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**NUTRIENT SENSOR CHALLENGE**  
**REQUEST FOR TECHNOLOGIES**  
**FOR**  
**ACT VERIFICATION TESTING**  
September 18, 2015

**SUMMARY**

**Background:** The Nutrient Sensor Challenge is a global competition to incentivize the development and production of accurate, reliable, and affordable nutrient sensors to profoundly improve our ability to understand and measure aquatic nutrient pollution.

Similar to all past ACT Technology Verifications, instrument performance will be evaluated in laboratory and field tests against reference water samples analyzed using EPA-approved standard methods.

Unlike previous ACT technology verifications, entries will be **judged** on accuracy, precision, range, deployment length and cost by an independent panel of judges of impartial, highly qualified experts with relevant backgrounds in order to address all of the requirements of the competition.

**Eligibility to Apply:** The Challenge is open to technology developers globally. To be eligible for ACT verification testing, **all** interested parties must complete and submit an application package. This requirement applies to developers who registered of the Challenge and/or participated in the optional Beta Testing phase as well as any new applicants. The application must be approved and accepted by ACT in order for a developer to participate in verification testing and be considered in the Challenge. The developer must comply with all the terms of the **Challenge Guidelines**; successful applicants must sign a **Participant Agreement**.

**Application Package:** A complete application package must include a signed cover letter, completed application form, and attached supplementary documents. The application form may be downloaded from [www.nutrients-challenge.org](http://www.nutrients-challenge.org). The application package must be submitted via email to [info@nutrients-challenge.org](mailto:info@nutrients-challenge.org).

**Application Deadline:** December 18, 2015, 5:00 p.m. EST.

**Additional Information:** Additional details and downloads of the **Challenge Guidelines** and the **Application Form** can be found at [www.nutrients-challenge.org](http://www.nutrients-challenge.org) and [www.act-us.info](http://www.act-us.info). More information can also be obtained by contacting Drs. Tom Johengen ([johengen@umich.edu](mailto:johengen@umich.edu)), Beth Stauffer ([stauffer@louisiana.edu](mailto:stauffer@louisiana.edu)) or Mario Tamburri ([tamburri@umces.edu](mailto:tamburri@umces.edu)).

**Background:**

ACT is working with several partners and agencies to help address the environmental and ecological problems associated with nutrient pollution. A critical step in this process is facilitating the development and adoption of the next-generation in situ nutrient sensors and analyzers. The ACT Nutrient Sensor Challenge employs a Market Stimulation Challenge Model to provide clear market incentives, stimulate innovation, and drive technology costs down through competition. This ACT Request for Technologies is the final step in formally challenging the technology development/innovation community to develop the next generation of in situ nutrient sensors (Table 1, below) while providing an opportunity to verify instrument performance. A full description of this Nutrient Sensor Challenge can be found at [www.nutrients-challenge.org](http://www.nutrients-challenge.org).

ACT is a NOAA- and EPA-funded partnership of research institutions, state and regional resource managers, and private sector companies that are interested in developing, improving, and applying sensor technologies for studying and monitoring coastal environments. ACT was established on the premise that instrument validation of existing and emerging technologies is essential to support both coastal science and resource management, and the development of the US Integrated Ocean Observing Systems (IOOS). The specific functions of ACT are to serve as: (1) an unbiased, third-party testbed for evaluating existing, new, and developing coastal sensors and sensor platforms, (2) a comprehensive data and information clearinghouse on environmental monitoring technologies, and (3) a forum for capacity building through workshops and seminars on specific technology topics. However, ACT does not certify technologies or guarantee that a technology will always operate at the certainty and reproducibility verified, especially under different environmental conditions. Furthermore, ACT itself does not: (1) seek to determine regulatory compliance; (2) rank technologies or compare their performance; (3) label or list technologies as acceptable or unacceptable; or (4) seek to determine “best available technology” in any form.

Accepted applicants will be publicly identified as participants in the Nutrient Sensor Challenge Verification Testing. Ownership of all intellectual property will remain with applicants/participants. ACT (and associated partners/collaborators) will keep confidential any proprietary information identified by applicants/participants. All instrument performance testing results generated for the Challenge Verification will be made available to the public and used by an independent Judging Panel assembled by the Challenge Nutrient Coalition to recognize accomplishments and select award winners.

Please visit our web sites at [www.act-us.info](http://www.act-us.info) and [www.nutrients-challenge.org](http://www.nutrients-challenge.org) for information on ACT and to download **Challenge Guidelines** and **Application Forms**. More information can also be obtained by contacting Drs. Tom Johengen ([johengen@umich.edu](mailto:johengen@umich.edu)), Beth Stauffer ([stauffer@louisiana.edu](mailto:stauffer@louisiana.edu)) or Mario Tamburri ([tamburri@umces.edu](mailto:tamburri@umces.edu)).

