oceanic and Atmospheric Administration (NOAA). This gives readings of stream gauges around the US, which depict the current water level in the measured areas. It is added as a layer to the base map



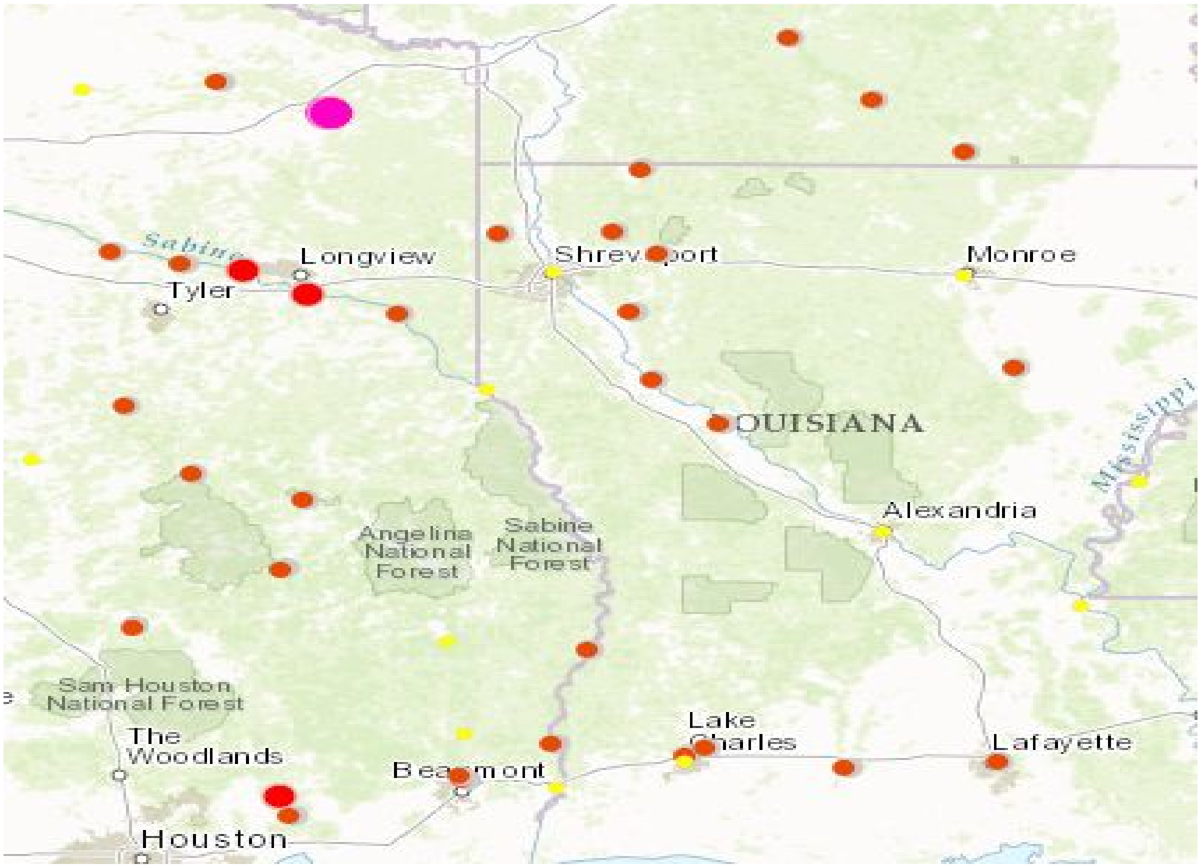


Figure 20: Stream Gauge Map

4.1.1.3. Base Map

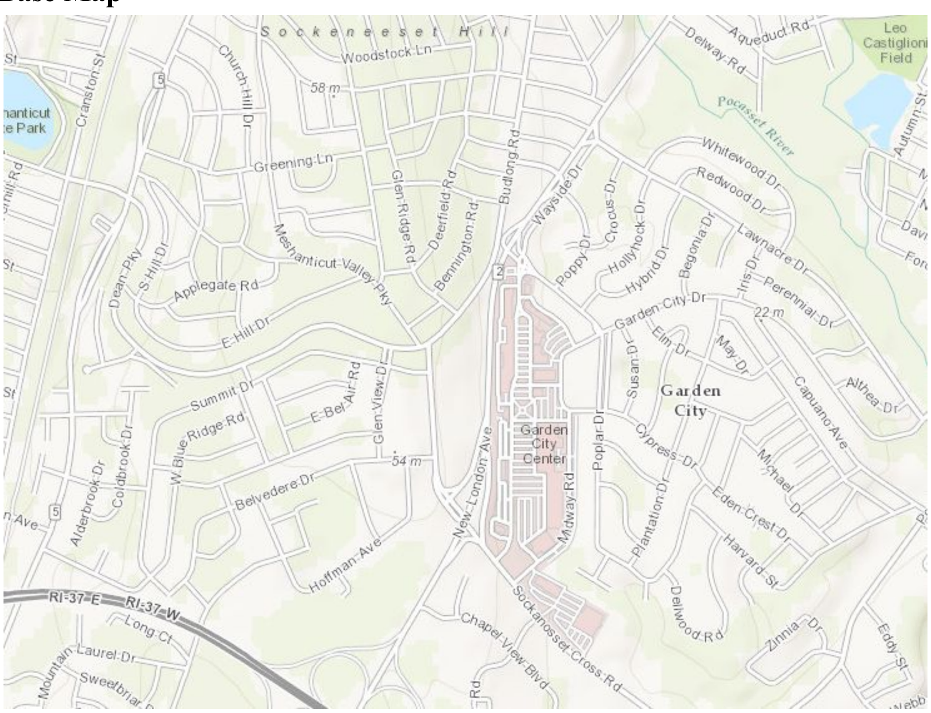


Figure 21: Phone Application Base Map

4.1.1.4. Excel Data Sheet

This is the sheet where the sensor platform will send the real time data. The ArcGIS application then will monitor and access the sheet every 2 second. It will include the following columns
SensorID: unique identifier. It will be used to identify each sensor.
Longitude: used to calculate the coordinates of the device
Latitude: used to calculate the coordinates of the device
Altitude: used to calculate the coordinates of the device
DepthStates: A bite indicated the sensor status. 0 not flooded. 1 flooded
Accelerometer: x, y and z axis, and roll, pitch and yaw values
Contamination: String indicates the sensor contamination statues
Acceleration: the rate of change of the velocity of the device

4.1.1.5. National Weather Service

A weather service that provides weather data and it will be used as a weighted input for flood probability estimation

