Task 2. Transpacific Yacht Race—Sailboat-mounted Ocean and Atmospheric Sensors

Proposed and Sponsored by: X2nSat

Your team has the opportunity to design an ocean/atmospheric monitoring device that can be used globally for years to come to understand climate and ecosystem changes.

Background

Each year, trans-Pacific Ocean sailboat races, such as the Pacific Cup Race (in even years) and the Transpacific Yacht Race (a.k.a. Transpac) (in odd years) attract 60+ sailboats in multi-day journeys from California to Hawaii. Mounting environmental sensors on the sailboats provides a unique opportunity to collect oceanic and atmospheric data that can contribute long-term to the understanding of global ecosystems.

Since the races are held regularly at the same time of year, and boats travel somewhat different paths as they sail across the Pacific, this yields an opportunity to collect large amounts of multi-dimensional data over time. X2nSat's advanced satellite communication technology will make it possible for your team to communicate data in real-time or near-real-time during a trip across the Pacific Ocean.

For over twenty years, X2nSat has been at the forefront of satellite communications technology. In 2003, the network operator became the first to build a network capable of bringing broadband internet to ships at sea. Today X2nSat is known as the Satellite of Things, continuously innovating communication solutions where previously not thought to be possible.

Historically, collecting data at sea has been expensive and difficult. Typically, one of two methods of collecting data are employed: buoys are deployed to permanently monitor oceanic data in fixed locations, or costly research vessels are periodically hired to collect data. Sailboat races provide a particular advantage to collecting data economically over time because 1) the boats are already traversing the ocean on annual or biennial cycles, thus reducing the need for high-cost research vessels; 2) each boat travels a unique route, creating a broad swath over which data can be collected, as opposed to the single-point buoy sensors currently used.

"We are always looking to test the capabilities of our communications," said Garrett Hill, CEO of X2nSat. "We believe that showing satellite's ability to maintain live readings while in the middle of the Pacific Ocean, thousands of miles from land, will be something incredible."

In this task, teams are challenged to collect up to three specific types of data. The choice of data should significantly contribute to the understanding of global environmental issues.

<u>Data that interest climate-change researchers include:</u>

1. Water temperature measured at regular intervals down to 30' depth (or more challenging: to 60' depth)
2. Water pH (an indicator of acidification and directly correlated with CO_2)
3. Electrical conductivity (a measure of salinity)
4. 'Chlorophyll a' content (an indicator of phytoplankton that respond rapidly to global climate change)
5. Bacteria content (species-dependent climate-change indicators)
6. Water oxygen levels (reveals anoxic conditions; measurable if bubbles due to the boat can be minimized).
7. Other oceanic/atmospheric data of your choosing

Each team is challenged to rely on their own ingenuity to identify environmentally significant data to collect and should consider data types that are not specifically mentioned in this task. Once the data type(s) are chosen, your team will design and/or procure the sensors needed to collect the data, build a device to contain the sensors while on a sailboat, and use a data logger to send data to X2nSat's satellite communications device.

Significant to this challenge is the requirement of sending the data in real-time, or near-real-time, to the mainland via satellite. Historically, it has been difficult to send signals to satellites in remote areas, such as regions of the Pacific Ocean. Today, X2nSat's satellite technology not only makes this possible but increases the opportunities to explore satellite communications in remote areas across the earth. X2nSat will provide the satellite equipment capable of transmitting sensor data back to the mainland.

Data collection will be challenging and should consider that the boat will be traveling almost constantly while data is being collected. Note that any sensor that is deployed in the water or air must minimize drag on the boat. Data to be collected at a particular water depth must ensure and confirm that the sensor remains at the specified depth at expected travel speeds. Data-collection devices should be low-maintenance, as the crew will be busy trying to win a race. If samples will be collected, it would be advantageous for sensors to analyze the data immediately after collection, without the need to bring samples back to shore.

Multidisciplinary Teams

This oceanic/atmospheric monitoring project is ideal for a multidisciplinary project. It would benefit from the expertise of students in electrical, mechanical, and environmental engineering; computer science; environmental science; biology; climatology; etc.

