Automated Rescue Vehicle
(A.R.V)

Group 7

Bernardo Correa
Electrical Eng.

Malik Santos
Electrical Eng.

Samuel Frisco
Electrical Eng.

Dariel Tenf
Computer Eng.

Motivation

Speaking: **Malik Santos**

- The increasing capabilities, but constant risks in ocean exploration
- Human dependence on large water sources
- Provide an independent device to assist in ocean search and rescue, following shipwrecks or passengers overboard
- The enormous difficulty in finding survivors or wreckage amid rapidly changing conditions
- Autonomous operation to allow for the operator to remain contributing to the search efforts, alongside the A.R.V.

Goals and Objectives

Speaking: **Malik Santos**

- Provide an additional set of eyes in search and rescue
- Report a degree of certainty that the A.R.V. is in fact sees a person or wreckage
- Differentiate between people and debris, rocks, marine life, buoys, etc
- Once a specified degree of certainty is met, travel to the detected survivor autonomously
- Transmit a constantly updating GPS signal for the operator and rescue team to track

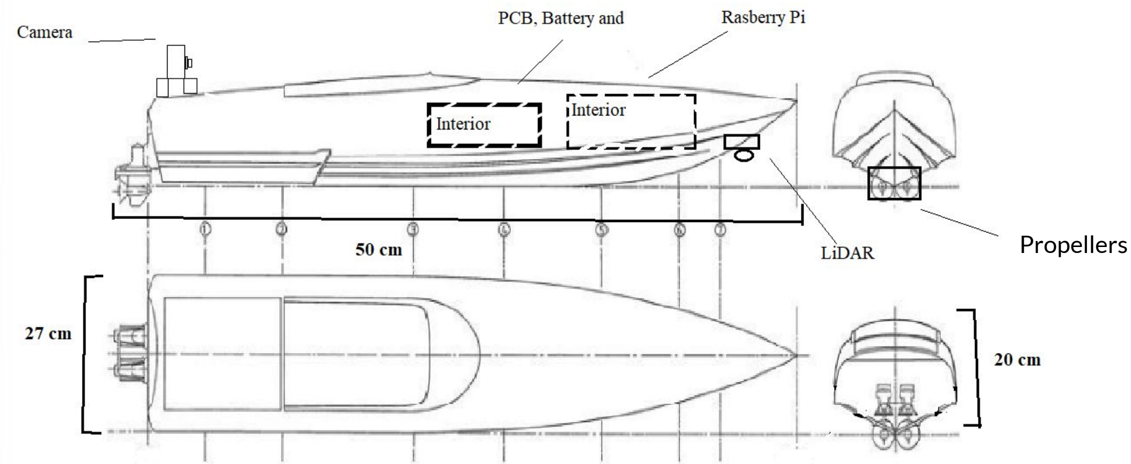
Application

Speaking: **Malik Santos**

- Helping Cruise Ships detect man overboard.
- Busy harbor or Inlet
- Customers provide GPS location for search and rescue help efforts.

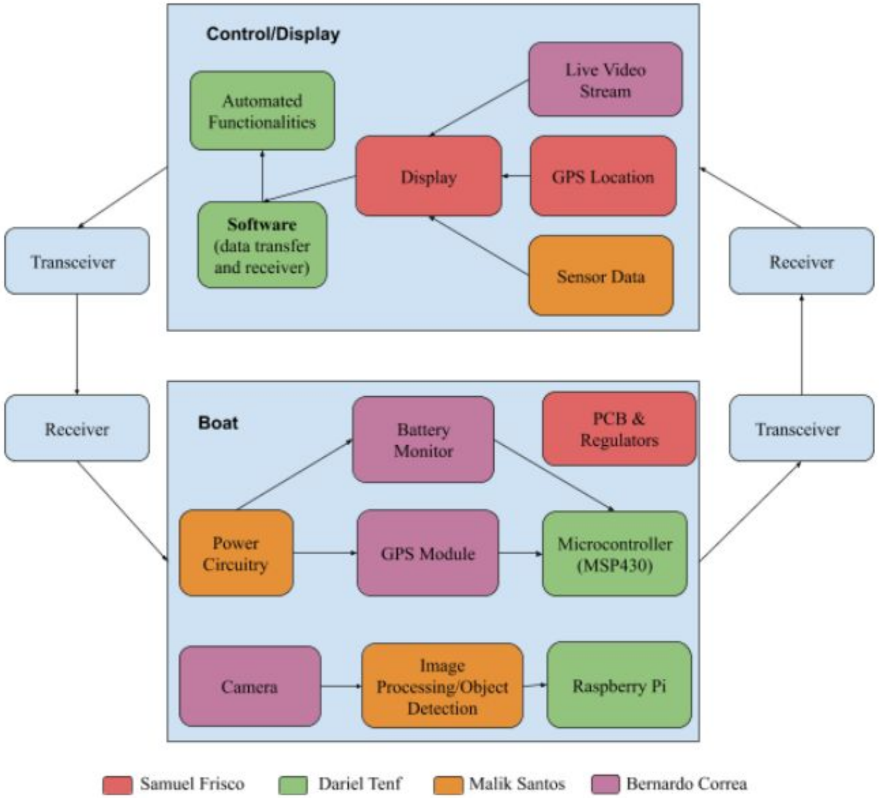
Prototype Illustration

Speaking: **Malik Santos**



Speaking: **Malik Santos**

Complete Block Diagram



Requirements

Speaking: **Bernardo Correa**

Requirement	Value
Object Detection for a Person	70% assurance
GPS Location Update	<Accurate to 3 decimal places
Communication Range	>10 meters
System Runtime	>30 minutes
Speed	<6 miles per hour
Battery Lifetime	>30 minutes
Low Battery Alert	<= 6V

_____: Demonstrable

Specifications

Speaking: **Bernardo Correa**

Power Specifications	Tolerance
7.4V 5200mAh Battery Power	±2V
3.3V DC-DC Converter	5V-12V input range
	± 0.1V
3.3V GPS Chip (Locator)	1 - 3%
3.3V Wifi Chip for Wireless Data Transmission	1 - 3%
Dual Motor and H-Bridge	5V -12V Input range
Raspberry Pi & Camera (Image Processing)	5V, 2A - 10% Tolerance

The Boat: Flytec 2011-5

Speaking: **Malik Santos**

- Lightweight, yet durable ABS plastic construction
- 2-24hour run time, 10-12 hour charge time, 500 meter control distance
- Large size: 50x27x20 cm (height accounting for antenna)
- Ample internal space for additional components
- Sturdy 4 ½ lb weight, yet capable of 3.4 mph (2.95 knots)

Microcontroller Selection (for PCB)

Speaking: **Malik Santos**

- G2553
  - Positives
    - Low Pin count, Easy to solder
    - Cheap
  - Negatives
    - Low Memory & RAM
    - 1 UART
- FR6989
  - Positives
    - High Resolution
    - Good RAM memory
  - Negatives
    - 2 UART
    - High Pin Count, Expensive
- FR5994
  - Positives
    - 8kB of RAM, High Resolution
    - 4 UART
  - Negatives
    - High Pin Count
    - Expensive

Specifications	MSP430G2553	MSP430FR6989	MSP430FR5994
Memory (kB)	16	128	256
RAM (kB)	0.5	2	8
ADC	10-bit	12-bit	12-bit
UART	1	2	4
Pins	20	80	80
Price	$0.79	$3.30	$3.07