**Benefits of Technology Challenge:**

The Nutrient Sensor Challenge is a market stimulation and innovation effort to accelerate the development, adoption, and use of affordable (< \$5,000 purchase price), reliable, and accurate sensors measuring nitrate and orthophosphate in water. The goal is to accelerate these new technologies to commercial availability by 2017. Benefits to Challenge participants include:

- Enable developers to assume a leadership position in this growing market. Technologies participating in the competition will be highly visible to potential buyers looking for cost-effective solutions to monitor nutrients.
- **High-visibility exposure.** All participants selected for Verification Testing will be featured on the Nutrient Sensor Website (individual dedicated pages with profiles, links, etc.) and announced broadly through a variety of media outlets. Winners will demonstrate robust and creative



technical approaches that showcase expertise and leadership within the industry. The most successful developers will garner credibility and publicity with academic, environmental, industry, and technology leaders.

- **Verified performance.** Participants will benefit from independent verification testing that can be used to promote and market sensors and as a foundation for future instrument approval or certification.
- **Access to resources.** Participants will gain access to experts in the field, the end user community, entities that certify and approve methods and instruments, and potential innovation partners and/or supporters.

As part of the Challenge, ACT will provide technology developers an independent, scientifically objective process for testing their instruments in a range of aquatic environments and under actual conditions for which their products were designed. Test protocols for the verification will be designed to address Challenge target criteria (see below) under controlled laboratory conditions and varying natural environmental conditions, with input from the Technical Advisory Committee (TAC, see below) and participants.

Potential **pilot opportunities** are now also being developed. Matches between pilot partners and high-performing sensors will be made in the final stages (post-verification) of the Challenge. Pilot partners are likely to include: government agencies and programs (e.g. IOOS, USGS, EPA, NOAA, USDA), industry (e.g. POTW), non-profits, and academics. Pilot opportunities are meant to provide participants with additional opportunities to demonstrate use in a wider variety of environmental settings, as integrated components of existing environmental operational monitoring/observing systems/networks, and for more diverse applications (e.g., water treatment, ground water, citizen science, etc.), ultimately to facilitate connections with end users across multiple sectors.

### **Foci of Nutrient Sensor Challenge:**

Interested groups must apply, be selected, and participate in Verification testing to be eligible for Challenge recognition and awards. Judging protocols with specific scoring procedures based on commonly accepted practices will be detailed in the final Verification Protocols, to which all Verification testing participations must agree. Table 1 (below) summarizes how weighted points will be assigned. A final independent judging process is under development that will involve a weighted points system, which takes into consideration, strengths in specific areas, partial attainment of target features, and exceedance of the targets. In the event that no sensors meet all of the target sensor features, the Challenge organizers reserve the right to present awards for first, second, and third place performers in both the nitrate and phosphate categories.

In order to score highly in the Challenge, entries must be affordable and easy to use, operate over a wide range of concentrations, and be highly accurate and precise. However, special consideration may be given to instruments that perform very well in a subset of test conditions (e.g., focused only on measurements in freshwater and not meant for use in brackish or marine waters) or that excel at a subset of target features, even if all targets are not met (e.g., very low cost and accurate but only able to achieve 1-month deployments). The Challenge recognizes that transformation of our ability to collect in situ measures of nutrients at high spatial and temporal resolution may depend on a variety of innovations beyond those outlined in the specific target sensor features.

*Table 1. Target Nutrient Sensor Features*



Measurement Criterion	Nitrate ( $\pm$ nitrite)	Orthophosphate	Weights
Accuracy	$\pm 5\%$ or 0.01 mg/L - N (at upper range) from reference value	$\pm 5\%$ or 0.005 mg/L - P (at upper range) from reference value	<b>20%</b>
Precision	$\pm 5\%$ or 0.01 mg/L - N (at upper range) from reference value	$\pm 5\%$ or 0.005 mg/L - P (at upper range) from reference value	<b>15%</b>
Range	0.005 - 60 mg/L - N	0.005 - 2 mg/L - P	<b>15%</b>
Deployment Length	3 months (at 15 minute sampling interval)		<b>25%</b>
Cost	Less than \$5,000 purchase cost Bill of materials for sensor and package		<b>25%</b>

For the purposes of this Challenge, “**nutrients**” are defined in terms of the dissolved nitrate ( $\text{NO}_3^-$ ) and/or soluble reactive orthophosphate ( $\text{PO}_4^{3-}$ ) concentration in water. Nitrate concentrations may be inclusive of nitrite ( $\text{NO}_2^-$ ) if disclosed. Entries will be judged on accuracy, precision, range, deployment length, and cost according to the targets and weights in Table 1.

