REQUIREMENTS SPECIFICATION

Autonomous Water Quality Sampler (AWQuSam)

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1. SCOPE

1.1 Introduction

This document establishes the requirements and specifications for the Autonomous Water Quality Sampler, hereafter referred to as the AWQuSam.

1.2 Statement of Problem

There is a need for water quality and hydrographic data from the coastal environment in order to understand the processes that mix and transport nutrients, carbon, pollutants, and other material entering the ocean from sources on land.

Ship-based measurements are expensive because of the operating cost for a sea-going vessel and crew. New platforms for sampling the ocean at high resolution are being used now in many coastal regions around the United States. These platforms, called gliders, are roughly torpedo shaped and, like gliders in the atmosphere, have a relatively large glide ratio in order to translate vertical motion into horizontal distance.

In the shallow environment of the Florida shelf, there is no room for large vertical excursions to provide for the buoyant force to drive the horizontal motion and gliders are not practical.

A new kind of platform is needed that moves across bays and estuaries and measures key water quality parameters like temperature, salinity, etc.

1.3 System Description

The AWQuSam supports the gathering of water quality and hydrographic data along Florida's coastal environment. The AWQuSam consists of hardware and software items which satisfy the requirements of this specification. It employs means that facilitate acquisition of useful scientific data, such as temperature and salinity, in the shallow environments off the Florida shelf. A GPS system will also be incorporated into the AWQuSam for use by the navigation, guidance and recovery systems. In addition to the AWQuSam, a base station will be developed in order to stream commands and/or data with the AWQuSam. The main feature of the AWQuSam is for it be capable of remaining autonomous for the duration of the trip.

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein.

NFPA 70: National Electric Code

IEC/UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

The Apalachicola Estuarine System Site Characterization, A River Meets the Bay. December 2008.

3. REQUIREMENTS SPECIFICATION

3.1. OPERATIONAL REQUIREMENTS

3.1.1 Environment

3.1.1.1 Salt Atmosphere

The AWQuSam shall not suffer any degradation of performance when operated in and when stored in a salt fog atmosphere.

3.1.1.2 Solar Radiation

The AWQuSam shall not be damaged by extended exposure to sunlight.

3.1.1.3 Humidity

The AWQuSam shall be operable in a hot, humid environment with a diurnal cycle peak of 100% humidity.

3.1.1.4 High Temperature

The AWQuSam shall be fully operable at a continuous, ambient temperature of +55°C, and shall suffer neither damage nor degradation due to storage at a temperature of +70°C.

3.1.1.5 Low Temperature

The AWQuSAm shall be fully operable at a continuous ambient temperature of -5°C, and shall suffer neither damage nor degradation due to storage at a temperature of -20°C.

3.1.1.6 Rain and Water

The AWQuSam shall operate and remain functional during driving rain. The vehicle instrumentation shall not suffer any damage from waves up to 1m in height.

3.1.1.7 Water Immersion

The AWQuSam shall remain functional after water immersion to a depth of up to 2m.

3.2. FUNCTIONAL REQUIREMENTS

3.2.1 Instrumentation

3.2.1.1 Guidance and Navigation

3.2.1.1.1 The AWQuSam shall be able to navigate a path of at least 10km in length (*See 3.2.5.1*)

3.2.1.1.2 The AWQuSam's autonomous guidance and navigation system must be able to plot its trajectory based on GPS reference points, obstacle information, and wave, wind and current data uploaded to it from the base station.

3.2.1.1.3 The AWQuSam will be able to perform collision avoidance tactics.

3.2.1.1.4 The AWQuSam guidance and navigation system shall be aware of the propulsion systems steering angle and speed at any given time.

3.2.1.2 Measurement

3.2.1.2.1 The AWQuSam shall possess the ability to measure, at a minimum, the following parameters:

- Water Temperature
- Water Salinity
- Position

3.2.1.2.2 [Optional] In the future, it may be desirable for the AWQuSam to possess the ability to measure the following parameters:

- pH
- Water Turbidity
- Dissolved Oxygen
- Nitrates

3.2.2 Data Handling

3.2.2.1 Data Logging

The AWQuSam shall have the ability to log and maintain all data obtained during the mission.

3.2.2.1.1 The AWQuSam shall record, at a minimum, the following parameters:

- Position
- Water Temperature
- Water Salinity

3.2.2.1.2 [Optional] In the future, it may be desirable for the AWQuSam to be capable of recording the following parameters:

- Distance traveled
- Duration of mission
- pH
- Turbidity
- Oxygen
- Nitrates

3.2.2.2 Data Acquisition

All recorded data shall be downloadable onto a base station system for analysis.

