ECE4011/ECE 4012 Project Summary

Project Title	**Robotic Sailboat System**
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Project Abstract (250-300 words)	The Robotic Sailboat System is one kind of unmanned surface vehicles (USV) which is designed to provide an effective ocean sampling capability. Current commercial products are too expensive and cannot achieve the best engineering tradeoffs because energy management prevents such USV from maintaining high speed and long operation duration simultaneously. Our design combines a hybrid energy supply system and open-source electronic prototyping platforms to gather and transmit data. It utilizes the Global Positioning System (GPS) and the long range wireless communication for navigation. Our robotic sailboat system has better energy management system and is marketed to track the route of the penguin and analysis the ocean conditions at a lower price. Additional energy resources and power efficient prototyping platforms make it possible. Better energy management leads to a higher speed and a longer operation duration. The long range wireless communication module enables real time data transmission and manual control. Current commercial products aim to be implemented in the research area, and therefore sold at a very high price. By lowering the prices, our device can be accepted by general research and protection of the penguins. Replacing normal sensors for research such as thermometers and anemometers with GPS tracking and cameras, scientists and environmentalists are able to utilize this product to track and analyze the conditions of the penguin's habitats. At the beginning stage of the design, the team will investigate an appropriate sailboat kit. Sensors and modules like IMU and GPS will be implemented to the sailboat. By the end of the development stage, the team will produce one complete built-up prototype which includes all possible energy resources and will also make sure the hybrid system is also able to be disintegrated. The device will be tested on a lake to demonstrate the speed, operation duration, and data sampling.

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List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	1). **I2C, Inter-Integrated Circuit.** Low-level peripheral bus in order to connect a wide range of sensors. 2). **SPI, Serial Peripheral Interface.** Synchronous serial interface which connects relatively higher speed sensors and MultiMediaCard/Secure Digital (MMC/SD) card. 3). **UART, Universal Asynchronous Receiver/Transmitter.** So-called serial port, a very easy way to utilize popular industrial communication device, including simple baud generator, transmitter and receiver. 4). **IEEE 802.15.4**. Basis of Zigbee. The telemetry protocol we will use for digital data communication. 5). **USB, Universal Serial Bus.** In the project, we will use USB to connect High-definition (HD) camera and other high-speed peripherals. 6). **TTL, Transistor–Transistor Logic.** Logic 0 is defined between 0V to 0.8V and logic 1 has range from 2.2V to 5V (Vcc). This standard will be used in our digital circuit design. 7). **SD, Secure Digital.** The type of nonvolatile memory card we will use to store sensor data and system logs.
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	1). **Energy Consumption.** The application requires the sail boat to cruise on ocean for a couple of months. Since the energy from the environment is limited, power management is required to reduce the consumption of the energy. 2). **Limited Budget.** The total budget is \$1000 so high-end or professional products are out of the budget. Inexpensive, on-shelf, and proven components are needed for the project. 3). **Accuracy of Sensors.** Civilian GPS modules have 10-meter accuracy, and mainstream MEMS Gyroscopes drifts with time. 4). **Limitation of Actuators.** On shelf servos have limited precision, speed and torque. For example, Turnigy 1370A has speed of 0.1sec/60º and torque of 0.4kg/cm. 5). **Extreme Cases**. Extreme cases like no-wind operation need to be considered, since the sailboat highly depends on wind energy. 6). **Limited Size.** Limited size of the boat constraints the possibility to install higher power energy harvesting devices. For instance, limited area of the sail and the solar panel can be mounted on the sailboat, and therefore the maximum harvested power is limited.

Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	1). **Battery Life vs. Self-discharge Rate.** Use rechargeable batteries instead of super capacitors. The rechargeable battery provides a more stable output voltage, and has much lower self-discharge than super capacitor does. Although super capacitor has almost an unlimited life cycle and shorter charging and recharging periods, it can not store energy for long time and is not suitable for the seawater environment. 3). **Computational Performance vs. Energy Consumption.** Use ARM mbed to handle sensor data collecting and navigation, and use Raspberry Pi only for Digital Signal Processing (DSP) algorithms. Performance is limited when using mbed but it consumes much less energy. 4). **Navigation Accuracy vs. Cost.** Differential GPS and higher-grade inertia sensing components can provide better navigation but the cost will blow up. Compromise is made to use conventional GPS module and mainstream Micro-Electro-Mechanical System (MEMS) Inertial Measurement Units (IMUs). Inexpensive gyroscopes drift a lot. As a result, accelerator and digital compass are required to compensate the error. Also, even with a cheap, conventional GPS module, better antenna along with Low-noise amplifier (LNA) can increase the number of satellites from which we receive signals. 4). **Actuator Performance vs. Cost.** Use on-shelf RC servos instead of professional system including stepper motor, gearbox and shaft encoder system. By doing this, we don't need to worry about the feedback control of the actuators, all we need to do is to send the desired angle to the servo. This trade-off will significantly reduce complicity of the system even though it is less accurate and efficient. 5). **Wireless Communication Performance vs. Cost.** Most of the satellite data communication transceivers are beyond budget. So we are using alternate solution instead of satellite to reduce cost. However, this trade-off greatly limits the range. Most satellite system such as Iridium can provide global access, but the range of our alternate solution is limited by transmitting power, receiver sensitivity and operating environment.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	For the energy source of the boat, the team will use solar energy as a starting point and try other source like wind energy based on the project progress. Because of that, the power consumption of on-board electronics will be strictly limited, so the team decides to use ARM mbed as a low-power platform for processing and navigation. **The inputs of the system are:** 1. Wind speed and other sensor data collected via several peripheral buses for later analysis. 2. The destination longitude and latitude received via wireless module. 3. Location information from GPS module for navigation purpose. **The outputs of the system are:** 1. Pulse Width Modulation (PWM) actuator command signal computer by mbed for wing and rudder servos. This signal is used to drive the sailboat to desired destination. 2. Sensor data processed by SBC will be sent to base station via wireless communication device.