Microcontroller Selection (For Image Processing)

Speaking: **Malik Santos**

- **Raspberry Pi 4, Model B - image processing**
  - Object detection via TensorFlow library
  - WiFi communication
  - Implemented in machine learning
  - User friendly, proprietary OS and camera

- **STM32 ARM Cortex M4 - considered for image processing**
  - High power, low RAM (relative to Pi)
  - Fast memory access times (proximity)
  - Less support

Specification	TI MSP430 (Sensor Use)	Raspberry Pi 4 (Image Processing)	STM32
Operating Voltage	1.8-3.6V	5.1V	3.3V
Current Consumption	12.5mA	640mA	117mA
Chip		Cortex A-72 ARMv8	ARM Cortex M4
Clock Frequency		1.5 Ghz	84 -180 MHz
Memory	0.5-512 KB	SD card/external	128KB - 2056KB
RAM	0.125-66KB	2-8GB	32KB - 384KB
I/O Pins	4-100	40	114
Architecture	16-bit	64-bit	32-bit
Dimensions	1.75x1.85 in	2.2x3.35 in	3.27x2.26 in
Weight	0.7 oz	1.5 oz	----

Speaking: **Malik Santos**

Raspberry Pi 4

- **Raspberry Pi 4, Model B - image processing**
  - Powered via 3.7V LiPo add on battery for portable power
  - Internal protection from battery circuit board
  - Proprietary camera optimized to work with the board
  - Video transmission over WiFi

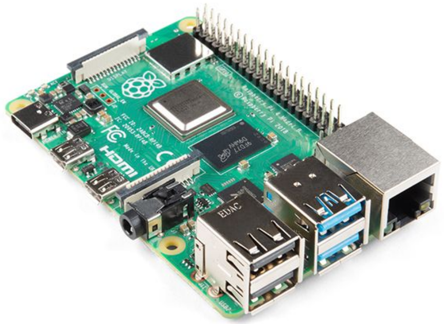
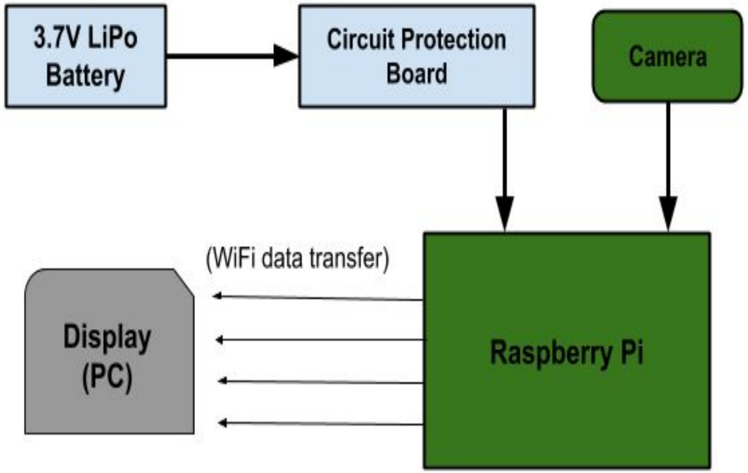


Figure 31: Raspberry Pi Interface Design Block Diagram



Speaking: **Malik Santos**

Raspberry Pi Camera

- Camera Module V2
  - Maximum 1080p
  - OpenCV and TensorFLow capable
  - Wired connection, easy installation

Feature/Specification	Camera Module v2
Operating Voltage	Regulated by Raspberry Pi Board
Resolution	1080p/1080TVL (high-definition)
Pixel	8 megapixel 3280 x 2464
Weight	3g
Data Transmission	Wired
Connector Type	CSI/Flex Cable
Power/Current Rating	Regulated by Raspberry Pi Board
Cost	$29.95

Secondary Camera Options

Speaking: **Malik Santos**

- **Eachine TX06**
  - Positives
    - Voltage Rating
    - Light weight, Wireless
    - Cheap
  - Negatives
    - Low Resolution
    - No Night Mode

- **Foxeer Razer Micro Camera**
  - Positives
    - High Resolution
    - Night Mode
  - Negatives
    - Voltage Rating
    - Heavy

Specifications	Camera Module v2 (Selected)	Eachine TX06	Foxeer Razer Micro Camera
Operating Voltage	Regulated by Raspberry Pi Board	3.3V - 5.5V	4.5V - 25V
Max Resolution	1080p/1080TVL (high-definition)	700p/700TVL	1200TVL
Night Mode	No	No	Yes
Weight	3g	2.8g	4.5g
Wireless Compatibility	Yes	Yes	Yes
Power/Current Rating	Regulated by Raspberry Pi Board	25mW/280A (Typical)	30mA/250A (typical)
Cost	$29.95	$16.05	$24.99

Battery Selection: Boat Power

Speaking: **Malik Santos**

- Technologies: LiPo vs NiMH
  - NiMH cheaper, easier to use, longer life
  - LiPo higher maintenance, lighter, more efficient,

- Factory Lithium Ion Polymer battery for the Flytec 2011-5
  - 7.4V 5200mAh, 4 cell
  - Reduction required for ADC implementation (see voltage monitoring)
  - Up to 12 hours run time powering the boat each (24hr total)

Battery Comparison

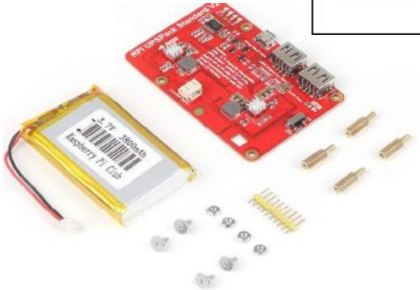
	Nickel-Metal Hydride	Lithium Ion Polymer
Specific Energy	60-120 W*h/kg	100-265 W*h/kg
Energy Density	140-300 W*h/l	250-730 W*h/l
(Charge) Cycle Durability	180 - 2000 cycles	300-500 cycles
Cell Voltage Rating	1.2 V	3.0 V

Battery Selection: Pi Power

Speaking: **Malik Santos**

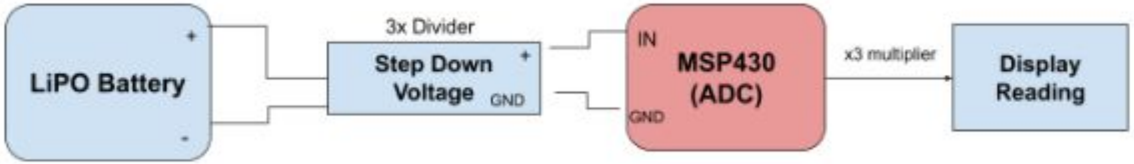
- Makerfocus Raspberry Pi Battery Pack, selected
  - LiPo, 3.7V, 3800mAh
  - Up to 9 hours run time powering the Raspberry Pi
  - Integrated under and overvoltage, and overcharge protection, charge level indication,
- PiJuice HAT, considered
  - Proven, but expensive
  - Doubles as a UPS, protects from data loss
  - Built in RTC
- MakerHawk RPi UPS HAT, considered
  - Replaceable battery option
  - Lacks support

Specifications	PiJuice HAT	MakerFocus RPi Batt Pack	MakerHawk RPi UPS HAT
Capacity	1820 mAh	3800 mAh	3600-7000 mAh
Battery Voltage	3.3-5V	3.7 V	2.5-4.2 Volts
Cost	$88.95	$20.99	$21.99
Runtime	4-6 hours	9 hours	>8 hours
Dimensions	4.33 x 4.92 x 1.38 inches	3.35 x 2.17 x 0.79 inches	3.82 x 2.24 x 0.39 inches