3.2.3 Power Management

3.2.3.1 The AWQuSam shall include manual means to place all hardware components into an on/off mode.

3.2.3.2 The AWQuSam shall not require tethering to an external power source during a mission.

3.2.3.3 The AWQuSam shall be operable for at least 12 hours.

3.2.3.4 [Optional] The AWQuSam shall report propulsion systems power level status when it detects the level has fallen to 10% of capacity.

3.2.4 System Interface

3.2.4.1 Wireless Transmit

3.2.4.1.1 Real-time Data Transfer

Data recorded via AWQuSam shall be transmittable to a base station receiver over a maximum distance of no less than 5km.

3.2.4.1.1.1 Data Transfer Rate

A sample of data recorded via AWQuSam shall be transmitted to a base station receiver at a rate of approximately 3.33 mHz (*See 3.2.5.2*)

3.2.4.1.2 Wireless Receive

3.2.4.1.2.1 [Optional] Real-time Commands

At some point, it may become desirable to transmit commands from a base station transmitter to the AWQuSam. In this event, commands shall be receivable over a maximum distance of no less than 5km.

3.2.4.1.2.1.1 [Optional] Emergency Stop

In the future, it may become desirable to transmit an emergency stop command from

a base station transmitter to the AWQuSam. If implemented, this command shall cause the AWQuSam to stop navigating its presently programmed path and return to the starting point.

3.2.5 Programmability

3.2.5.1 Configurable Paths

Navigation path must be programmable with GPS coordinates before each mission.

3.2.5.1.1 Navigation path shall, at a minimum, consist of starting point, one waypoint, and finishing point.

3.2.5.1.2 Untrained personnel shall be able to program a new mission path into the AWQuSam with only the aide of instructional documentation.

3.2.5.2 [Optional] Configurable Transmission Rate

In the future, it may become desirable to configure the rate at which sampled data is sent to the base station.

3.3. PERFORMANCE REQUIREMENTS

3.3.1 Speed

3.3.1.1 Average Speed

(*See 3.4.4.1*)

3.3.2 Throughput

3.3.2.1 Recording Rate

The AWQuSam shall record data at a sampling rate of no less than 8 Hz.

3.3.3 Stability

3.3.3.1 Winds

The AWQuSam shall remain operable and maintain its heading in winds of up to 40 knots.

3.3.3.2 Current

The AWQuSam shall remain operable and maintain its course in currents of up to 5 knots.

3.3.4 Buoyancy

3.3.4.1 Salt Water

The AWQuSam shall be able to float at the surface of the water indefinitely.

3.3.5 Precision

3.3.5.1 Salinity

Salinity recorded by AWQuSam shall be precise to 0.01ppt.

3.3.5.2 Temperature

Temperature recorded by AWQuSam shall be precise to 0.01°C.

3.4. STRUCTURAL REQUIREMENTS

3.4.1 Weight

3.4.1.1 The total weight of the AWQuSam shall not exceed 18kg.

3.4.2 Size

3.4.2.1 The AwQuSam dimensions shall not exceed:

- Length: 1.2m
- Width: 0.8m
- Height: 0.5m (excluding antennas)

3.4.3 Transportability

3.4.3.1 The AwQuSam design shall incorporate handles to facilitate easy transportation by one or two people.

3.4.4 Propulsion/Steering

3.4.4.1 The propulsion system shall be capable of propelling the AWQuSam at an average speed of no less than 5 knots.

3.4.4.2 The propulsion system shall be capable of enduring continuous usage for at least 12 consecutive hours.

3.4.4.3 The propulsion system shall be submersible and its housing, water tight.

3.4.4.4 Steering system shall be reliable, clutter free, and simple.

3.4.4.5 In ideal conditions, the turning radius shall be no more than 3m.

3.4.5 Robustness

3.4.5.1 The AWQuSam shall withstand an accidental collision with a small boat and scraping with oyster bars.

3.4.6 Casing

3.4.6.1 All internal components shall be easily accessible when out of the water;

however, when in operation all seals shall be water tight indefinitely.

3.5. SUSTAINABILITY REQUIREMENTS

3.5.1 Safety

3.5.1.1 Electrical Safety

The AWQuSam shall meet the electrical safety provisions identified in NFPA 70: National Electric Code.

3.5.1.2 Mechanical Safety

The AWQuSam shall include the mechanical safety provisions specified in UL 61010. Adequate provisions and markings for handling shall be provided on system components where necessary.