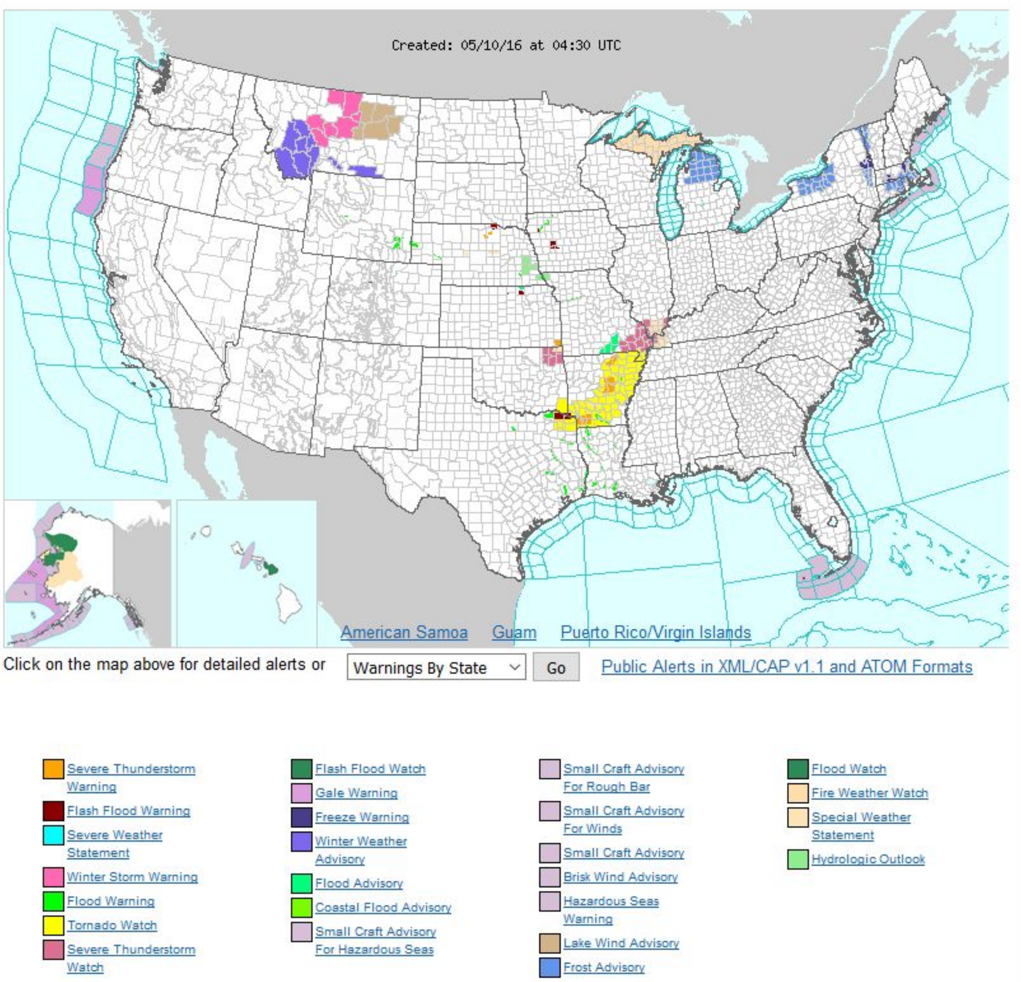


Figure 22: National Weather Surface Map

4.1.2. "Hack That Flood" Device

Attribute	Functionality
Microcontroller	Primary
Depth Gauge Transducer	Primary
Accelerometer	Primary
GPS Locator	Primary
16 x 2 Liquid Crystal LCD Screen	Primary
GSM Shield	Primary
Power Regulation	Secondary
Communications	Secondary
Seakeeping/Survivability	Secondary
Flashing Red LED	Secondary

Table 5: "Hack That Flood" Device Major Processes and Functions

4.1.2.1. Microcontroller

The microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory is often used in the chip. This often comes in the form of Ferroelectric RAM, NOR flash, or OTP ROM. Microcontrollers are often embedded inside another device so that they can control the features or actions of the product. They are dedicated to performing one task. However, this one task may take on multiple functions. As for the "Hack That Flood" device, the microcontroller can read and verify data from several different electronic devices. The microcontroller utilized in the project is the Arduino Mega 2560. It's multiple pins and operating system give it a design to complete complex projects.

4.1.2.2. Depth Gauge Transducer

As mentioned in section 3.2.2 a transducer is a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa. The depth gauge transducer has the elements needed in order to measure and transmit the depth of the water where the "Hack That Flood" device is located. The transducer uses echo sounding, a type of SONAR specifically used to determine depth. By using sound pulses, the depth gauge transducer can time the interval between the emission and the return of the pulse. The CruzPro "Active" Thru-Hull Transducer will remain outside of the housing unit in order to measure and accurate reading of depth.

4.1.2.3. Accelerometer

An accelerometer is an instrument that measures acceleration, or the rate of change of velocity of an object. The one chosen for the "Hack That Flood" device is an accelerometer that has the ability to measure velocity in three directions; x, y, and z. Acceleration measures the wave motion of the object by using the x, y, and z to calculate the roll, pitch and yaw of the device. The roll, pitch and yaw are basically the rotational movement between the x, y, and z axis. For example, an aircraft is free to rotate at three dimensions, where pitch is considered to the the nose up or down about an axis running from wing to wing; Yaw is the nose left or right about an axis running up and down; and Roll is the rotation about an axis running from nose to tail. By implementing the accelerometer, the device will be able to monitor the motion of the body of water where it currently resides. This information will be utilized in knowing how the conditions of the area are at the present time. SparkFun has a triple axis accelerometer that provides accurate readings. It is a small chip that is powered by the Arduino Mega, with an output pin that transmits into an input pin of the microcontroller.

4.1.2.4. GPS Locator

Global Positioning Systems (GPS) are helpful in giving the location of the systems that are using them. In order to maintain knowledge of the "Hack That Flood" device's whereabouts a GPS locator has been implemented. The GPS is part of a GSM (Global System for Mobile Communications) Shield that is attached to the Arduino Mega. The battery life of the Arduino Mega last from 9-10 days, depending on the current environment, such as temperature. Within this time frame the device will have to be collected in order to restore the battery life. A GPS locator is a sure way to be able to track its whereabouts and find it in a short time span.

4.1.2.5. GSM Shield

GSM, or Global System for Mobile Communications, devices are able to communicate over a cellular network. This allows for such things as making and receiving calls, sending and receiving SMS messages, sending GPRS data, and fully integrated GPS signals. The ADAFruit FONA 808 Shield is a chip that allows for the Arduino Mega to communicate with the phone application and internet. Using the microcontroller, the GSM will be able to send data over the cellular service that is provided. This signal can then be sent to a Google Drive Sheet. This will allow the phone application to read, analyze and display the data to the user.

