Initial Project Proposal

Year: 2019 **Semester:** Fall **Project Name:** Motion of the Ocean
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1.0 Description of Problem:

Whether it is for fun, weather prediction, science, or industry, ocean waves have a great impact on the lives of a variety of people. Waves can cause massive destruction on offshore structures and coastal buildings, typically from tsunamis, hurricanes, or large rogue waves. Hundreds of lives and millions of dollars are lost when these structures collapse, and current prevention efforts are focused on building systems to shield structures from ocean waves. Often times when these structures collapse, it is without warning.

2.0 Proposed Solution:

Our solution to this is a dedicated device or network of devices for assessing the continued structural integrity of offshore structures to provide early warning for structural collapse. The device would measure wave characteristics and would analyze the data using known algorithms for total impact on offshore structures. Using the measurements and analyses, it would be able to characterize an ocean area near a structure. The determined characteristics could be used to find the total impact load on an offshore structure and assess how it compares to the total load predicted during construction, serving as an early warning system to prevent large amounts of damage the incoming waves may cause.

3.0 ECE477 Course Requirements Satisfaction

3.1 Expected Microcontroller Responsibilities

The microcontroller will primarily be responsible for taking in data from a variety of sensors and analyzing it to find certain parameters. The device will take in accelerometer and GPS data and process it within the microcontroller to determine parameters such as first and second wave moments, steepness, wave height, and wave number. Ocean depth and temperature may also be required, which would require more sensor integration. It may be necessary to include a dedicated signal processing unit depending on the model used to model ocean wave behavior. Waves will need to be sorted into short-crested and long-crested wave and it may be necessary to decompose irregular waves into their regular wave components. The wave parameters will be transmitted wirelessly and may also be stored on the device.

3.2 Expected Printed Circuit Responsibilities

The device will use a variety of sensors which will need to be integrated using a PCB. It will use an accelerometer to measure wave effect and GPS to measure gross movement. It may also include a gyroscope as another method to input wave data. It will utilize long distance bluetooth or another close range wireless communication protocol to transmit the data collected. Additionally, it may be useful to store the data on external memory (SD card) that can be recovered in the event transmission fails. The device will use a battery and voltage regulator for power. It may also be necessary to include a dedicated signal processing unit as well. Finally, the device will include lights to demonstrate device power and distress, as well as buttons to control power and reset.
[1]

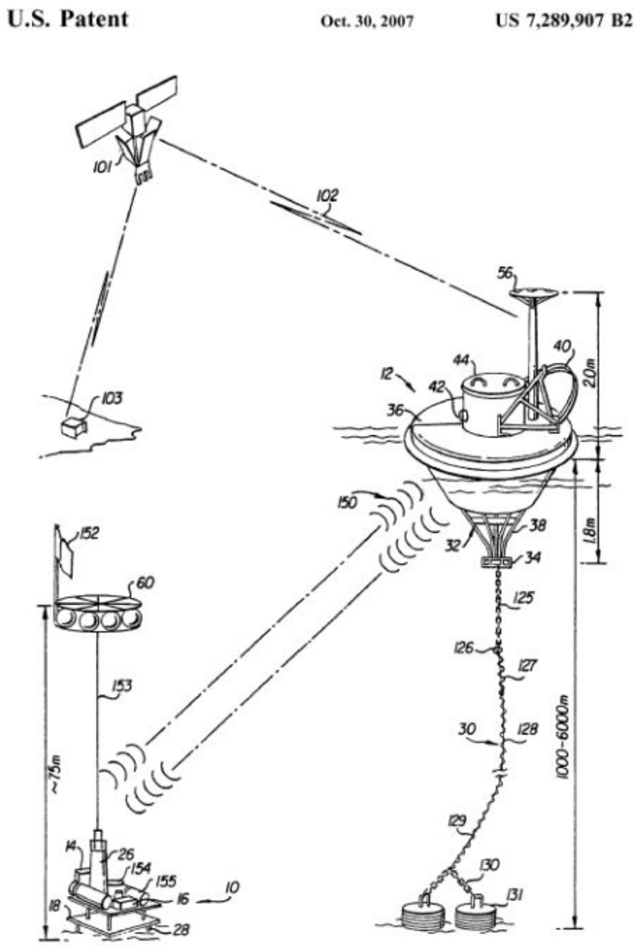
4.0 Market Analysis:

Offshore construction has played a significant role in the financial growth of oil, electricity, and gas industries. Offshore environments introduce the challenging problem of mitigating effects of ocean wave patterns on large structures, and often these structures employ tactics to shield themselves from harsh or resonant waves. The largest portion of offshore construction is in the oil rig industry, which, in the last two years, has produced revenues of over two million, according to *IBISWorld*'s industry statistics. The oil drilling and gas extraction industry alone creates annual profits of nearly 21 billion. Due to improvements on technology and techniques in the oil drilling and gas extraction industry, its profits and prevalence is expected to increase.
[2],[3]

5.0 Competitive Analysis:

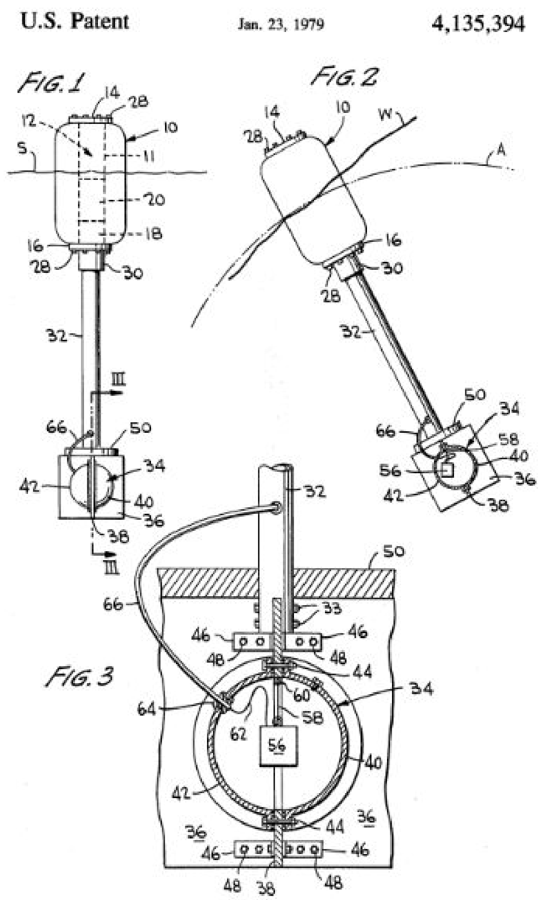
5.1 Preliminary Patent Analysis:

5.1.1 System for reporting high resolution ocean pressures in near real time for the purpose of Tsunami monitoring:



This system is the NOAA Deep ocean Assessment and Reporting of Tsunami (DART) system. It is used in a deep ocean environment to avoid coastal effects. Its application is primary tsunami prediction and warnings, as well as seafloor monitoring and satellite altimetry. The system was invented to prevent loss of life and property from tsunamis as well as to prevent false alarms, which cost millions of dollars. It has a reliability of >80%, can be deployed at 6000 m depth, and has a lifetime of >1yr. It samples every 16 seconds and has a report time of <3min. It contains a embedded computer and PCB that does data input/output, data storage, and detects tsunamis using an algorithm. It also contains a counting circuit, an acoustic modem and transducer for real time control and communication, a Digiquartz pressure sensor, a tilt sensor, and batteries. It has bi-directional communication abilities so that data can be corrected without retrieving the sensor. [4]

5.1.2 Wave measuring buoy



This device is a buoy used to measure amplitude and frequency of ocean waves. It contains a single axis accelerometer suspended in a waterproof casing. The accelerometer is located at the base of the buoy and measured the vertical acceleration of the buoy. This device was invented in response to the need for wave data in areas where there are no existing structures to mount measurement devices to. Prior to this buoy, there existed only large buoys that minimize pitch and tilt effects but are large and difficult to deploy. There were also smaller devices which use gyroscopes to keep accelerometers in a vertical position, but those are expensive. By suspending a single-axis accelerometer as a pendulum, this device is able to minimize effects of roll and pitch while still taking the necessary vertical acceleration data, but at a lower cost. The device contains a battery, an electronic re.bcorder, and an accelerometer. It is not clear if the device performs data transmission or if the data must be retrieved with the device.
[5]