3.5.1.3 Ionizing Radiation

Use of radioactive materials shall be kept to an absolute minimum. If radioactive materials are determined to be required, the least hazardous type and form of radioisotope shall be selected.

3.5.2 Reliability

3.5.2.1 The AWQuSam shall be expected to operate with a Mean Time Between Failure of 2400 hours. A reliability failure is defined as any hardware or software failure (event) that results in the inability for the overall AWQuSam system to receive and process information from the sensors.

3.5.3 Maintainability

3.5.3.1 Serviceability

The AWQuSam shall be serviceable by an untrained person utilizing maintenance documentation.

3.5.3.2 Preventive Maintenance

The AWQuSam shall be easily disassembled, cleaned, and reassembled, with the aid of maintenance documentation.

3.5.4 Marking

3.5.4.1 The AWQuSam shall include identification that specifies the item name, user agency, and relevant contact information. Identification shall be located to prevent interference with operation of the system.

3.6. NONFUNCTIONAL REQUIREMENTS

3.6.1 Documentation

3.6.1.1 The AWQuSam shall be delivered with documentation detailing instructions for programming new paths.

3.6.1.2 The AWQuSam shall be delivered with documentation detailing instructions for performing maintenance and service of system or components.

3.7. CONSTRAINTS

3.7.1 Budget

3.7.1.1 An AWQuSam prototype shall be developed with expenditures not to exceed $1000. Additional funding may be provided, with customer approval.

3.7.2 Timeline

3.7.2.1 An AWQuSam prototype shall be ready for demonstration before customer no later than April 13, 2012. This demonstration shall highlight concordance with the requirements of this specification.

4. VERIFICATION

4.1. OPERATIONAL VERIFICATIONS

4.1.1 Environment

4.1.1.1 Salt Atmosphere

The AWQuSam shall be subjected to the saline coastal atmosphere for 48 hours. Following exposure, all electrical connector covers, and any ancillary covers shall be opened or removed. Verify the AWQuSam does not show evidence of corrosion, erosion or pitting. Verify the AWQuSam completes a functional checkout.

4.1.1.2 Solar Radiation

The AWQuSam shall be subjected to not less than two (2) continuous diurnal cycles of solar radiation. The direction of the solar radiation shall be incident to the top of the AWQuSam in the normally installed orientation. Verify the AWQuSam passes a functional checkout during the peak cycle temperature and post-test.

4.1.1.3 Humidity

The AWQuSam shall be subjected to not less than two (2) three-hour cycles of exposure to humidity levels of 95 ±4%. During the first period of exposure, the AWQuSam shall be powered off. Perform a functional checkout at the end of that cycle. During the second period of exposure, the AWQuSam shall be powered on. Verify the AWQuSam passes a functional checkout following the cycle. Also, verify that no visual damage has occurred to the AWQuSam.

4.1.1.4 High Temperature

The AWQuSam shall be subjected to one 24-hour typical diurnal cycles with temperatures proportionally adjusted such that the lowest temperature shall be +25°C and the highest temperature shall be +55°C. During this test, the AWQuSam shall be in operating configuration and powered on. Following completion of this test, verify that the AWQuSam is still operating functionally.

Then, the AWQuSam shall be subjected to not less than two (2) 24-hour typical diurnal cycles with temperatures proportional adjusted such that the maximum temperature is 70°C. The AWQuSam shall be in storage configuration and powered off during this test. Following exposure to high temperature storage conditions, verify that no visual damage has occurred. Verify conformance with a post test functional checkout.

4.1.1.5 Low Temperature

The AWQuSam shall be subjected to one 24-hour typical diurnal cycles with temperatures proportionally adjusted such that the lowest temperature shall be -5°C and the highest temperature shall be +15°C. During this test, the AWQuSam shall be in operating configuration and powered on. Following completion of this test, verify that the AWQuSam is still operating functionally.

Then, the AWQuSam shall be subjected to not less than two (2) 24-hour typical nocturnal cycles with temperatures proportional adjusted such that the minimum temperature is -20°C. The AWQuSam shall be in storage configuration and powered off during this test. Following exposure to low temperature storage conditions, verify that no visual damage has occurred. Verify conformance with a post test functional checkout.

4.1.1.6 Rain and Water

Weigh the AWQuSam. Then, subject the AWQuSam to 30 minutes of rain falling at a rate of no less than 5cm/hr. The wind velocity for this test shall be 10 m/s. After the test, weigh the AWQuSam again. The weight shall remain unchanged ±0.1%. Verify the AWQuSam completes a functional checkout.

