Silent Aluminum Fishing Boat

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***Abstract* — The Silent Aluminum Fishing Boat aimed to provide an ultra-quiet, low weight, and innovative take on the modern-day flats fishing boat. With Internet of Things integration becoming more prevalent in recent years, smart phone and app integration with sensors such as water temperature, pressure, and GPS navigation was the underlying goal with regards to our electrical system. Users of the app would have access to the modern amenities of a basic marine GPS unit with the system operating at a fraction of the power and cost. Final integration would produce a working boat with all electronics including motor, navigation lights, and necessary pumps operating off the sponsor provided Torqeedo-5000 batteries.**

Index Terms* — *Microcontroller, Accelerometer, Pressure, Global Positioning System, DC/DC Conversion

I. Introduction

Initially seeking an interdisciplinary project, our group decided that the 'Quiet Aluminum Fishing Boat' sponsored by Correct Craft would provide a challenging and unique experience do demonstrate our hardware and software skills. With one of the Electrical students having a strong interest in power and the others having experience with marine electronics, the electrical aspect of this project was of strong interest. The software and programming requirements were also of great interest to the Computer Engineer members of our group, as Bluetooth capability and interfacing between various boards for sensor measurements and GPS offered a unique opportunity to design an engaging user experience aboard this craft.

It was important to our team that we ensured new experiences and new subjects were explored as we were interested in using our project to learn skills we did not have the ability of learning in course work. Working with Mechanical Engineers and Computer Science students was also of interest to our group, as this would afford us the opportunity to perhaps glance into another side of engineering not seen with our tailored coursework and broaden our horizons with the intensive material design aspect of this project. With this interdisciplinary project came a confirmed sponsor, Correct Craft, which provided guaranteed funding of $1500 and would enable us to design a high-quality electronics/software system with a degree of financial freedom. Collaborating with Correct Craft would give every group member a new experience of working and consulting on a client-based system. With the requirements that Correct Craft requested, this allowed each team member to understand the flow and process of working with a client-based project. Upon consulting with the sponsor, further reassurances were made with regards to this financial freedom and our group gained a greater understanding of the design specifications which were being sought with this project.

II. Electrical System Design

Upon meeting with our sponsors, it was clear the electrical system would be anchored in utilizing the batteries provided by Torqeedo to reduce overall weight of the system by eliminating the need for additional lower voltage batteries. As such, our system would require a step down to be utilized before distributing power to the 12V marine electronics and our 5V PCB with digital sensors. As this was a relatively high-power project with the motor drawing 10kW at max load, the user's safety was paramount. Accordingly, marine standards regarding wiring ampacity would strictly be adhered to, so as to ensure the safety of the users and meet the parameters set forth by our sponsors. It was of great importance that the wiring choices suited the system such that all components could be safely housed in the center console of the boat. The component choice for subsystems and the microelectronics portion utilizing sensors will be discussed further in the following sections.

III. Sponsor Provided Electrical Systems

A. Batteries

Due to the nature of sponsorship with this project, battery choice is limited to those provided by 'Torqeedo' which are compatible with the electric motor chosen to power the boat. The batteries to be used are the Torqeedo 48-5000, connected in parallel and together these batteries can produce 10kW of power which is more than sufficient for our system, as our microelectronics would draw no more than 1 amp at any given time which is negligible compared to that drawn by the motor. Of note is the lightweight nature of these batteries, with each weighing approximately 80lbs. Compared to lead acid batteries of similar power, these lithium ion variants are vastly superior in terms of weight as well as efficiency of power distribution.

B. Motor

As with the battery choice, our sponsorship and partnership with Torqeedo has afforded an opportunity to use their proprietary electric motor for propulsion of the boat. Specifically, the Torqeedo 10.0RL would be utilized for propulsion. It is a single prop outboard motor with adjustable trim and is controlled via a steering wheel and throttle. A tiller option is available for the motor, however to provide the most user-friendly product the center console design was the chosen configuration. The electric nature of propulsion also offers more noise reduction than a typical gas-powered outboard motor which falls in line with the expectations of the sponsor. It is worth noting that telemetry and various readouts of the motors can be obtained through a CAN bus or Bluetooth. While not successful with our design, future designs if this is pursued further may integrate this option.