Problem Statement

Teams are challenged to research, evaluate, design, and demonstrate a data-collection device capable of traversing the Pacific Ocean on a sailboat.

The device should carry up to three sensors that contribute to the understanding of global environmental issues. Sensors may be designed by the teams or purchased.

X2nSat will provide a device (described below) that will send the data to the mainland via satellite during the boat's voyage.

Pre-Contest Field Trials

X2nSat will offer pre-contest field trials in the San Francisco Bay in March-April 2021, allowing teams to test and fine-tune their designs prior to the contest. Teams that choose to ship their sensor to X2nSat for testing will be linked to a video interface to observe the performance of their device.

After the contest, select team(s) will be invited to have their design(s) mounted on a boat that sails in the Transpac 2021. X2nSat will assist the selected teams in conducting post-contest field trials to enable teams to make design refinements prior to the July 2021 race. If Transpac logistics prohibit sailing in 2021, another trans-Pacific sailboat venture will be arranged.

Boat Parameters and Dimensions

- Expected Transpac route: from Point Fermin in Los Angeles to just south of Diamond Head, Honolulu.
- Transpac travel distance: approximately 2225 miles
- Depth of boat hull = 9 feet
- Average boat travel speed: 7.6 knots
- Boat length: 44 feet LWL, 48 feet LOA
- Boat width: 12 feet
- Boat weight: approximately 24,000 lb.
- Boat mount locations and dimensions: The first choice for mounting your equipment will be the fixed stainless-steel lifelines rail at the rear of the boat. A simple clamp can be used to secure to the rail. Specifications will be made available at a later time.

Satellite Communications Parameters

- The X2nSat-provided equipment will have several interfaces available for use with your device. These include RS-232, RS-422, RS-485, USB, Ethernet, and Bluetooth.
- The device provided by X2nSat has a small amount of CPU and storage available.
- You may choose to focus just on the sensor, or you may also build a data-logger that records the values sent by the sensor.

Design Parameters

- Teams will design one device that is equipped to measure up to 3 different environmental parameters.
- The device should require little maintenance or tending from the sailboat crew.
- Devices and mountings must allow for quick and easy replacement.
- The device must be connected to a flexible line that can be rolled up into the boat for maintenance and have a quick-disconnect feature and/or be easily cut in case of an emergency.
- The device and line must avoid the prop/rudder area of the boat.
- The device should not interfere with the sailing apparatus or safety systems on the boat.
- Sensors and mountings must be built in a robust fashion to weather storms and voyages 2000+ miles.
- If samples are collected during the voyage, sensors should analyze collected samples immediately after collection, rather than storing them on the boat, if possible.
- The team-provided data logger must send out data that is compatible with the X2nSat-provided communication device. (*See Satellite Communications Parameters, above*).
- Teams should provide 3-5 duplicate versions of the device. At least one of these will be used during the bench-scale discussion with the judges; the remainder will be used for back-ups in case of damage/failure.

Design Considerations

Your proposed design should provide specific details and outcomes as follows:

- Contribute to the understanding of climate change and the environment.
- Provide a schematic diagram and technical specifications for the device and each sensor.
- Provide data flow diagrams for the sensors and data logger.
- Establish a protocol for determining proper sensor functioning/malfunctioning.
- Provide results from fluid dynamics studies that estimates the effect of the device on fluid flow at expected sailboat travel speeds.
- Calculate the overall drag on the boat due to your sensor-carrying device.
- Calculate the difference in travel time between a sailboat that carries the device and one that does not carry it. Use the Boat Parameters and Dimensions above. (Racers want to know how much time it will cost them to carry the device.)
- Confirm the integrity and/or environmental safety of the sensor and its mountings. Consider that the device may be under constantly changing loads due to sailing conditions.
- Estimate the capital expenses (CAPEX) and operating expenses (OPEX) to build a set of sensors for full-scale deployment of 50 sailboats. Assume that all boats will have the same mounting dimensions. Items to include in your calculations may be items such as materials, equipment, building use, land use, labor costs, mounting time, back-up sensors, sacrificial components, and energy requirements and costs (assuming industrial electricity rates), etc.
- Identify and address any potential environmental impact of your device while in use or if lost at sea.
- Document success in improving energy efficiency, pollution prevention, and/or waste minimization, as it applies to your project to qualify for the P2E2 Award. Place this in a separate section of the report.
- Discuss your plan's adherence to appropriate federal (USA), state and local laws and regulations. Attend WERC's webinar for helpful tips for addressing regulatory issues. (See website or email us for webinar info.)
- Include a Public Involvement Plan, as applicable (See Team Manual).
- Address safety aspects for the crew. Safety issues should be addressed in both the written report and the Experimental Safety Plan (ESP). Be sure to attend WERC's webinar for helpful tips for addressing health and safety issues. (See website or email us for webinar info.)
- Discuss any intangible benefits of the sensor.