- **Accuracy:** Closeness of agreement between the result of a measurement and reference values. Estimated by repeated comparisons between instrument measurements and reference water samples. Reported as percent difference (or absolute difference, for high limits of quantification) between reference and measured values.
- **Precision:** Closeness of agreement between independent test results obtained under stipulated controlled conditions. Determined by high-frequency, repeated measures during laboratory tests with instruments placed in, or exposed to, known stable conditions. Reported as percent difference (or absolute difference, for high limits of quantification) between repeated samples as compared to one another.
- **Range:** Upper and lower limits of quantification. Determined by collecting instrument readings on a known (prepared, sampled, and analyzed) dilution series of the measurement parameter.
- **Deployment Length:** Amount of time the instrument can operate in a submerged deployment setting at a depth of one meter below the surface without needed maintenance or recalibration. Successful deployment requires the sensor to perform within the required ranges of accuracy (see Table 1) throughout the deployment duration. Determinations on details (e.g., acceptable levels of instrument drift and/or data loss) will be finalized during the Verification Testing Protocol Development Workshop.
- **Cost:** Total cost as demonstrated by the Bill of Materials submitted in the Application for Verification Testing for item 1, sensor components (including enclosure) and item 2, package for unattended, continuous operation of the instrument. Components in item 2 must include the equipment for data storage and management, power, and anti-fouling accessories required for an unattended three-month deployment. Evaluation of cost will be based primarily on the sensor components (item 1) and secondarily on the total package cost (items 1 and 2) relative to the other sensors in the verification testing phase.

### Eligible Technologies and Requirements:

The challenge is open to all technology developers globally. To be eligible to participate and receive any recognitions and awards participants must comply with all terms of the participant Agreement (available at [www.nutrients-challenge.org](http://www.nutrients-challenge.org)). The Agreement contains restrictions and requirements for



applicants that are intended to prevent conflicts of interest and provide a transparent, open Challenge. ACT reserves the right to limit, or restrict upon notice, participation in the Challenge to any person or entity at any time based on resource or logistical limitations. Similarly, applicants and participants may withdraw from the Challenge, and ACT Verification, under conditions set forth in the Agreement.

### **Application Process and Acceptance for Evaluation:**

The application and acceptance process for participation consists of completing the following four steps: (1) Developers submitting a complete application (via email at [info@nutrients-challenge.org](mailto:info@nutrients-challenge.org), details below), (2) ACT and Nutrient Sensor Challenge TAC reviewing and selecting final Verification participants, (3) ACT and Participants working together to develop final Test Protocols, and (4) Participants signing the Verification Agreement. Details of each step are as follows:

**Step 1. Application** - Applicants are requested to provide detailed information about the technology proposed for the Challenge and about their organization or team by submitting a signed cover letter and by completing the initial ACT Application form (available at [www.nutrients-challenge.org](http://www.nutrients-challenge.org)). The basic purpose of the application is to assess that: (1) the technology or approach is likely to meet the criteria/requirements set forth in this Request for Technology; (2) ACT facilities are capable of conducting an appropriate and safe evaluation; and (3) no conflict of interest exists between the applicant and ACT or the TAC.

The application form requests additional information to ensure a clear understanding of the proposed technology, including the scientific and engineering principles of operation and preliminary performance data. The application should include any appropriate references (e.g., peer reviewed literature, technical articles, reports), process flow diagrams, equipment specification sheets, operating instructions, and other related materials to enable the reviewer to fully understand the instrumentation. Applicants may include any other relevant information that is available to support the application. Confidential technical, commercial, or financial information should be listed as such (marked clearly and appropriately) and will be kept confidential (i.e., not be made publically available). Intellectual property will be protected, as appropriate, throughout the Challenge. However, basic cost estimates (but not detailed list in Bill of Material details) and basic sensor operational principles and descriptions (but not trade secrets or confidential information) may be released as part of Challenge judging and final award selections (after consultation with individual participants).

Only complete applications (maximum 25 pages, including appendices and supporting material) will be reviewed for selection in Verification testing, and must include the following components:

- Detailed description of the sensor methodology, detailed engineering drawings, specifications (including physical characteristics), and photos (top, end, and side in overview and all key components) of the sensor(s) or prototype(s).
- Technical data (accuracy, precision, range, etc.) from prior laboratory- and/or field-based testing (internal and/or independent). Results from Nutrient Sensor Challenge beta testing may be used for this section.
- Estimates for cost:
  - A flat-file Bill of Materials, or a simple listing of parts, required quantities, and their associated costs, including:
    - Item 1: The essential parts (electronic/electrical, mechanical, and associated materials) of the sensor (including enclosure required for field deployment).
    - Item 2: Any peripheral components and/or accessories necessary for stand-alone deployment and continuous, real-time data logging and/or transmission (onboard data storage/management, power, and anti-fouling accessories required for a three-month unattended