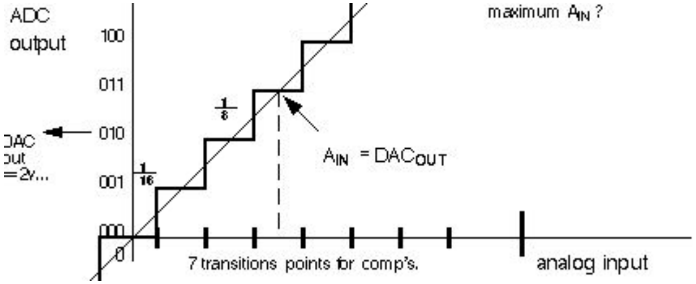


Battery Voltage Monitor

Speaking: **Bernardo Correa**



- Voltage is monitored using ADC (Analog to Digital Conversion)
  - MSP430 Analog Pinout has a 3.5V limit
- Voltage is stepped down for microcontroller input
- ADC Resolution is 10 bits
  - Digital Output will be converted to appropriate voltage reading
- Voltage reading is multiplied by 3 and sent to display



Speaking: **Bernardo Correa**

Battery Voltage Monitor Requirements and Limitations

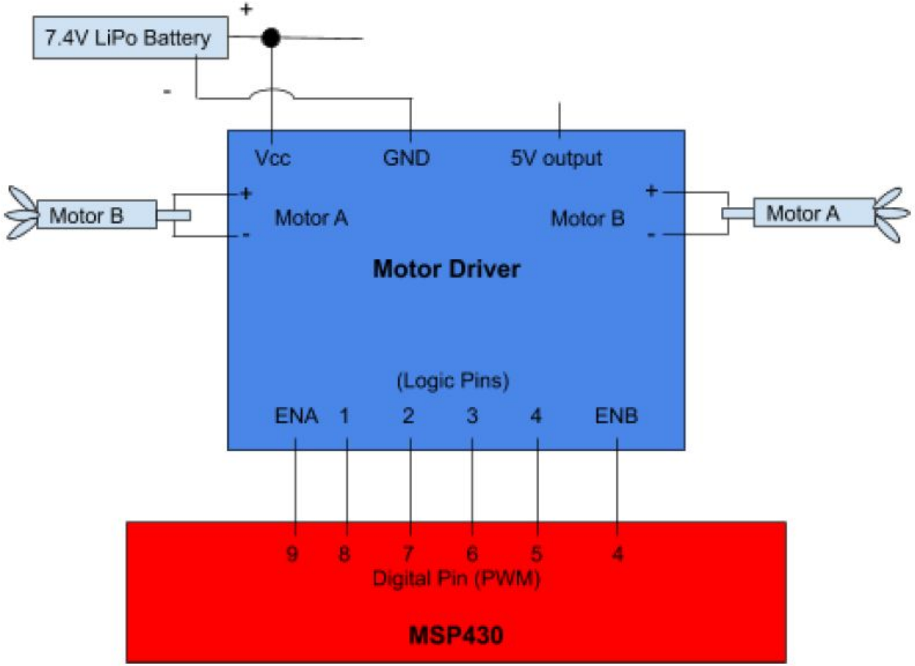
Using ADC to Monitor Battery Life

Voltage Monitor Requirement	Send Battery Voltage 10% Tolerance
Reference Voltage	2.5V or 2.0V
ADC Resolution	10 Bits
Analog Pin Limitation	3.5V Max

Progress Report:

Initial Prototype Testing - Completed
PCB Implementation - Completed
Total Subsystem Progress: 100%

Dual Motor Interface for Automation



- H-Bridge Motor Driver: Used to drive motor either forwards or backwards
- Input voltage: System Requirements is 7.4V but motors can run at >5V

<u>Two Enable Pins and 4 Logic pins</u>

- **Enable Pins** : PWM (Pulse Width Modulation) Controls Speed
- **Logic Pins** : Controls Forward and Backward Movement of each motor.

Speaking: **Bernardo Correa**

Motor Driver Chip Selection

Speaking: **Bernardo Correa**

L298N

- Wider Operating Range
- Allows for longer operation since LiPo battery is 7.4V
- Cheapest

Specifications	L293D	L298N	Viper 35A
Voltage	Up to 14V	5V – 24V	7V – 30V
Current	Up to 2A	Up to 2A	Up to 35A
Dual Motor	Yes	Yes	Yes
Speed Controller	Yes	Yes	Yes
Price	$5.89	$4.30	$21.89

Motor Driver Functionalities

Speaking: **Bernardo Correa**

Motor Driver Parts/PinOuts	Function
VCC	5V - 12V Operating Voltage Range
MOTOR A/B (+ -)	Positive and Negative Terminals for both motors. Internal connection to H-Bridge
5V output pin	Internal 5V regulator that outputs 5V
ENA, ENB	Logic Pin for Speed Control using Pulse Width Modulation
Pins 1,2,3,4	Logic Pins for Forward/ Backwards Motion
H-Bridge	Internal Chip to drive motors Forward and Backwards.

Motor Driver Design Decisions and Difficulties

Speaking: **Bernardo Correa**

- Autonomous movements using GPS Interface or predetermined location ?
  - Dependent on scale of system
    - Small Scale Prototype: Predetermined Location
    - Large Scale Product: GPS Interface for autonomous movements
- Dual Motor Driver and H-Bridge is critical for design completion
  - Allows for speed control on 2 motors simultaneously

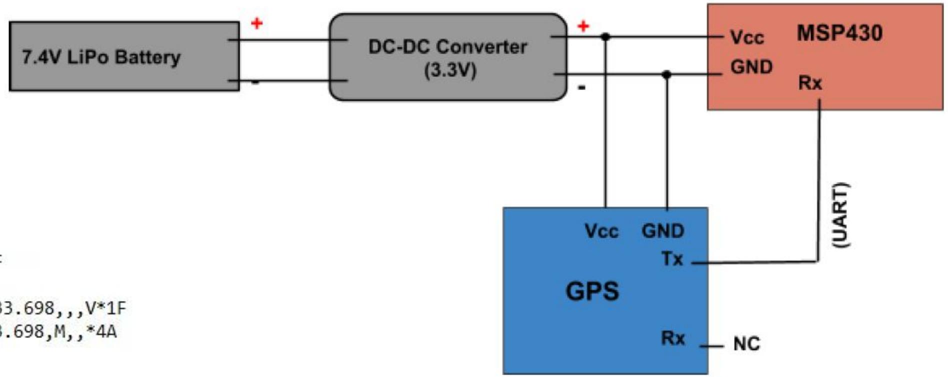
Progress Report:

Initial Prototype Testing - Completed
Full Autonomous Test using Predetermined route - Completed
<u>Total Subsystem Progress:</u> 100%

GPS Locator Chip Diagram

Speaking: **Bernardo Correa**

- 3.3V Input Requirement
- UART Communication @9600 Baud Rate
- GPS Chip Sends NMEA Sentences (National Marine Electronics Association)