4.1.2.6. Power Regulation

One of the major constraints of the "Hack That Flood" device was the fact that it would eventually run out of a power source. A 12-volt battery would be able to completely power the system for a very short period of time. In order to extend the battery life, the power needs to be regulated to turn the devices on and off. The Arduino Mega is programmed to complete this action. The power is regulated to the transducer and accelerometer on eight minute delays. This is to reduce the power drawn from these two devices. The GPS/GSM Shield is regulated at two minute intervals. This shorter interval is to increase the amount of update GPS coordinates of the device. When searching for the device, it is imperative to have as many up to date data points. This will increase the chances of finding the device while the battery is still able to power the system.

4.1.2.7. Communications

Communications is very important for the "Hack That Flood" device portion of the project. The system will have to maintain a strong communication stream between itself, and the user. The main focus of communication is the transmission of data collected by the microcontroller. The whole idea of these sensors is to give the user measurements of depth, location, and acceleration. The GSM device will communicate over a cellular provider. This will ensure that as long as the device can get a proper signal, all data will be successfully transmitted.

4.1.2.8. Seakeeping/Survivability

Housing for the “Hack That Flood” device is manufactured out of PVC piping. This material is a durable, waterproof plastic that will be able to withstand the aquatic conditions that it will be exposed to. The housing will be able to endure rough conditions while maintaining the safety of the electronic devices inside. It will be allowed to survive harsh conditions with a small amount of damage, if any at all.

4.1.2.9. Flashing Red LED

The housing material is a bright green and white color. This will make it easily visible when floating around in the body of water. However, there are chances that the device can become lost, or fall among obstacles such as reeds. After following the GPS coordinates provided, the red LED will provide a signal to find and follow. This will increase the visibility of the “Hack That Flood” device.

4.1.2.10. 16 x 2 Liquid Crystal LCD Screen

This screen acts as the serial monitor screen when the computer is disconnected from the Arduino. It will display the data on the screen as they also get uploaded to the cloud. This helps the user deploying this device for a test run have a detailed visual data while it is being uploaded to the cloud.