IV. MICROCONTROLLER

The microcontroller is the most essential part of the hardware design. It is key to choose a microcontroller that will have enough performance characteristics to allow for a full integration of all other peripherals and allow us to meet or exceed all goals set out by the project. For this project the microcontroller (MCU) oversaw receiving all data from various sensors on the boat such as GPS, temperature and pressure readings and relaying that information using the Bluetooth module attached to the hardware and sending off all the data to the mobile app part of the project. Thus, we went for a well performing but still cost-effective choice for our MCU to be used in the project. During the initial thought process of purchasing a microcontroller we took into consideration multiple popular brands of microcontroller units such at Atmel, Texas Instruments, PIC and Parallax. We decided to choose Atmel as the brand of microcontroller we wanted to use and decided to research most of their models to find one that best fits our needs.

After researching the market and multiple MCUs we settled on a ATmega1284P since it is quite a powerful microcontroller that is capable of processing all the data necessary for the full implementation of all other hardware in the project. It comes in a 40-pin package which provides more than enough space for us to connect all assets needed and also comes with two serial UART pins which is critical as we need to transmit data via Bluetooth and receive data via a GPS system all at the same time. Another large positive of using at ATmega MCU is that since the electronics community has been using these chips for years and there is a lot of documentation and forum blogs on various types of implementations available along with a multitude of intricate projects that have been created using this family of chips.

Figure 1:ATmega1284 Microcontroller

From a technical standpoint, although low cost at around five dollars (USD) per microcontroller which is great, this MCU is capable of being operated up to 20MHz and comes with plenty of analog to digital conversion pins with 10 bits of conversion possible. The 1284P comes with many I/O pins such as it is possible to interface a multitude of different sensors using SPI or I2C protocols which makes it easy for us to breadboard designs and then transfer them onto a PCB for final integration. Regarding our design specifically, the schematic for the designed PCB utilizing the microcontroller can be seen in figure 2 below with corresponding pin locations and designated headers for each component to be utilized in our system.

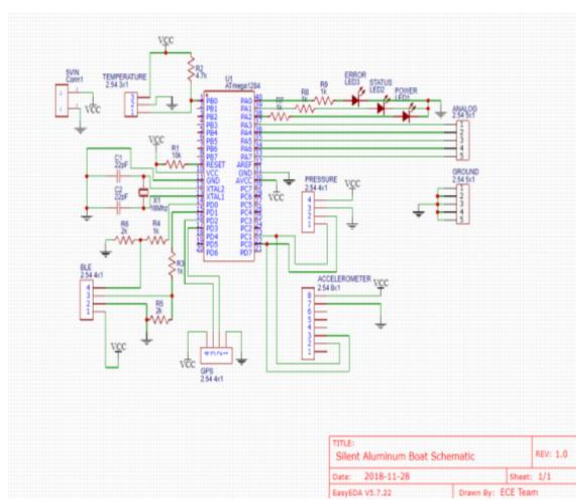

Figure 2: ATmega1284 Schematic

V. Communication Platform

Given the nature of the project there must be a way to transmit all the data collected by the microcontroller and display the captured data to the mobile application developed by the computer science team. For this communication between our hardware and a cellular phone we had to research different types of communication devices and modules that are compatible with the microcontroller chosen in the section beforehand. During this process we reviewed Bluetooth communication, 4G cellular communication and the relatively new XBee communication platforms. Initially 4G communication would have been quite a great choice as we could easily store data onto the cloud straight from our microcontroller, but there was one large downside is that the end user would need to go out and purchase a prepaid SIM card in order for this to work which is just unnecessary costs. In terms of the XBee communication although it is a powerful tool we decided it would be overkill because it is mainly used when multiple MCU boards need to communicate with each other and then to a central board to send data away to its destination. Given the nature of our project and the fact we are only going to use one board, the XBee platform proved to be too much and would be costly per module we needed.

Thus, we decided on using Bluetooth communication in order to receive data from our microcontroller. After being assured that the computer science team can develop an app that will successfully capture data over Bluetooth we decided to start researching how Bluetooth modules work and how they interface with our chosen microcontroller the ATmega1284P. Given the fact that we need to obtain a good quality signal to transmit all of our data and have a signal range that is large enough to accommodate the length of the boat. For this reason, we decided to use the HM-10 Bluetooth module because it is compatible with our microcontroller and has a strong enough transmission rate in order to send our data to the mobile app as a good rate. This is a Bluetooth Low Energy 4.2 which was released into market in 2014, it is capable of data packing, link layers, enhance security features and smart links for IoT (internet of things) devices.