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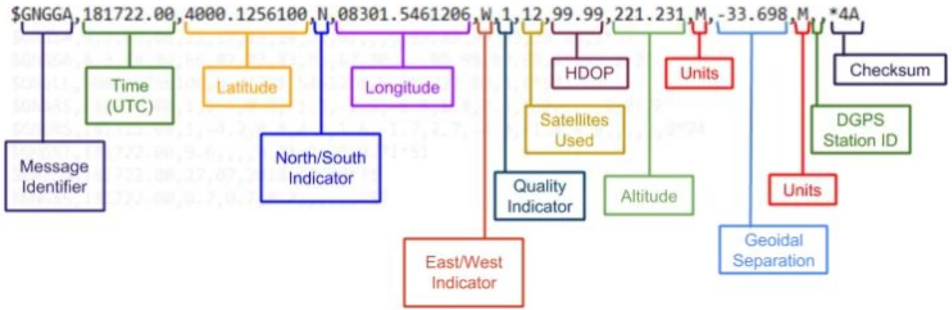
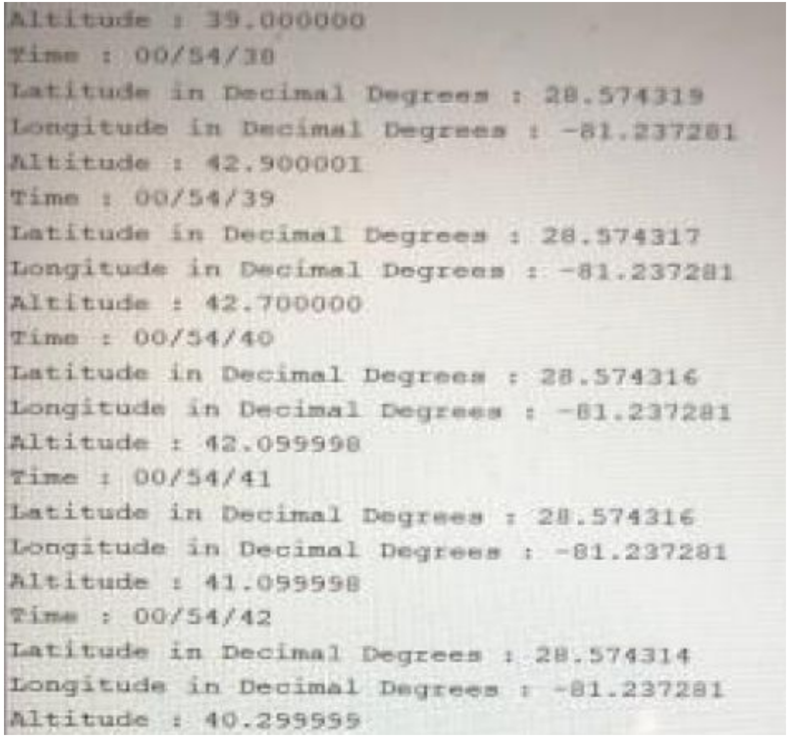
Coordinates Sent to Receiver

- NMEA Sentences are decoded, sorted and organized.
- Display Shows Latitude, Longitude, and Altitude.
- Time Interval is confirmed at 1 Second Update Time





Speaking: **Bernardo Correa**

GPS Selection Progress Discussion

Speaking: **Bernardo Correa**

- NEO 6m Selection
  - Operating Voltage contains 3.3V
  - Data Transfer Rate (constant update)
  - Fast Start Up
  - Cost effective

Specifications	NEO 6m Module (selected)	Pharos 360 Module	Particle Boron LTE
Operating Voltage	2.7V - 3.6V	3V	3.7V
UART Interface	Yes	Yes	Yes
Receiver	50 Channel	12 Channel	-
Wireless	No	No	Yes
Data Transfer Rate	1 Hz	1 Hz	-
Location Start-Up Time	27 Seconds	60 seconds	<1 second
Cost	$21.95	$18.50	$59.99

Progress Report:

Initial Prototype Testing - Completed
PCB Implementation - Completed

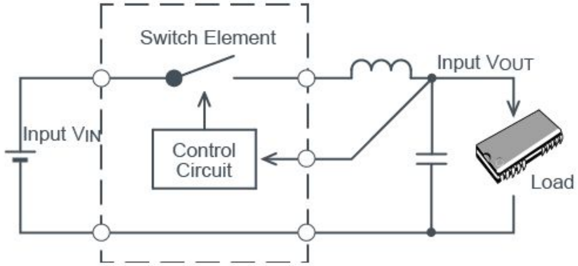
<u>Total Subsystem Progress:</u> 100%

Speaking: **Bernardo Correa**

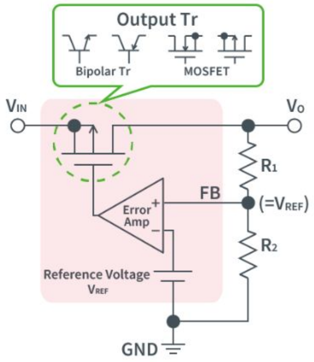
DC-DC Converter, Technology Comparison

- Switching Regulator
  - Buck, boost, buck-boost, and flyback types
  - Switching element used to convert power from supply to pulsed voltage, then smoothed by L's & C's
  - Constant switching allows for heat dissipation
- Linear Regulator
  - Simpler, cheaper designs
  - One configuration - the step down converter (buck)

Switching



Linear

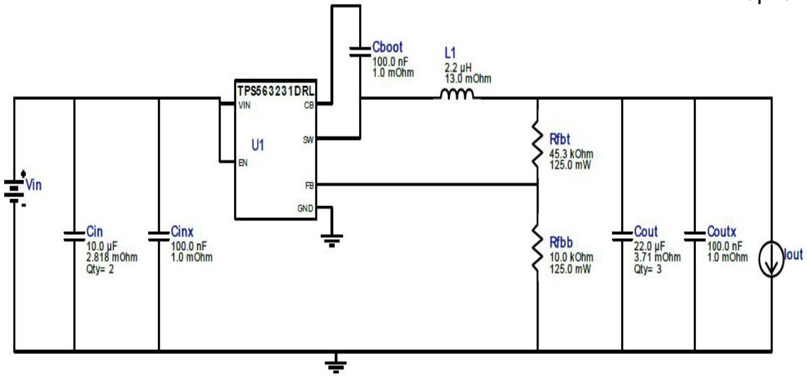


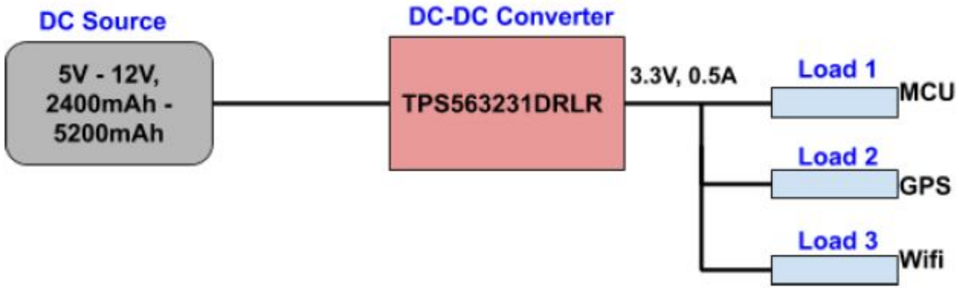
Specifications	Linear Regulator	Switching Regulator
Noise	Low	High
Efficiency	Low	High
Heat Generation	High	Low
Circuit Complexity	Low	High
Operations	Buck (Step-up)	Buck, Boost, Negative