4.2. Process Flow

4.2.1. System Architecture

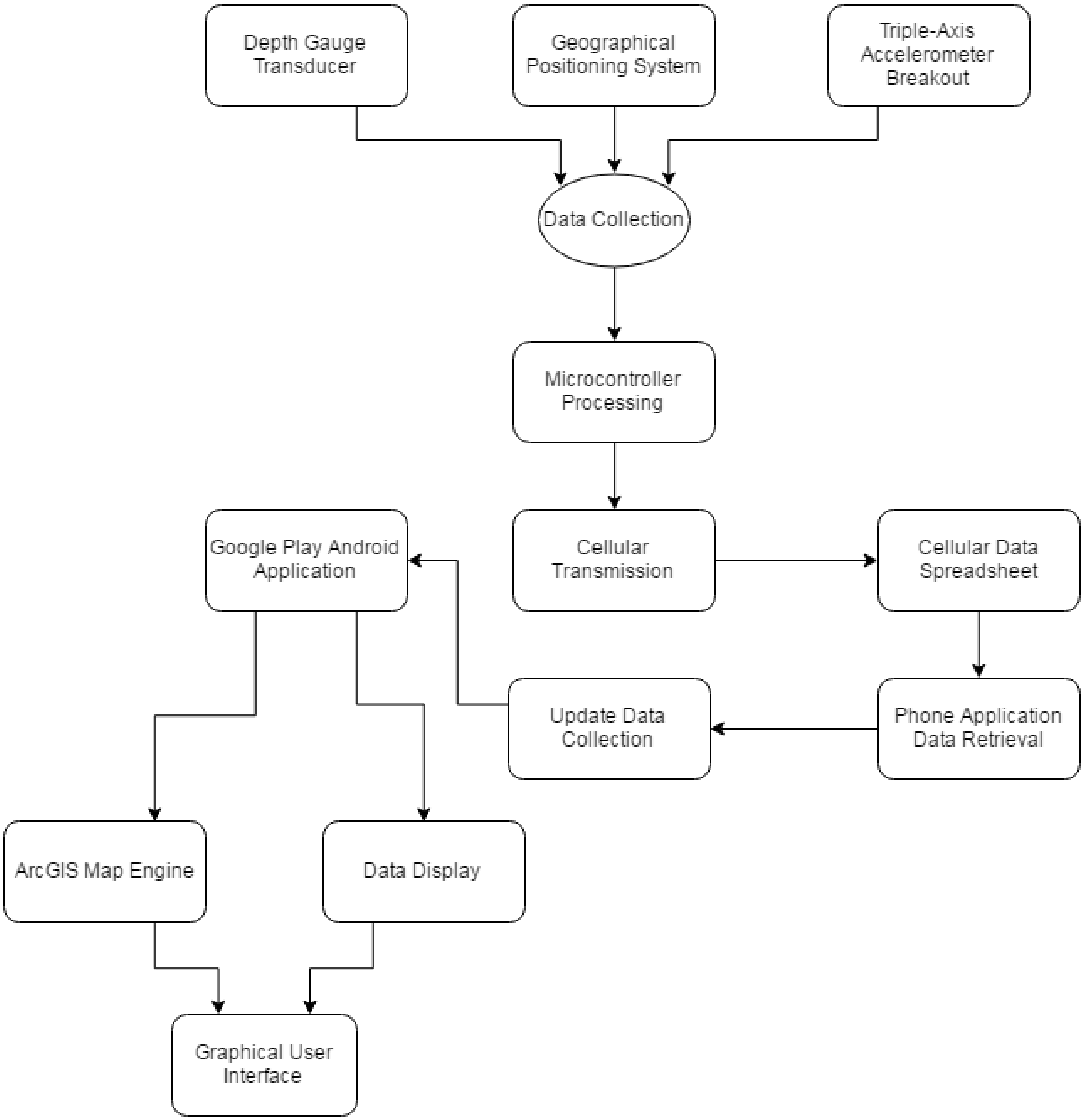


Figure 23: System Architecture Map