Figure 4: HM-10 BLE Module

VI. DC/DC Conversion

Using the batteries provided by one of our sponsors Torqeedo, power distribution and management is a key factor with regards to component choice and design. DC-DC convertors are a necessity for this project as the 48V batteries used would need to have the voltage stepped down before delivery to the microcontroller unit, sensors, and other electrical components. For our system, a 48V/12V step down would be used in conjunction with a 12V/5V step down for the more sensitive electrical components such as our microcontroller.

A. 12V/5V Step Down

For powering of the MCU and all sensors not directly wired to our switch panel, a 12V to 5V step down was used to ensure safe operation of the microcontroller and designed PCB. A switching regulator, the LM2576, was chosen for this purpose to deal with the incoming input of 12V from the fuse box. With the use of this regulator, a power PCB board was designed utilizing surface mount components to assist with space and overall functionality of this device. The schematic for this designed PCB can be seen in figure 3 below.

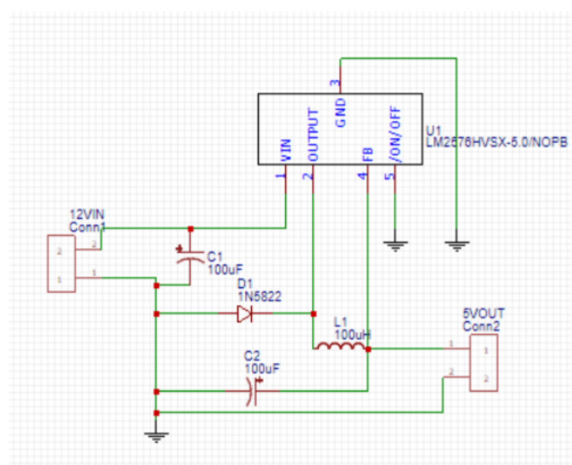

Figure 3: 12V/5V Step Down Schematic

B. 48V/12V Step Down

To meet specific coast guard standards and ensure the functionality of the systems set forth by our sponsors, a step-down device will be used for power distribution to the lighting and bilge system. As the bilge pump requires a higher voltage than what is needed by the MCU, (12V in this case), a separate device from the LM2576 switching regulator will be utilized. The Cllena DC 48V Buck Transformer was chosen for relatively high efficiency (96-97%) and its ability to withstand the maximum current draw of 20A. It is worth noting that as the lighting systems and Bilge are desired to be wired to physical switches for safety purposes, they are capable of being separate from the MCU powered system.

VII. Sensors and Sub-Components

Several sensors were considered and used within our system to communicate via Bluetooth to the user. These sensors would allow the user to have easy navigation while using the mobile application during a fishing trip. Each component was chosen in order to ensure the power of the overall system remains low while also keeping the accuracy of each sensor. Contained in the center console along with the GPS module are the pressure sensor and accelerometer. The water temperature sensor is wired from the center console to the back of the vessel.

A. Barometric Pressure Sensor

Since this vessel is created for flats fishing, a barometric pressure sensor is vital for the fishermen during a trip. In shallow water fish are more responsive to changes in pressure which has an effect on their air bladders. A higher pressure will place a different amount of pressure on their air bladders than a lower pressure. When there is less pressure on their bladder, the bladder will expand which causes the fish to become uncomfortable and leads to fish moving deeper. A high barometric pressure will be desired for a successful fishing trip.

An accurate and wide range barometric pressure senor is crucial for this system. The BMP180 Digital Barometric Pressure sensor has a range of 300 hPa to 1100 hPa with about 0.03 hPa resolution. Since pressure changes in altitude this sensor is also capable of measuring altitude as well as air temperature. These features will also be available for the user through the mobile application to accurately asses the current fishing conditions on the water.

B. Water Temperature Sensor

Water temperature also has an effect on a fishing experience as their activity and metabolism is highly affected by the temperature of the water, they are in. In warm water, fish tend to have a faster metabolism which leads to an increase in feeding and activity. In colder water fish can become lethargic and their metabolism slows which then decreases activity and feeding. In order for a fishing trip to be successful, fish must be willing to take bait which could depend on the temperature of the water.

This inspired a water temperature sensor that was accurate and had a wide enough range for all practical waters. The DS18B20 Waterproof Digital Temperature sensor was chosen for its range of -55 degrees Celsius to 257 degrees Celsius and a ±0.5 degrees Celsius accuracy. This sensor includes a waterproof, moisture-proof, and anti-rust stainless steel probe connected to a 3-meter wire. This allowed the sensor to run from the center console to be mounted on the transom or stern of the vessel.