DC-DC Converter

Speaking: **Bernardo Correa**

- **Buck Converter**
  - Input range: 5V-12V
  - Output: 3.3V
- Critical for multiple subsystems
  - Microcontroller
  - GPS
  - WiFi
  - Depth Sensor (Oscillator)





Progress Report - 75%

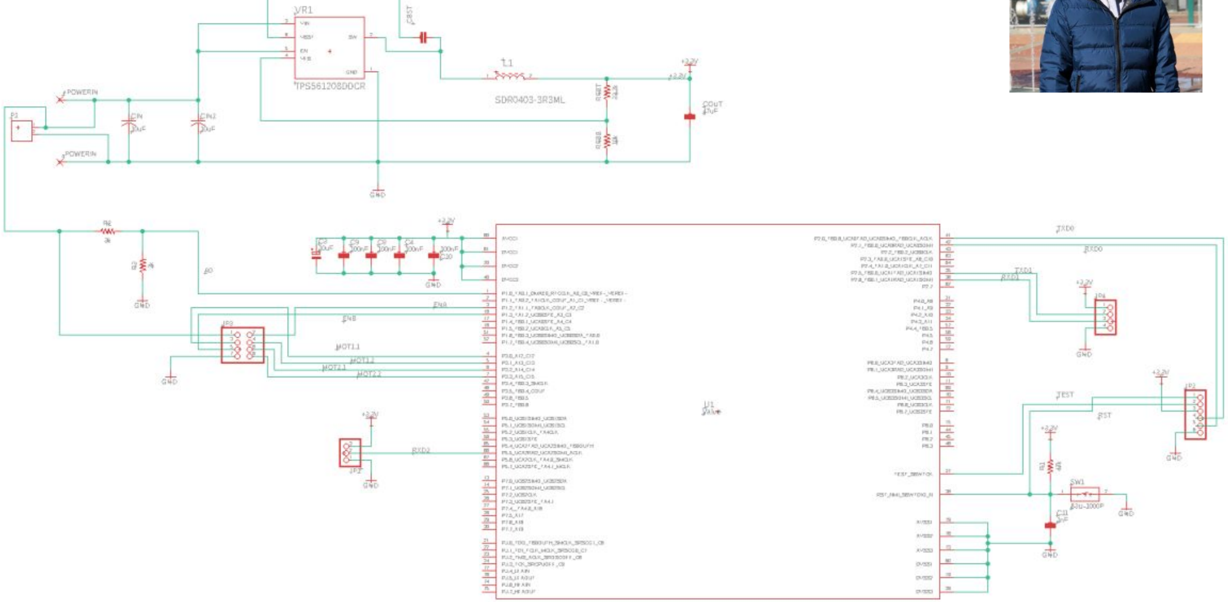
Regulator Output Testing on PCB - Completed
PCB Design Layout - Completed

PCB Schematic

Speaking: **Bernardo Correa**

Schematic Diagram for Prototype PCB

- MSP430FR5994
- 4 Connector Pin Headers
  - GPS
  - Dual Motor Driver
  - Wifi Module
  - Code Upload
- Buck Converter



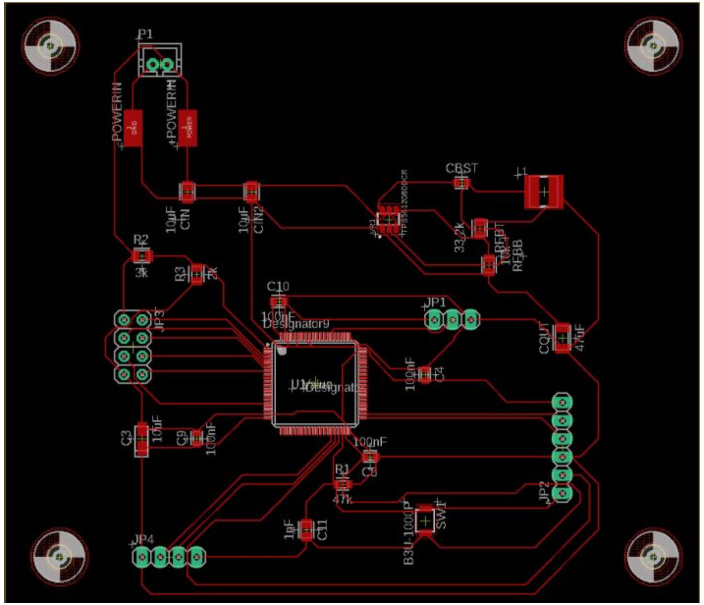
Design Progress : 85% completed

PCB Design

Speaking: **Bernardo Correa**

- PCB will be used for all system functions
- Image Processing is solely done on the Raspberry Pi

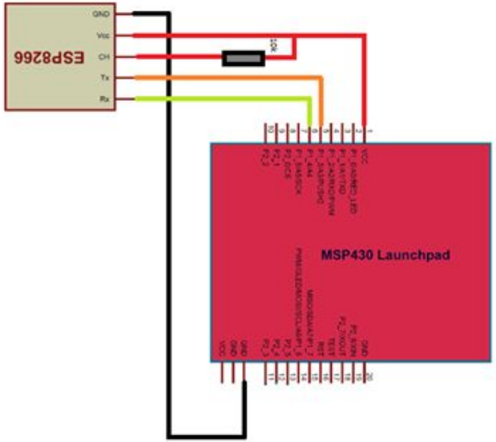
PCB Progress: 100%



Communicating Wirelessly with the MSP430

Speaking: **Dariel Tenf**

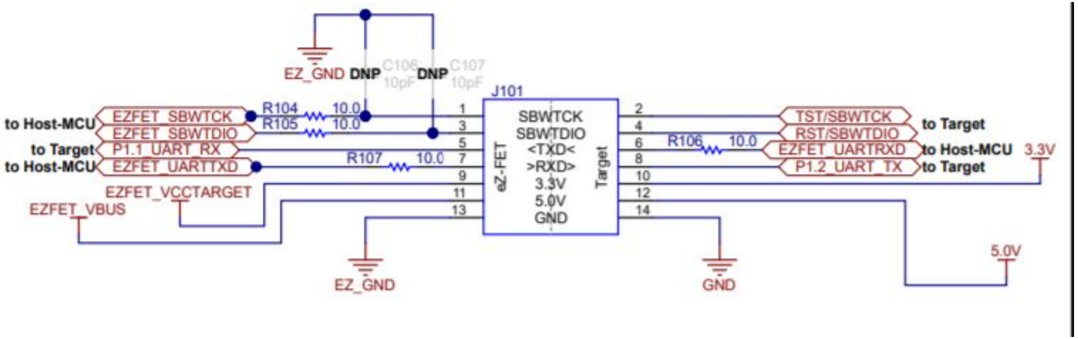
- MSP430's typically do not come with a WiFi adapter.
- To compensate, we will be using a ESP8266 WiFi module.