5.1.3 System for Monitoring, Determining, and Reporting Directional Spectra of Ocean Surface Waves in Near Real-Time From a Moored Buoy:

U.S. Patent Jun. 5, 2012 Sheet 1 of 2 US 8,195,395 B2

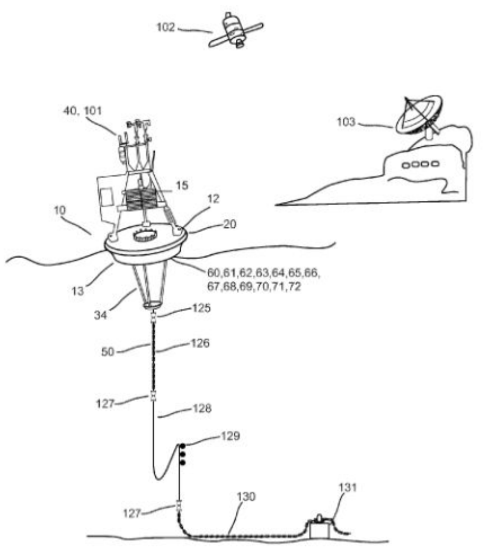


FIG. 1

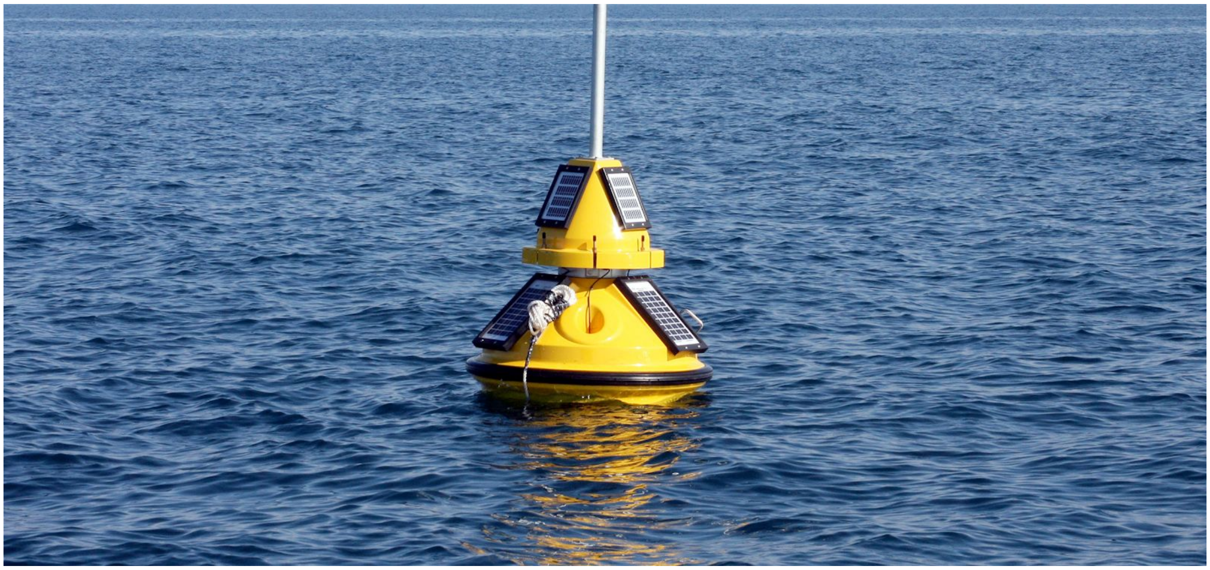
This device is a moored buoy which measures acceleration, pitch, roll, and magnetic flux of the buoy. The device contains a buoy, a mooring system, a data logger to control communication between the system and the on-board remote telecommunication system, an embedded computer for I/O, data storage, algorithms, accelerometer sensors, three orthogonal angular rate sensors, three orthogonal magnetometers, a telecommunications systems to connect to a shoreside processing system, and a shoreside processing system to determine wave parameters. This device fills the gap in the art for a device which generates a complete wave data spectra while compensating for accelerometer data noise due to pitch and roll. This device is most similar to our project.
[6]