4.1.1.7 Water Immersion

Weigh the AWQuSam. Place the AWQuSam in operating conditions (with all seals sealed and connectors capped). Immerse AWQuSam in water such that the upper-most point is maintained at a depth of 1m beneath the surface of the water for 5s. Following immersion, verify the AWQuSam completes a functional checkout. Wait 24 hours and weigh the AWQuSam again. The weight shall remain unchanged ±0.1%. If water intrusion has occurred, the AWQuSam shall be opened to determine the probable point of water entry.

4.2. FUNCTIONAL VERIFICATIONS

Basic Functional Test

Program the AWQuSam with starting point, one waypoint, and finishing point. Verify the AWQuSam successfully arrives at the finishing point. Verify the AWQuSam measures and records position, water temperature, and water salinity.

Comprehensive Functional Test

Power on the AWQuSam. Program the AWQuSam with starting point, one waypoint, and finishing point. The length of the mission shall be no less than 10km.

Verify the AWQuSam successfully arrives at the finishing point and that the mission occurred at an average speed of no less than 5 knots. Upon arrival at finishing point, allow AWQuSam to keep recording data until the mission duration is twelve hours.

Verify the AWQuSam measures position, water temperature, and water salinity at a rate no slower than that outlined in Requirement 3.3.2.1.

Verify the AWQuSam records position, water temperature, and water salinity for the entire duration of the mission with precision outlined by Requirement 3.3.5.

Verify that one sample is transferred to a base station receiver approximately every 5 minutes. Also, verify that all recorded data is offloadable for analysis on an analysis

computer.

Satisfies Requirements: 3.2.1.1, 3.2.1.2, 3.2.2.1, 3.2.2.2, 3.2.3.1, 3.2.3.2, 3.3.3.3, 3.2.4.1, 3.2.5.1, 3.3.1.1, 3.3.2.1, 3.3.5.1, 3.3.5.2

4.3. PERFORMANCE VERIFICATIONS

4.3.3 Stability

Place AWQuSam in water. While AWQuSam is operating, it shall be subjected to variable winds with maximum speed of 40 knots. AWQuSam shall not capsize. It should continue along its programmed course.

4.3.4 Buoyancy

The structure of the vehicle with placebo masses to simulate electronic components shall be placed in salt water. The structure shall be able to remain stable and on the surface at all times taking into account waves and currents. Device antennas shall always be pointing upward.

4.4. STRUCTURAL VERIFICATIONS

4.4.1 Weight

The AWQuSam will be put on a scale and weighed. Different components shall be weighed before assembly to ensure final product will be within the 18kg limit.

4.4.2 Size

The AWQuSam shall be measured with a measuring tape and compared to the standard measurements of the interior of a van.

4.4.3 Transportability

Handles shall be subjected to rigorous testing to verify their strength.

4.4.4 Propulsion/Steering

Handling characteristics shall be tested in a body of water with remote control. A small jon boat may be operated alongside AWQuSam for more rigorous testing.

Steering shall be tested in light currents similar to the ones experienced along Florida's Gulf coast.

The AWQuSam shall successfully navigate around two bouys that are 3m. apart.

Prior to production, AWQuSam's steering system will be rigorously tested to identify any vulnerabilities.

4.4.5 Robustness

The structure of the AWQuSam and its joints shall be submitted to stress tests that are not yet specified.

4.4.6 Casing

Casing alone shall be tested by submerging in water 3m for 1 minute. Casing should remain water tight.

4.5 SUSTAINABILITY VERIFICATIONS

4.5.1 Safety

4.5.1.1 Electrical Safety

Verify that the AWQuSam complies with the electrical safety provisions identified in NFPA 70.

4.5.1.2 Mechanical Safety

Verify the AWQuSam meets mechanical safety provisions specified in UL 61010. Verify any required safety markings are included on the AWQuSam. Verify the AWQuSam has no unnecessary raw, sharp, or rough adges that would create a safety hazard.

4.5.1.3 Ionizing Radiation

Verify radioactive materials, if used, are the least hazardous type and form of radioisotope. Verify that any optical products (including lens elements and fiber optics) contain no thorium or other radioactive source materials in excess of 0.05 percent by weight (500 ppm).

4.5.2 Reliability

Verify the reliability requirement via analysis of hardware and code.

4.5.3 Maintenance

Simulate natural fouling. Using only maintenance documentation, attempt to clean AWQuSam. Difficulty and duration of maintenance service shall meet or exceed customer requirements.

4.5.4 Marking

Verify the AWQuSam contains identification markings that specified item name, user agency, and relevant contact information. Verify the identification markings do not interfere with operation of the AWQuSam.