Uploading Code to MSP430FR5994

Speaking: **Dariel Tenf**

- On board serial FET using the TI Launchpad



Development Process

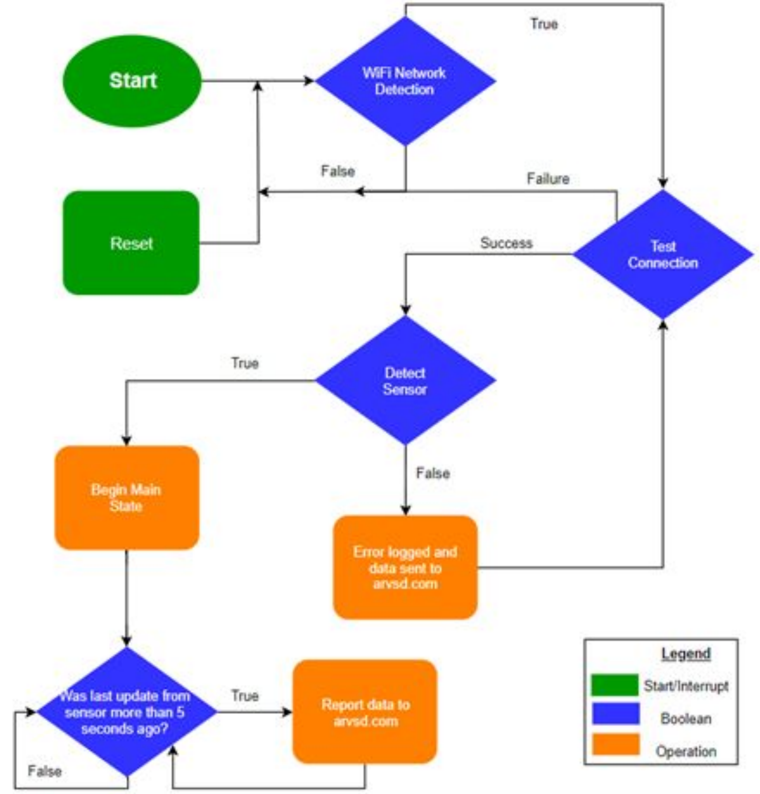
Speaking: **Dariel Tenf**

For the production stage of the A.R.V., we've decided to utilize the Agile software development technique to optimize the pace at which we can accomplish the project. We've split the production stage into three sprints which are listed as follows:

Sprints	Product
1st Sprint	Automation implemented
2nd Sprint	Camera streaming implemented
3rd Sprint	Image processing implemented

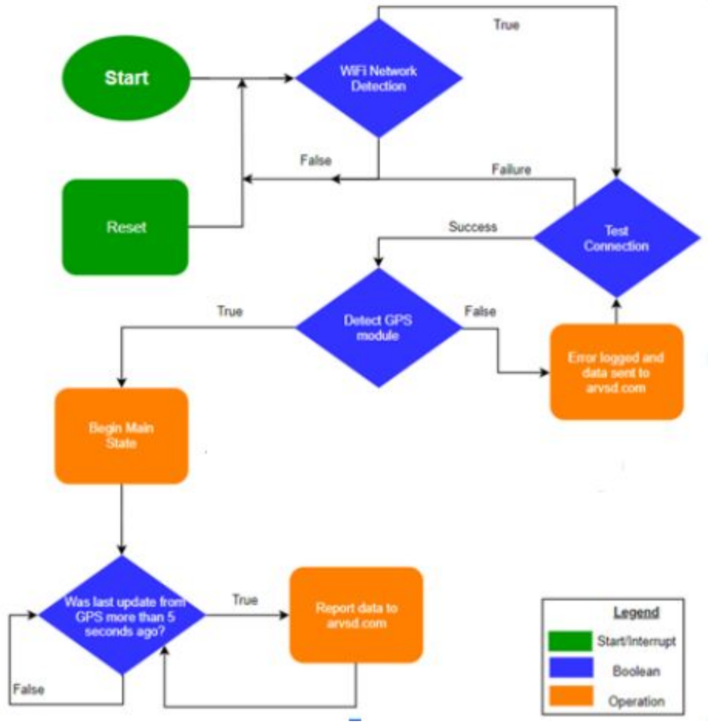
Sensor Software

Speaking: **Dariel Tenf**



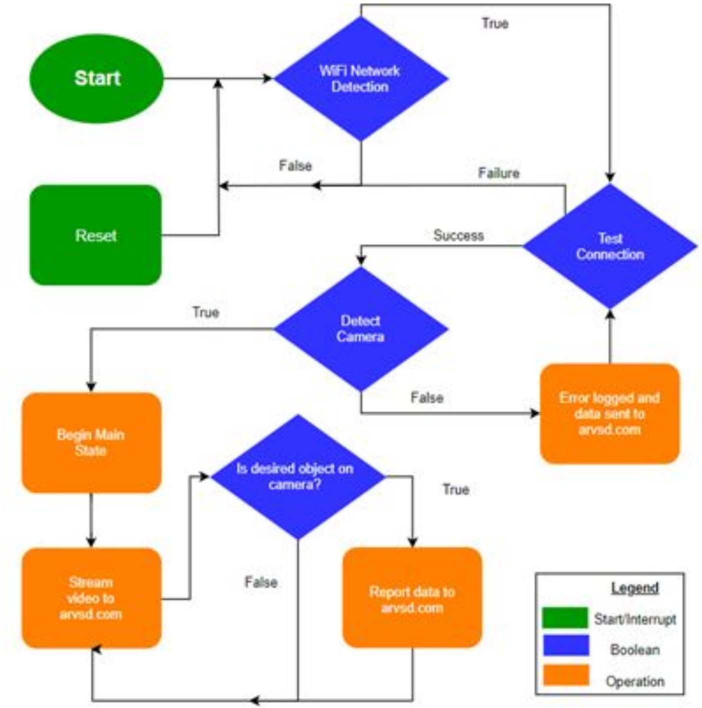
GPS Software

Speaking: **Dariel Tenf**



Camera Software

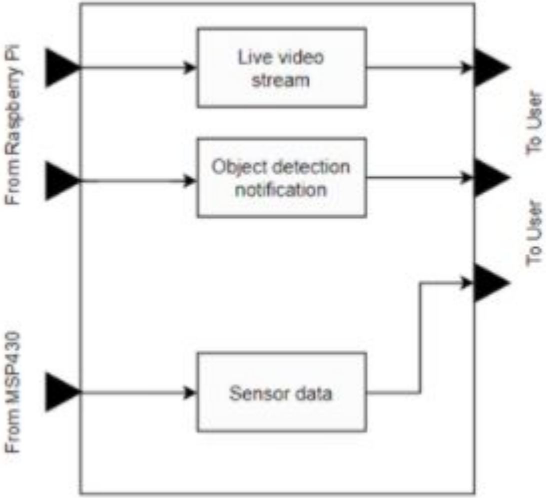
Speaking: **Dariel Tenf**



User Interface

Speaking: **Dariel Tenf**

- The user will interface through a website, Ubidots will be used to receive data wirelessly and allows for updating data to be refreshed.



Testing

Speaking: **Samuel Frisco**

- The final product was put through 9 distinct levels of testing
- Each one is used to test a different complexity of this product
- Level one is the initial testing of the equipment alienated from their counterparts
- Each level is is more complex than the next until the end of the product
- Level nine is the final test of a fully integrated product in the terrain it was meant for

Standards and Constraints

Speaking: **Samuel Frisco**

1679.1 Lithium Based Batteries Standard - Design Impact

- Over discharge for a prolonged time causes critical voltage values.
  - Possibility of shorts and failures
- For safety, the solution is to constantly monitor the batteries voltage

Ethical, Health and Safety Constraints

- LiPo Battery is placed in secure location in the design
  - Decreases safety hazards that can be caused by water damage or heavy vibrations
- Tightened Specifications and requirements for system due to constraints
  - Delays in data or inaccurate data can result in failure of system functions

Difficulties and Successes

Speaking: **Samuel Frisco**

Difficulties

- Image Processing
- Using Wifi to transfer data from MSP430 to Website
- GPS Compatibility with ESP8266 Wifi Chip

Successes

- GPS is fully functional and meets requirements of 3 decimal places of accuracy
- Motor driver testing was successful and functional.
- ADC for battery monitoring was successful and displayed accurate results
- Image Processing was successful
- Regulator output was accurate and efficiently supplying power to multiple components.