C. Accelerometer

In order to track the orientation and tilt of the vessel, an accelerometer is used and placed in the center console. This sensor's main purpose is to assist the fishermen with understanding the load effect on the boat. If time permitted, this sensor would be able to show the user that the boat is titled up and would then need to be trimmed down. If a load was carried on the vessel, either on the bow or the stern, the user would be informed through this sensor and would be advised to distribute this load more evenly such that it does not affect the orientation.

The MMA8451 Adafruit Triple-Axis Accelerometer Sensor which included a PCB that contained the needed pull-up resistor, a regulator, and AC to DC converter. The extra components on this board and an I2C connection allow for accuracy and a range of +-2g up to +-8g.

D. Global Position System

Finally, the GPS or Global Position System is a vital component to this system as it allows for the user to keep track of their direction, location, and speed. This feature offers a unique opportunity to design an engaging user experience aboard this craft. The GPS is required to be accurate as it is imperative for the end-user to have a reliable source of information such that they may find their way back to a starting point of desired fishing location. This feature also allows for the user to keep track of and record their successful fishing trips or spots.

The NEO-6 Series GPS was chosen for its ability to communicate effectively with our Microcontroller and a comparatively much lower

Figure 5:NEO-6 Series GPS

price. This module transmits data in the form of NMEA sentences. National Marine Electronics Association, or NMEA, sentences contain characters that describe the type of message being transmitted, which are then followed by the data recorded. The raw data from the GPS can be converted into a readable and useful format for the user to read on the mobile application. Various NMEA sentences are produced by the device as this is the standard for global positioning communication. From these NMEA sentences the latitude, longitude, and speed are also recorded to the mobile application.

Component	Current Consumption
ATmega1284 MCU	40mA
HM-10 Bluetooth Module	20mA
NEO-6 Series GPS Module	10mA
DS18B20 Waterproof Digital Temperature Sensor	1.5mA
MMA8451 Adafruit Triple-Axis Accelerometer Sensor	2µA
BMP180 Digital Barometric Pressure Sensor	0.5µA

Table 1: Sensor Current Consumption

E. Bilge Pump

Within a vessel, nuisance water is often leaked into the bilge and needs to be removed in order to keep the water levels low and avoid the risk of sinking. The bilge will consist of a float switch which will turn the pump on when the bilge fills to a certain level. The bilge will be placed near the floor of the bilge and allow for only a thin layer of water to arise before being pumped out of the bilge. In the case where the water level sensor fails, and it is unable to turn on the bilge pump, there is a switch located on the switch panel on the center console that allows the user to manually turn on the bilge pump.

The bilge pumped used is the Rule-Mate automatic bilge pump. This bilge pump is powered at 12 Volts with a 2A current draw. This bilge pump is a light weight and compact device which will not affect the load of the stern.

F. Livewell Pump and Aerator

A livewell is imperative on flats fishing boats to keep both bait and caught fish alive. This compartment needs to be filled with water as well as oxygen in order to keep the fish alive. The water used inside the livewell will be drawn from the outside water to provide the fish and bait with the freshest possible water. This pump will be located on the stern of the vessel near the livewell and pump directly to the livewell. To pump the water and oxygen into the livewell, a switch will be located on the switch panel to allow the user to control this feature.

VIII. Waterproofing

Waterproofing of the electrical systems was a critical design choice as this was a marine based project. With the most electrically sensitive components residing on our designed PCB's for the microcontroller and step down, utilizing an IP67 rated waterproof enclosure was the clear choice. Our choice was the Polycase SK-28 waterproof enclosure as it provided knockouts for wiring to the components while providing a low profile and compact design. All wiring out of this box would be routed to the fuse box with proper insulation for the conductors to mitigate the risk of any environmental interference. Ensuring that the wiring was up to marine safety standards was crucial to ensure the safety of the user, and as such waterproofing was imperative to our design. Specifically, AWG 16 was used for all non-PCB related components, AWG 10 for the connection to the step down from the batteries, and AWG 18 for the low voltage/current PCB.

IX. Software

Software is a critical piece of any large project, and this one is no exception. The sponsors of the project wanted Internet of Things (IOT) features available to owners of this high-tech boat. In order to fulfill these needs, the microcontroller monitors all sensors on the boat and reports all the data to the mobile application via the HM-10 BLE module. The mobile application then shares the data with the user, as well as with the website and database, which may be accessed in the future utilizing the software detailed in the following sections.