4.2.2. System Flow chart

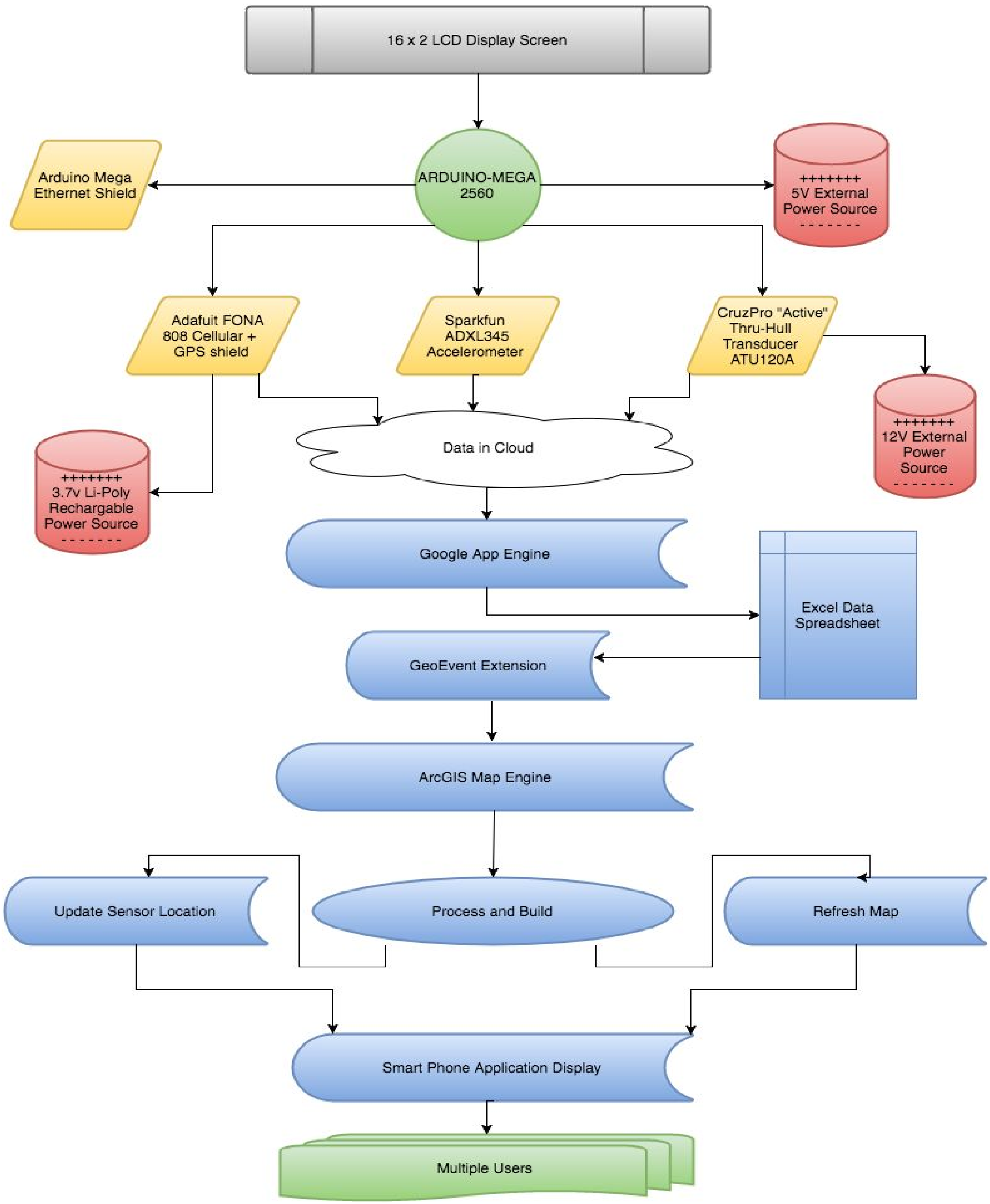


Figure 24: Flow Chart of the System

4. 2.1. **Description of Block Diagram**:

16 x 2 LCD Display Screen: This screen acts as the serial monitor screen when the Arduino Mega is disconnected from the computer. It will display the data on the screen as they also get uploaded to the cloud. This helps the user deploying this device for a test run have a detailed visual data while it is being uploaded to the cloud.

Arduino Mega 2620: The Arduino Mega is a microcontroller device that is used in complex, electronic components. It is based on the ATmega2560, which executes powerful instructions in a single clock cycle. This allows for the device to achieve a balance between consumption of power and processing speed. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is intended for creating and developing interactive projects.

Arduino Mega Ethernet Shield: This device serves as the intermediate between the Arduino and the server. With the help of a connected wireless network or a hotspot, all our collected data can be sent to the cloud for the Google App Engine to control. Please refer to the next few lines to fully understand the function of the Google App Engine tool.

Adafruit FONA 808 Cellular + GPS shield: This is where the altitude, longitude and latitude of the device will be calculated, which enables the tracking of the location of our device. This device is also used to activate the mobile network, where data can be sent through a 2G cellular network, but this feature is currently not in use at this stage of the project.

Sparkfun ADXL345 Accelerometer: Acceleration measures the wave motion of the object by using the x,y, and z to calculate the roll, pitch and yaw of the device. The roll, pitch and yaw are basically the rotational movement between the x, y, and z axis. For example, an aircraft is free to rotate at three dimensions, where pitch is considered to the the nose up or down about an axis running from wing to wing; Yaw is the nose left or right about an axis running up and down; and Roll is the rotation about an axis running from nose to tail. By implementing the accelerometer, the device will be able to monitor the motion of the body of water where it currently resides. This information will be utilized in knowing how the conditions of the area are at the present time.

CruzPro "Active" Thru-Hull Transducer ATU120A: This is our most durable device which serves as the depth gauge. This device calculates the depth of the water in real time, noticing the users any change in the water depth.

Google App Engine: This is a cloud based environment that will host the excel data sheet. The sensor buoy platform will write the data to the file. The GeoEvent Extension which is part of the ArcGIS will pull the data from the same data sheet.

Excel Data Spreadsheet: This is the sheet where the sensor platform will send the real time data. The ArcGIS application then will monitor and access the sheet every 2 second. It will include the following columns

SensorID: This is a unique identifier. It will be used to identify each sensor.
Longitude: used to calculate the coordinates of the device

Latitude: used to calculate the coordinates of the device
Altitude: used to calculate the coordinates of the device
DepthStates: A bite indicated the sensor status. 0 not flooded. 1 flooded
Accelerometer: x, y, and z axis and the roll, pitch and yaw values
Contamination: String indicates the sensor contamination statues
Timestamp: the time when the data was received

GeoEvent Extension: Serves as a server used to connect any type of streaming data feed and transform GIS applications into frontline decision applications. An analysis is going to be performed using the live data. There will be alerts set up to display red dots on the map, indicating that the sensors are floating. These red dots will be imported to the GeoEvent Extension inputs. The application is going to receive RSS feed, NMEA 0183 which is standard GPS data format. The data will be sent from the sensors using HTTP Protocols, which will write the received data to a shared google doc using google app engine.

ArcGIS Map Engine: This is a geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web. There is the possibility of adding a plan state layer, then adding a roads and buildings layer, or adding a built in layer of a base map with labels.

Process and Build: This is the step where GeoEvent Extension will process the data read from the excel data sheet. It will process the locations with the filters we have on the map and decide if there is any alerts or updates needed that are associated with the filers. Lastly, will build the data to binary representation and will create a map accordingly.

Update Sensor Location: Since each data has a time-stamp, GeoEvent Extension will keep track of the last data it processed, and will look for anything newer in the datasheet. Every time there is new data, it will remove the old sensor location and display the new sensor location after it goes through the process and build to make sure it has the right coloring as well.

Refresh Map: This step is necessary to get the new map that the ArcGIS build and created. It happens every three second. If there is no new map. Simply it will refresh to the same one.