Speaking: **Samuel Frisco**

Successful Completion

- Image Processing with Raspberry Pi - 100%
- Autonomous Motor Control using Motor Driver - 100%
- GPS - 100%
- Voltage Monitor - 100%
- Wifi (for wireless transfer of sensor data) - 100%
- PCB/Schematic - 100%

Timeline

Speaking: **Samuel Frisco**

- GPS module and camera module powered and tested during SD1
- Motors fully functional and automated September, 21st
- PCB ordered and tested September, 21st - October 2
- Image processing software completed October, 28th
- Depth sensor using SM111 November, 5th
- Final integration of all software and hardware November, 20th
- Final product completion going into final testing November, 22nd
- Final video and presentation recorded before November, 28th

Expenses

Speaking: **Samuel Frisco**

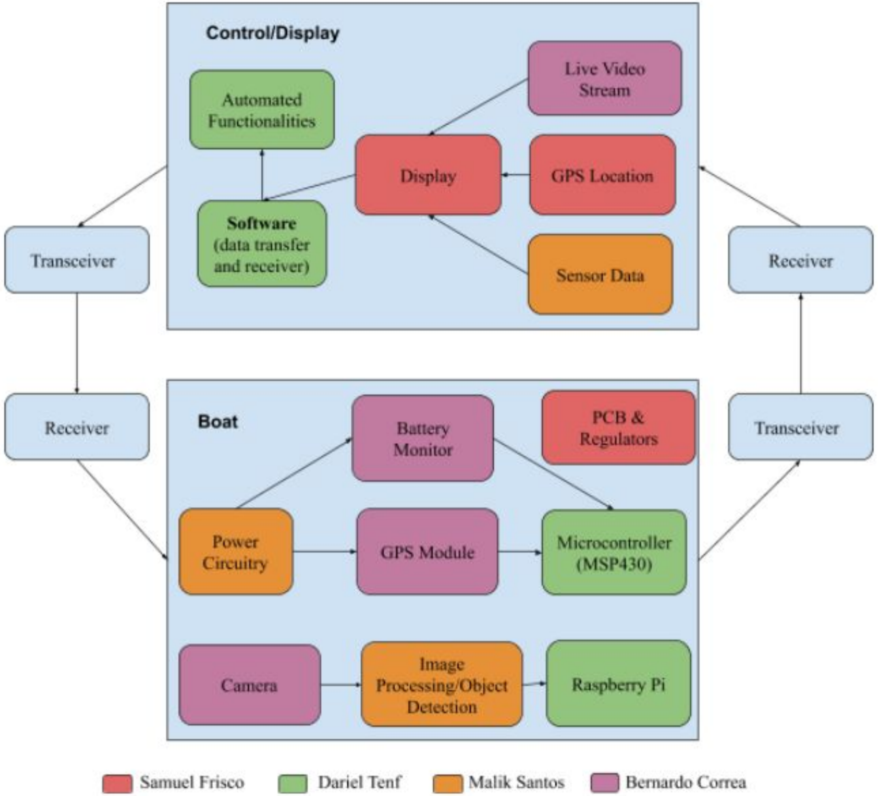
- Total Expenses $376.23

- **Large Expenses**
- Flytec HQ2011 $125
- PCB Components $49
- Raspberry Pi Camera Module $28

Item	Cost
MSP430FR5994 x4	$29.00
Flytec HQ2011 RC boat (and remote)	$125.00
Raspberry Pi Battery pack	$25.00
Components for PCB	$48.50
VytaFlex 20	$28.35
Raspberry Pi Camera Module V2-8	$27.01
Pcb Assembly	$23.90
NEO-6M GPS Receiver Module	$11.99
Jumpers	$7.49
Battery pack	$2.00
Wifi Module	$15.00
PCB Stands	$3.00
Camera and Pi Casing	$12.00
CPU Fan	$17.99
Total	**$376.23**