A. Embedded Software

The embedded software for this project is written in the Arduino IDE since the microcontroller is based on an Arduino. The embedded software utilizes several LED's to display error states and what the current status of the board is. Many of the sensors on our project must also be calibrated before they can be read in order to ensure that the data is accurate to the current state that the boat is in. If one of the sensors fails to initialize or calibrate, then the throwError helper function will be called. This helper function outputs an error message over Bluetooth Low Energy (BLE) and flashes the red LED in order to indicate that an issue has occurred to the user.

In order to send messages over Bluetooth Low Energy, the microcontroller has a variable to determine which sensor to read data from to send. Only one sensor is read every 150 milliseconds in order to ensure that there is no buffer overflow on the BLE module. When the sensor is read, the addData helper function is called in order to add this data to the string that will be transmitted over BLE.

Our GPS module allows us to transmit not only our location, but also provides a heading and a speed. This allows the user to have something akin to a digital gauge cluster in a car. The pressure sensor doesn't only provide the air pressure, but also the air temperature. These two numbers are crucial to fish activity, and therefore must be displayed to the user. The water temperature sensor provides the user with yet another piece of data that affects the likelihood that fish will bite. Lastly, our accelerometer provides the user with data about how the boat is tilting, which could later be used to create graphics for the user to monitor the boat's position.

B. Mobile Application

Since the project has IOT features, a mobile application was a must. The team decided that an IOS application would best fit the needs of our sponsors, and that an android version could be something that develop themselves after the project is completed. In order to develop and build the application, XCode was used. The mobile application's main purpose is to take data in from the electrical system via BLE, output this data to the screen for the user, and then to record that information to the database, so that the user may view it later on via the website. The mobile application can also send signals over BLE in order to toggle on various features on the boat, such as navigation lights, the bilge pump, the livewell pump, and the aerator utilizing basic relays via the 5V digital signal on the PCB. This allows the user to have control of these devices no matter where they are on the boat. The mobile device's built-in wireless connectivity is used to upload all trip data to the cloud.

The trip feature allows users to upload all trips that they do on the boat, as well as leave markers and annotations to save any useful information that they discover while out on a fishing trip.

C. User Interface

There are several different screens that users will experience when utilizing the mobile application. The first screen that will greet the user is the sign in screen. This screen, shown in figure 4, will allow users to sign into their account via google accounts while looking at a pleasant screen that shows our sponsor's logo. The login screen will utilize the user's Google account to sign into the mobile application.

Figure 4: Login Screen

The next major page is the home screen shown in figure 5. This is the page that would serve as a digital gauge cluster for the driver of the boat during normal operation. This screen includes relevant sensor data such as speed and heading for navigation, as well as data such as temperature and pressure that affect fish activity.

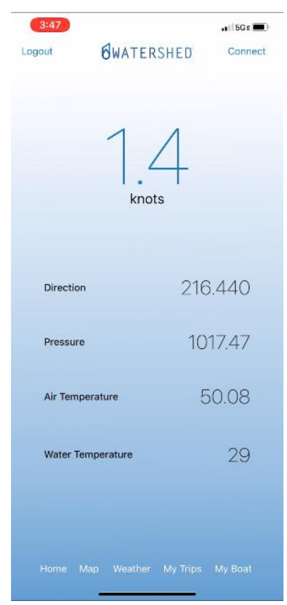

Figure 5: Home Screen

The weather page is also very critical for the user's experience. The weather app helps the user to recognize how ideal the current conditions are, as well as how long the conditions will stay ideal. Factors such as temperature, tides, wind, and humidity all affect how active the fish are. The tides specifically in saltwater conditions play a large role in the user's safety in shallow water conditions in addition to tracking potential fish activity. In general, this allows the user to monitor these conditions will aid in maximizing their productivity and catch rates while fishing.