Smart Phone Application Display: It has simple display contains a map in the middle of the screen and a drop down selection menu in the right side of the screen with few buttons to determine which layers to display, refresh button to refresh the map and zoom out button to allow fast zooming out functionality.

Multiple Users: The phone application will be available in the Play Store. Everyone who wishes to use our product will be able to install it from there to their phones.

5. High-Level Functional Requirements

5.1. Phone Application

The applications use a map id to retrieve map layers from ESRI servers, by no means is the app exerting any pre-processing or post processing of map content (Processing work is done on server end). Using the app, the end user is able to visualize the map produced by server application.

5.2. “Hack That Flood” Device

The “Hack That Flood” device is going to be able to utilize several sensors to measure and analyze the environment in which it is located. Utilizing a depth gauge transducer, it will be able to accurately measure the depth of the water. A GPS/GSM Shield will produce the longitude and latitude of the device, while also being able to send the data and measurements taken. An accelerometer is going to be able to determine the wave formations in the body of water that it is located. Using the GSM Shield, the device will be able to send all of the information through a cellular signal to the phone application. All of the sensors will be able to interact with the Arduino Mega. The microcontroller will be able to read, translate, and transmit the data through the GSM Shield. The GSM chip will be able to interact with the Arduino Mega in order to receive and transmit the data measured.

6. High-Level Operational Requirements

6.1. Deployment & Support Requirements

6.1.1. Phone Application

The application is developed for the phones with Android OS. The software will be deployed to the Play Store. It is a digital distribution platform serves as the official app store. A user will be able to download the application from the play store provided with any phone has Android OS.
The application does not require any subscription as of today.

6.1.2. “Hack That Flood” Device

The PVC pipe purchased for the device is very spacious, which allows for more room to design a system on how the devices will be safely placed in the PVC pipe. There are three batteries, which will be individually taped to their respective devices. Each device will then be connected to the Arduino Mega sharing a common breadboard. Every wire connected to the breadboard will be taped down using a paper tape. Enough room is left for a free flow of wire between the devices linking to the breadboard. The wires coming from the devices to the breadboard will also be taped down to the device. After all connections are made and carefully placed in the PVC pipe, foam will be wedged and placed to prevent the device from free and easy movement during floatation. The device poses no connection with the PVC pipe to prevent any wear and tear. A plastic bag will be put inside the PVC pipe housing to slow down any water penetration if slight leakage during a heavy storm ever occurs. It is trusted that the design resiliency and durability to withstand any storm and leakage.

6.2. Configuration & Implementation

6.2.1. Phone Application

The mobile application can be downloaded from the Google Play Store on any Android-enabled smartphone by following these steps:

1. If you haven't already, add a Google account on your device.
2. Go to Google Play or open the Google Play Store app.
3. Select an item.
4. Touch Install (for free items) or the item's price.
5. Follow the on-screen instructions. For paid items, you can select or edit your payment method with the down arrow.

6.2.2. "Hack That Flood" Device

Following the preparation of the "Hack That Flood" device will need to be implemented into the body of water. After it is dispersed the data will need to be transmitted to a Google Drive Sheet file. The file will be the connection between the device and the phone application. This online resource will be utilized to send, receive, and collect data for a display on the phone application.

6.3. System Environment

6.3.1. Phone Application (user interface)

Below is the actual user interface of the mobile app. When the app is launched, the user is brought to a single-view application where the map takes up the entire view, except for a bar at the top. By default, the map will be centered at the city of Cranston, but user is able to zoom in/out to explore different locations. At top right corner of bar, there is a menu option that grants the user some controls over the map. The main options are:

- Zoom out: allows zoom out of an area on the map
- Reset: Resets map back to original settings
- Base map options: user can switch between available options