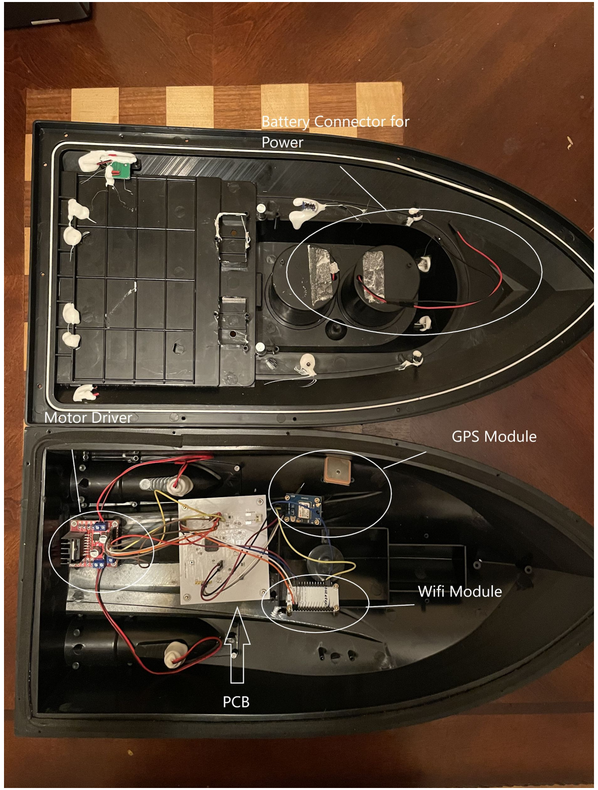
Work Distribution

Speaking: **Samuel Frisco**



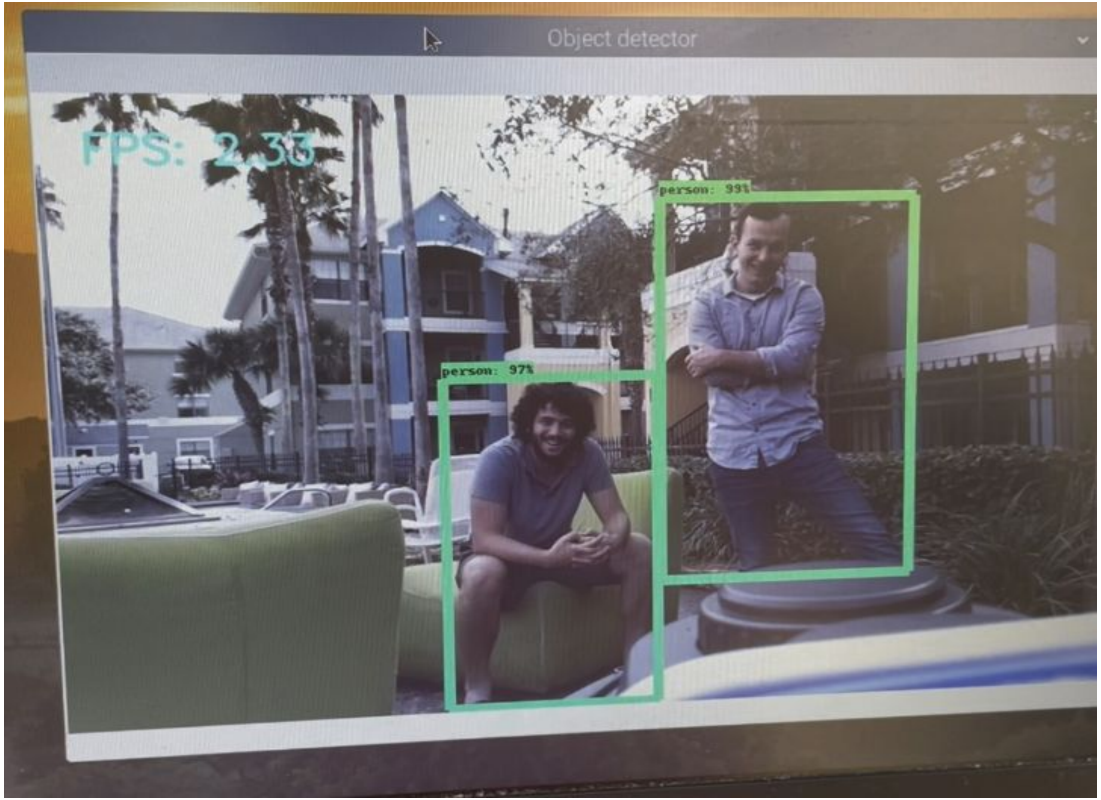
Final Product

Speaking: **Samuel Frisco**



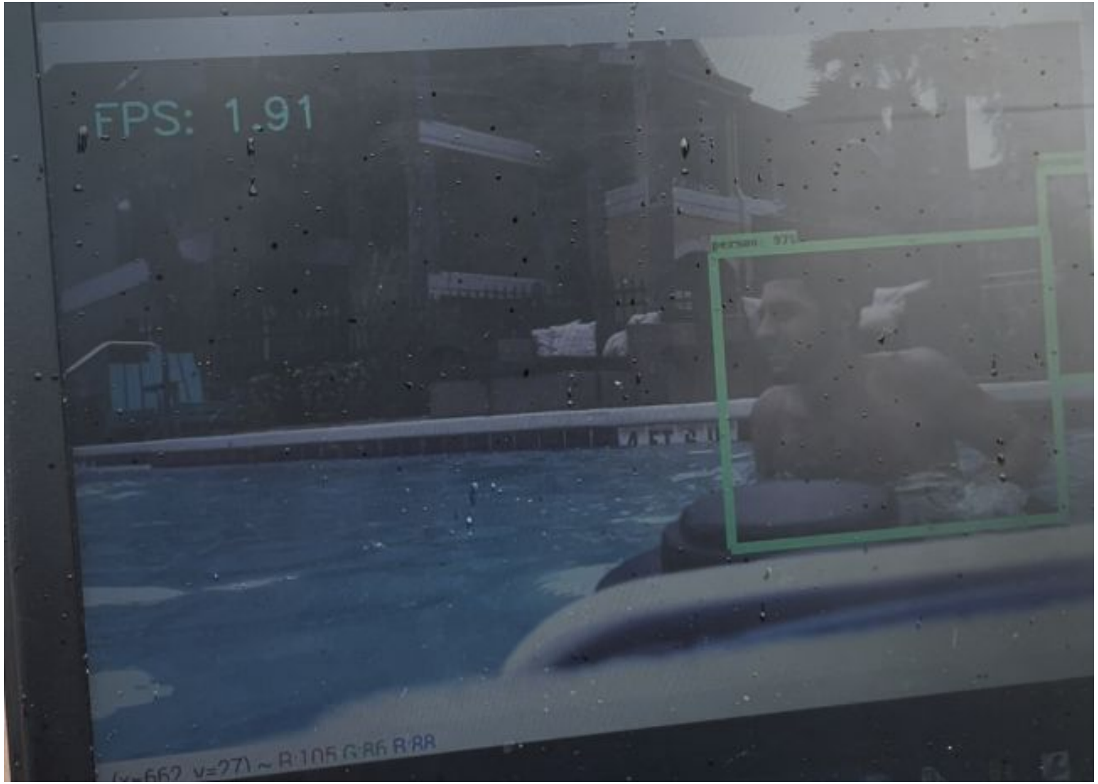
Object Detection Final Results

Speaking: **Samuel Frisco**



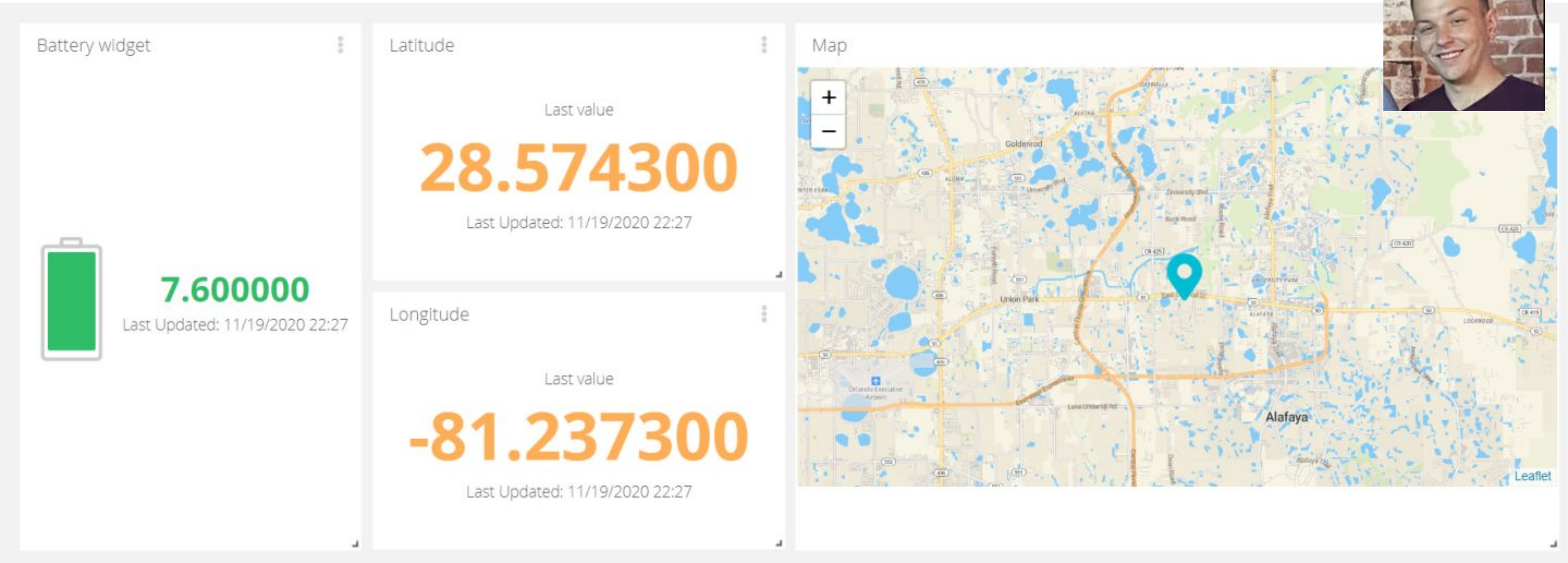
Detection in Water

Speaking: **Samuel Frisco**



Ubidots Website Interface

Speaking: **Samuel Frisco**



Speaking: **Samuel Frisco**

Thank You

Any Questions?