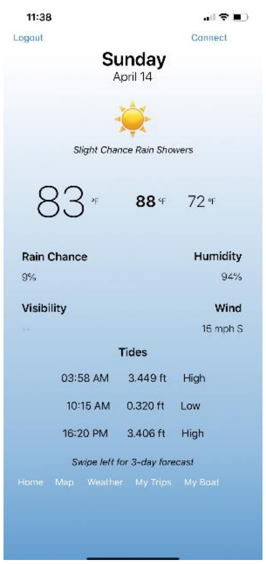

Figure 6: Weather Screen

The last major page is the trips page. The trips page allows the user to record and review any trips that they take on their boat. This allows the user to backtrack if they get lost, which will prevent them from running out of battery power while they are out on the water. Keeping track of trips allows the user to remember what areas that they have recently been to, which would help the user to discover new areas to fish. The user can also leave notes about each trip, so that they may remind themselves what that location was good for. They can use the notes to discuss what fish were in that area, what wildlife they saw, features of the landscape, or how the tides affected the area. The user can also drop pins to mark that a fish was found at a specific location. This can be used to document how many fish were caught at a location, and what type they are. This creates an objective way to compare the success of one area vs the other and allow the user to assess a given areas production of specific species of fish. The trip page is seen in figure 7 of the following page.

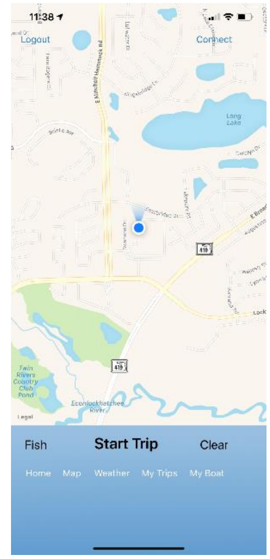

Figure 7: Trip Screen

D. Boat Sharing

Since owning a boat is a huge accomplishment, many owners will want to share this with others. Allowing the owner to be able to share the boat with others is a key requirement in order to make the end product viable. In order for another user to be able to use an owner's boat, the user must create an account. The owner can then give them a code to allow their data to be stored on the owner's page. When the new user does anything on the boat, their data will be stored on both their account and the owner's account.

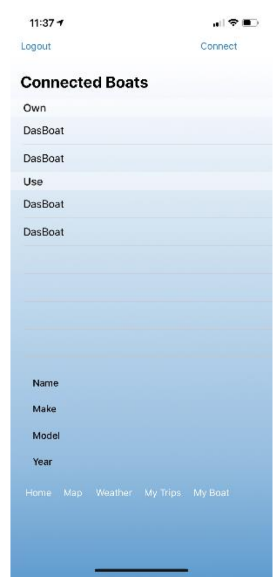

Figure 8: Boat Sharing Screen

X. TEAM MEMBERS

John Santiago is a 22- year old graduating electrical engineering student. He is currently working at Lockheed Martin as a CWEP performing hardware design and troubleshooting. John plans to continue working for Lockheed Martin post-graduation and in the future return to UCF to obtain his masters. His main career interests are electronics, three phase systems, and smart grid technology.

Tyler Brown is a 22-year old senior student at the University of Central Florida. He will be receiving his B.S. in Electrical Engineering in Spring of 2019 from UCF. Working as a Failure Analysis intern in the summer of 2018 for Renesas Electronics, he has plans to return as a test engineer post-graduation. His primary interest is in the IC and semiconductor field with analog power in mind.

Alec May is a 22-year old student at the University of Central Florida. He will be receiving his B.S. in Computer Engineering in Spring of 2019 from UCF. He has been on the Lunar Knights Robotic Mining Competition Team at UCF for four years, and has served as Vice President during his Senior year. He will be working as a Software Development Engineer at Texas Instruments starting in June.

Carley Camarotti is a Computer Engineering student at the University of Central Florida and will be graduating in May of 2019. She is currently interning as a programmer on a data science team researching F/A-18 aircrafts at Naval Air Warfare Center Training System Division (NAWCTSD) and has been offered a full-time position upon graduation.

ACKNOWLEDGEMENTS

We would like to give a special thanks to all of our sponsors: CorrectCraft, Watershed Innovations, Torqeedo, SeaArk and SeaDek for making this project possible and entrusting this interdisciplinary team of UCF students to embark on a task that's never been done before. It took the power of all of these companies collaborating with each other and collaborating with us over the span of nine months to make this idea come to reality. For the hardware of our project we would like to give thanks to QMS manufacturing services for aiding in populating our custom PCB even when the time was of the essence and free of charge. We finally would also like to extend a thanks to Dr. Lei Wei, Dr. Samuel Richie and any other UCF faculty that shared their opinions, advice and concerns while this project took place and quickly responded to any emails and messages even late into the night to ensure the we are doing the best job possible.

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