5.2 Commercial Product Analysis:

5.2.1 Buoyweather :

The company Buoyweather provides wind and wave prediction for any part of the ocean and lake michigan. Their service provides a free 2day prediction and an up to 16 day paid prediction. They do not disclose how they collect their data. Their market includes fishing, offshore cruising, marine industries, and recreational ocean sports.
[7]

5.2.2 Michigan City Buoy:



Purdue University Civil engineering and Illinois-indiana Sea Grant currently operate a buoy that provides data every 10 minutes of the current weather, including wave period, wave height and wave direction. This bouy is the TIDAS 900, and is powered by solar panels, and is a moored buoy (anchored in single position). It is 3'8'' in diameter and 16'4'' tall. Its total weight is 565 lbs.
[8],[9]

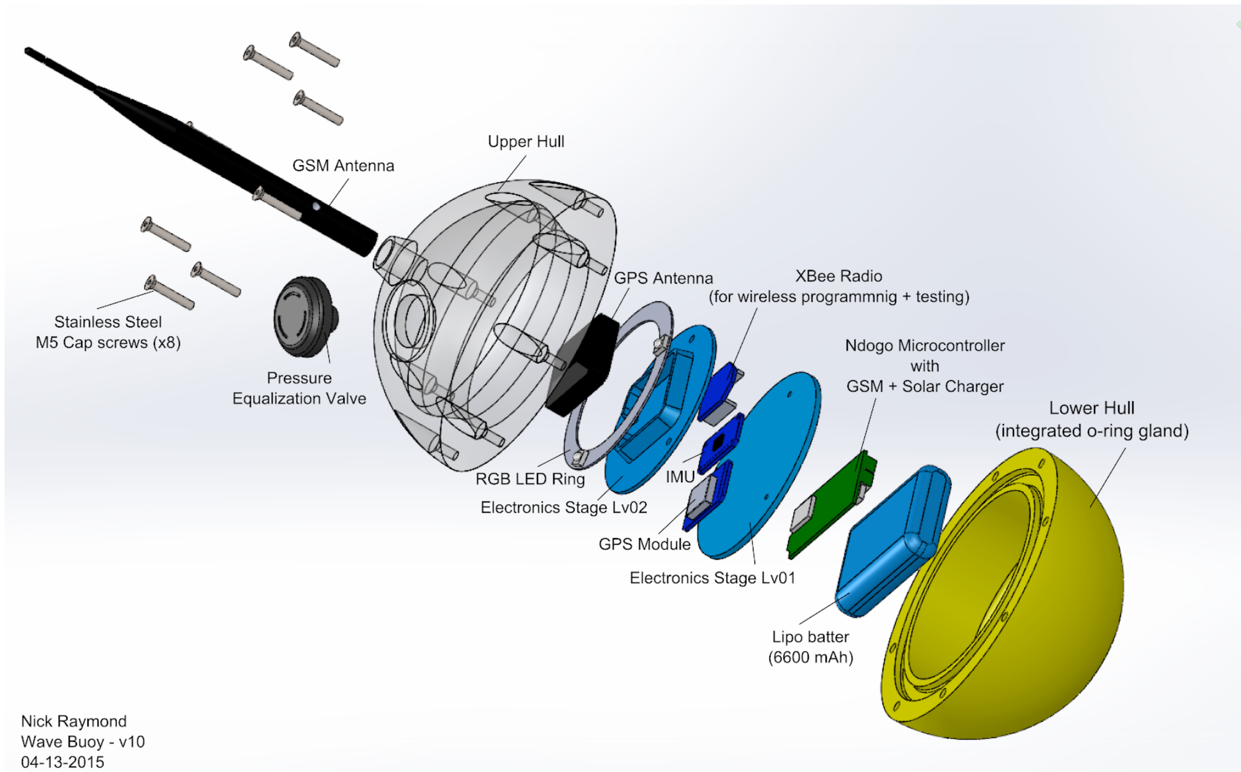
5.2.3 Spoondrift's Spotter:

The most similar product is Spoondrift's *spotter* they create a drifting data buoy. It communicates with satellites to relay data collected about wave height, peak period, direction, and its current location. It is powered via solar panels, is 16.4'' in diameter, and utilizes

"low-cost sensor technology". After retrieving the device, you can download all of it collected data off of an sd card. It's price is 6,995.00 USD.
[10]