Bench-Scale Demonstration

Your team's sensor will be tested under conditions that simulate a sailboat voyage.

The bench-scale demonstration will include mounting your device on a boat and traveling at speeds comparable to Transpac speeds. Judges will test for adherence to the Design Parameters and Design Considerations (above). Testing may also include testing in a wind tunnel or a water tunnel.

Details of the testing depend on the specific device that your team designs and will be determined after the Preliminary report is reviewed.

Technical Report Requirements

The written report should demonstrate the team's insight into the full scope of the issue and include all aspects of the problem and proposed solution. The report will be evaluated for writing quality, organization, clarity, reasoning, and coherence. Standards for publications in technical journals apply. In addition to the listed requirements, your report must address in detail the items highlighted in the Problem Statement, Design Considerations, Evaluation Criteria and 2021 Team Manual.

Preliminary Report

To ensure that your team's submission will be competitive and to help WERC prepare to test your device, each team will submit a preliminary report to X2nSat. The report should be no longer than a page or two and include:

- a list of all sensors, and their purpose
- a drawing of your device
- a diagram showing how your device will be mounted on the boat
- a description of how the device will be replaced while in transit, should it get damaged
- other considerations, such as plans for communication between your data logger and the satellite communication device.

Evaluation Criteria

Each team is advised to read the 2021 Team Manual for a comprehensive understanding of the contest evaluation criteria. The Public Involvement Plan is included in the Team Manual.

Additionally, your proposed solution will be evaluated on the following:

- Technical fundamentals, performance, safety, and other issues stated in the problem statement
- Potential for real-life implementation
- Thoroughness and quality of the economic analysis
- Originality, innovativeness, functionality, ease of use, maintainability, reliability, and affordability of the proposed technology
- How well the design can be mass-produced
- The quality and environmental value of the final product
- Other specific evaluation criteria may be provided at a later date.

FAQs/Deadlines

- Teams are expected to watch for FAQs online for any updates in the task requirements. (wercdesigncontest.nmsu.edu)
- Due 25 January 2021: Preliminary Report (the report may be submitted earlier, if desired)
- Due 1 February 2021: Experimental Safety Plan (ESP).
- March-April 2021: Pre-contest field trials in San Francisco Bay
- Due 29 March 2021: Written Report

Awards

Each year, the WERC Environmental Design Contest and its sponsors award more than $25,000 in cash prizes. Successful completion of every stage of the design project qualifies each team for the following awards.

1. Task awards (First, Second, Third Place; minimum amounts: $2500-$1000-$500, respectively).
2. Specific to this task, the prize package includes mounting select sensor(s) on a sailboat to travel across the Pacific Ocean in July 2021 as a part of the Transpac Race. A different sailboat venture will be substituted if Transpac logistics prohibit competing in 2021.
3. Virtual Desktop Study Awards (awarded independently of the full bench-scale designs). Amounts TBA.
4. WERC Resources Center Pollution Prevention/Energy Efficiency Award (P2E2 Award) ($500)
5. Judges' Choice Award ($500)
6. Peer Award ($250)
7. Terry McManus Outstanding Student Award. ($500-$1000, according to funding).

Additional awards may be announced at a later date.

Award amounts listed are minimum amounts and may increase with available funding.
Detailed criteria for each award are listed in the 2021 Team Manual:
https://iee.nmsu.edu/outreach/events/international-environmental-design-contest/guidelines/