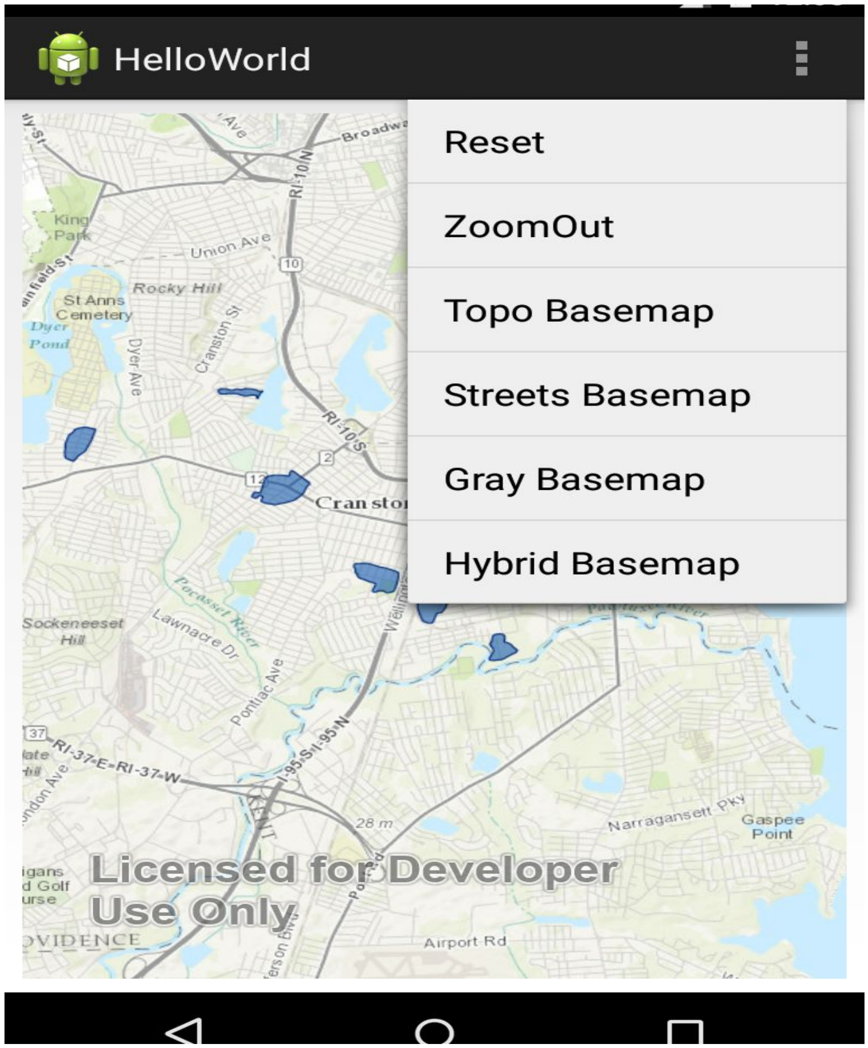


Figure 25: Graphical User Interface

6.3.2. "Hack That Flood" Device

The "Hack That Flood" device is designed to float in a body of water. There are no restraints as to whether or not this is salt or fresh water. Some examples of prime environments for this device are:

- Bays
- Estuaries
- Rivers
- Lakes
- Creeks

7. User Classes & Modes of Operation

7.1. Classes/Categories of Users

7.1.1. Phone Application

- Rhode Island Department of Transportation (RIDOT)

- US National Guard
- Emergency units
- Event Planners
- Any Person Who Install the applications

7.1.2. “Hack That Flood” Device

- Rhode Island Department of Transportation (RIDOT)
- US National Guard
- Event Planners
- Emergency dispatchers
- Engineers
- Schools

7.2. Sample Operational Scenarios

7.2.1. Person

The “Hack That Flood” device works with a phone application that a single user could operate. The phone application will be able to inform the user about flooded areas. This will allow for the user to know which areas to avoid. Driving in heavy rain can be dangerous, and having to drive through areas with flooded intersections. The phone application can be used by a single user to assist them with safe driving.

7.2.2. Company

Environmental companies are always looking for new ways to monitor the oceans and its elements. The device is built in a way that changes and alterations can be made. An environmental agency would be able to utilize the device to keep a constant observation on the conditions of certain areas of water sources. An example would be to add a sensor that can detect contaminants and pollutants, such as oil, gasoline, and saline.

7.2.3. Global

On a global level the “Hack That Flood” will be great to observe water depth levels. A country, region, or larger area could utilize the device to monitor water levels. This will be a great way to forewarn the proper authorities of a potential tsunami, or flood. Having the device in the ocean will monitor the sea levels. When sudden and extreme changes occur, it can alert the proper authorities of a possible tsunami.

8. Impact Considerations

8.1. Operational & Organizational Impacts

Allows the efficient and rapid deployment of first responder units to critically needed places (e.g.; Inundated schools, hospitals or other vital infrastructure) firsts. After situation is contained, local authorities would be able to assess the damage done, and what courses of actions need to be implemented to fix it and prevent it from happening (or minimizing the impact) in the future.

8.2. Potential Risks & Issues

Considering what the project could provide to the society, an analysis of safety is one of the top priorities in order to move forward in this design project. Many people have doubts about placing an electronic device in their riverine areas. Extreme measures were taken into consideration with the resiliency of the device, which is the ability to adapt well in the face of tragedy and treats towards the device by providing a long lasting durability in the river. This will ensure that our device will be stationed in a defined spot, water resistant and making sure it does not act as a conductor to promote any electronic crisis in the river.