5.3 Open Source Project Analysis:

5.3.1 Nick Raymond's Ocean Data Buoy:



A mechanical engineering graduate student at the University of California originally wanted to build a 3D printed buoy that could measure wave height and period data at a favorite surfing spot. Due to the lack of consistent ocean wave data in the local area, the project focused switched creating a network of multiple floating buoys to gather wave data for particular areas of interest. The buoy is designed to float at the surface and gather ocean weather information remotely as well as integrating temperature and salinity sensors.
[11]

5.3.2 Surfpy:
Github user mpiannucci, a ocean and software engineer, created a tool to analyze data buoy data. The project started in "Go" for speed reasons, but within the last two years transitioned to Python. His code includes polling for buoy data, tide events, wave modeling, and more. This would be useful for us to have a starting point for modeling our data.
[12]

5.3.3 Research on waves impact on offshore structures:

N. Harito's and S. Haver's both have research on waves and their effect on offshore structures. They have provided their mathematical modeling of waves the stress on structures. These two papers would be useful for our team by providing a deeper understanding of the impact of waves on structures, and how to interpret the data we collect.
[13],[14]

6.0 Sources Cited:

Internet Documents

1. W.R. Heinzelman, "Energy-efficient communication protocol for wireless microsensor networks" *IEEE,* Jan, 2, 2000. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/926982 [Accessed Spring, 2019]

2. IBISWorld, "US Specialized Industry Reports: Offshore Oil Rig & Platform Construction" *IBISWorld*, 2019. [Online]. Available: https://clients1.ibisworld.com/reports/us/industry/currentperformance.aspx?entid=4723 [Accessed Spring, 2019]

3. IBISWorld, "US Industry Reports (NAICS): Oil Drilling & Gas Extraction" *IBISWorld*, 2019. [Online]. Available: https://clients1.ibisworld.com/reports/us/industry/ataglance.aspx?entid=103 [Accessed Spring, 2019]

4. F. H. Middleton and L. R. LeBlanc, "Wave Measuring Buoy," 23-Jan-1979.

5. C. Meinig, S. E. Stalin, A. I. Nakamura, and H. B. Milburn, "System for Reporting High Resolution Ocean Pressures on Near Realtime for the Purpose of Tsumani Monitoring," 30-Oct-2007.

6. C.-C. Teng, R. Riley, and R. Bouchard, "System for Monitoring, Determining, and Reporting Directional Spectra of Ocean Surface Waves in Near Real-Time from a Moored Buoy," 05-Jun-2012.

7. Buoyweather, "Receive an accurate marine weather forecast for any GPS point." *buoyweather.com.* 2019. [Online]. Available: http://www.buoyweather.com/ [Accessed Spring, 2019]

8. Illinois-indiana Sea Grant, "IISG Michigan City Buoy" 2019. [Online]. Available: http://www.iiseagrant.org/buoy/ [Accessed Spring, 2019]

9. TIDAS Coastal Monitoring Buoys, "TIDAS 900 Specifications" *TIDAS*, 2016.[Online]. Available: *https://www.tidasbuoys.com/specifications* [Accessed Spring, 2019]

10. Spoondrift, "The Spotter Device" *Spoondrift*, 2019.[Online]. Available: https://spoondrift.co/ [Accessed Spring, 2019]

11. Nick Raymond, "Open Source Ocean Data Buoy Project" July, 2, 2018. [Online]. Available: https://opensourceoceanweatherbuoy.wordpress.com/ [Accessed Spring, 2019]

12. Matthew Iannucci, "Surfpy", *github.com/mpiannucci*, Feb 25, 2019. *Available: https://github.com/mpiannucci/surfpy* [Accessed Spring, 2019]
13. N. Haritos, "Modelling ocean waves and their effects on offshore structures" *Australian Earthquake Engineering Society,* 2010 [Conference] Available: https://pdfs.semanticscholar.org/f8c5/50f9821a526696d69a684820acbd3f0c49e7.pdf [Accessed Spring, 2019]
14. S. Haver, "Design of offshore structures: impact of the possible existence of freak waves" *Equinor ASA,* 2005. [Online]. Available: http://www.soest.hawaii.edu/PubServices/2005pdfs/Haver.pdf [Accessed Spring, 2019]

Appendix 1: Concept Sketch