- deployment). The flat-file Bill of Materials information provided will be verified in-person prior to laboratory testing. Discrepancies between the submitted Bill of Materials and the actual sensor and package components are grounds for disqualification from the Challenge.
- Estimated consumer price if (a) 50 and (b) 1,000 units were produced, with detailed description for how the estimates were generated.
  - Estimated annual operations costs to consumer, including expected manufacturer servicing intervals, post-warranty repairs, and any required consumables for one year of continuous operation.
- A detailed technical guide to calibration, preparation for deployment, and operation and maintenance.
  - A description of expected effort (including time requirements and required operator training and skill level) for calibration, deployment, and operation and maintenance,
  - Expected sensor lifetime (years), with description for how the estimate was generated.

**Step 2. Selection** - ACT staff and TAC will review all complete application packages and select up to eight (8) nitrate ( $\pm$  nitrite) and up to eight (8) orthophosphate sensors (maximum of 16 total) for Challenge Verification testing. ACT staff and TAC reserve the right to select fewer than 16 total sensors for Verification testing. To be selected, applicants must demonstrate ownership of the technology and the instruments themselves must:

- Fit within the scope and address the fundamental goals of the Challenge,
- Be based on sound scientific and technical principles,
- Demonstrate a maturity or technology readiness level (TRL) appropriate for independent verification testing, and
- Demonstrate ability to meet Challenge costs targets (or among the lowest estimates for sensor costs).

**Step 3. Agreement on Test Protocols** - ACT staff and Quality Assurance/Quality Control (QA/QC) Coordinator, TAC members, and representatives from each of the selected applicants will gather for a Protocol Workshop tentatively scheduled for February 2016, to discuss and draft a Verification Protocol and QA/QC strategy. The draft protocols may be externally reviewed for appropriateness of experimental design and statistical analyses before a Final Verification Protocol is submitted to the selected applicants. Although ACT does not conduct direct comparisons of instruments being evaluated, the standardization of methods in Verification Protocols and publication of Verification results in publicly-available reports will allow the simultaneous assessment of the various instruments. These results and reports will permit the independent Challenge Judging Panel to select winners and enable end-users to draw their own conclusions regarding the in situ nutrient sensor that best meets their needs.

**Step 4. Nutrient Sensor Challenge Agreement** - A legal agreement between ACT and individual qualifying applicants must be signed prior to initiating final Verification Testing (available at [www.nutrients-challenge.org](http://www.nutrients-challenge.org)), which states that all parties agree to conduct the evaluation in accordance with the final Verification Protocols and that the results will be released to the public. The agreement will also state that there will be no modifications to the final Verification Protocols, regardless of unforeseen circumstance encountered during testing, without written consent from all parties. Furthermore, the agreement will clearly state that: each participant will be allowed to view the Verification Statement for its own instrument before the Report is released to the public and allowed to include (in the form of a one-





page letter) a written response to be included as an appendix to the Verification Statements, and that company representatives will not be allowed to make changes to the final report. Finally, it is noted that all data collected during verifications by the instruments tested are the property of the participant and cannot be used by any other party beyond ACT and the Nutrient Sensor Challenge without consent. The agreement will be signed by the ACT Director and the appropriate representative from the selected applicant organization.

### **Timeline and Milestones for the Nutrient Sensor Challenge:**

(subject to change)

- Application (form with signed cover letter) must be received by 5:00 p.m. Eastern Time – December 18, 2015 (via email [info@nutrients-challenge.org](mailto:info@nutrients-challenge.org))
- Notification of Selection – January 8, 2016
- Protocol Workshop, tentatively New Orleans, LA – February 18-19, 2016 (just prior to the AGU/ASLO 2016 Ocean Sciences Meeting)
- Final Verification Protocol – March, 4, 2016
- Laboratory testing – May 2016
- Field testing – June - October 2016
- Final Reports – December 2016

### **Technical Advisory Committee:**

- Suzanne Bricker, NOAA
- Matt Cohen, University of Florida
- Chris Gross, USDA
- R. David Holbrook, NIST
- Brian Pellerin, USCG
- Joe Rudek, Environmental Defense Fund
- Dwane Young, US EPA

### **Additional Information and Forms:**

Please visit our [www.act-us.info](http://www.act-us.info) and [www.nutrients-challenge.org](http://www.nutrients-challenge.org) for additional information on the ACT program, details on the ACT Evaluation Process, and to download required application forms. More information can also be obtained by contacting Drs. Tom Johengen ([johengen@umich.edu](mailto:johengen@umich.edu)), Beth Stauffer ([stauffer@louisiana.edu](mailto:stauffer@louisiana.edu)) or Mario Tamburri ([tamburri@umces.edu](mailto:tamburri@umces.edu)).