Research Initiative for Real Time River Water and Air Quality Monitoring

REQUEST FOR PROPOSALS (RFP)

RFP Issue Date	**20 December 2016**
Submission Deadline for Applications	**10 March 2017**
Completed Application to be submitted to	***WAQM@indousstf.org***

Background and Overview

Access to clean water and air is indispensable to human life. Yet, managing this access in an efficient and effective way is an immensely complex challenge. The current paradigm for environmental quality evaluation relies on a few fixed air and water quality monitoring stations for large areas. These stations are instrumented with lab-grade equipment to assess several quality metrics. Alternatively, water or air is passively sampled from several locations and sent to laboratories for analysis. While this approach may be suitable on smaller scales of wells, lakes etc., it is inadequate for large water systems like rivers, watersheds etc. It necessitates considerable cost and effort, significant time-to-analysis as well as the possibility of the sample changing in the interim. Further, a key limitation of both these approaches is that they provide sparsely populated information about an ever-changing quantity. The overall picture that emerges is thus highly averaged over spatial and temporal scales. This often makes is difficult to identify and distinguish point and non-point sources of pollution.

With this background, the *Department of Science and Technology*, Govt. of India (DST) and *Intel*® have collaborated to jointly initiate a research program titled "***Research Initiative for Real-time River Water and Air Quality Monitoring***" soliciting research proposals from Academic/Research Institutions and providing grant-in-aid support to the selected project(s). The aim of this initiative is to develop key technologies for sensing, communication and analysis of large-scale data collected from autonomous networks of perpetual/long-lived sensor nodes, followed by integration and deployment for water and air quality monitoring in real-time. The program will be administered by the binational **Indo-U.S. Science and Technology Forum** (IUSSTF).

The goal of this research would be to enable the development and eventual deployment of low-cost, low-power, autonomous wireless sensor networks to provide a fine-grained view of several critical water and air quality metrics over large geographic areas (cities, rivers, watersheds etc.). Such networks may eventually replace the current paradigm of environmental quality management via localized stations. The development of such an IoT-based solution will require innovations in sensor technology for miniaturized platforms for continuous, always-connected multi-modal sensing, ultra-low power radios for efficient communication and energy harvesting technologies to enable very long or perpetual operation of sensor nodes. These key blocks will need to be woven together by a data analytics framework that spans edge devices, gateways and cloud-based analytics, to enable inferencing and sense-making in a low-latency manner. The development of such an end-to-end solution composed of several individual research elements can also potentially impact environmental quality monitoring systems in diverse contexts such as urban, domestic and industrial settings.

R&D Priority Areas

The overall objective of this research is to develop tools and constituent blocks that can enable end-to-end water quality monitoring systems that rely on smart, networked, low-cost, low-power sensor nodes coupled with largescale cloud-based data analytics. To realize this overall objective, four ***Research Vectors*** (RV) have been identified. Applicants may note that innovative proposals that do not directly fall within research vector descriptions below but promise to provide disruptive gains toward program goals will also be considered for support.

RV1: Sensing and Sense-making at the Edge: The goal of this vector is to develop novel low-cost, low-power sensor platforms for selective and sensitive detection of multiple water and air quality features. In addition, such platforms should constitute nodes imbued with analytics and sense-making capabilities that operate in resource-constrained settings. To this end, this vector is partitioned as below:

- Development of novel small form-factor, low-cost sensing technologies
    - Water quality
        - Miniaturization of existing (bio)chemical sensing technologies, while retaining sensitivity and selectivity (e.g., nutrients, salts, dissolved oxygen etc.)
        - Development of novel low-power signal transduction schemes relying on electrochemical, electrostatic, mechanical, colorimetric, imaging etc. approaches. Multi-modal sensing capabilities are especially encouraged.
        - New assays for rapid, *in-situ* detection of heavy metals (e.g., As, Pb etc.) and biological species (e.g., coliform bacteria) in water
        - New sampling and fluid transport techniques using microfluidic/nanofluidic approaches for low-volume sampling and rapid sensor response time
        - Low-cost sensing using printing of transducers on cheap, flexible, benign substrates.
        - Packaging materials and technologies for water-proof operation of transducers and integrated electronics.
    - Air Quality
        - Novel sensing technologies to detect common U.S. EPA 'criteria' pollutants (CO, O_3, NO_x, SO_x, Particulate Matter and Lead) and select volatile organic compounds (VOCs) of relevance in domestic or industrial contexts (meeting clearly stated and justified sensitivity and selectivity goals)
        - Miniaturizing and lowering power of existing sensor solutions (electrochemical, metal-oxide semiconductor, optical etc.) while retaining sensitivity at levels mandated by U.S. EPA.

        - Approaches to understand causes of drift in sensor performance and loss of calibration with time, as well as approaches to rectify this.
- Sense-making and data analytics at low-power edge devices
    - Architectures and algorithms for "smart", always-on, context-aware nodes.
    - Inference from multi-modal sensor parameters (sensor fusion).
    - Data analytics at edge nodes in resources constrained (computation, power) settings: techniques for feature extraction, classification, compression, anomaly detection, calibration.
    - Compressive sensing, Dictionary Learning, Sparse Coding algorithms

RV2: Novel energy harvesting technologies: The sensor nodes for air and water quality monitoring share a requirement for either perpetual or extremely long operation times (>1 year), and thus some form(s) of energy harvesting from available sources will be important in order to sustain the sensor nodes especially in remote and hard to reach locations. The goal of this research vector is to develop novel technologies for energy harvesting that are especially suited for the deployment scenario – exploiting solar, wind, vibration, flowing water, wave motion, etc., and also combine more than one energy harvesting mode.

- Energy harvesting research to power fully submerged, partially submerged (floating), and dry land sensor nodes
    - Multi-modal energy harvesting combining solar, hydro-electric, wind, vibration and other modes
    - Combining fluidics of river flow and piezoelectric devices to generate 10s-100s of mW of power in a compact, highly reliable and robust structure that could be deployed on the river bed
    - Exploiting electrokinetic phenomena to convert hydrostatic energy from river flow to electrical current in nanofluidic channels
    - Miniaturized hydro-electric turbines for underwater power generation, designed for extreme reliability
    - Dispersed arrays of very small form factor energy harvesting sources such as hydro- or wind turbines to improve robustness to bio-fouling

RV3: Ultra low power wireless networking: The goal of this research vector is to explore a range of different wireless networking related challenges as applicable to a sensor network used for water quality monitoring over a large geographic scale

- Physical layer and RF circuits
    - Low power, long range radios (1-50km) such as LoRa could be an option to start with.
    - Ultra-low power short range (10-100m) radios
    - Underwater communications between nodes using alternative means – e.g. acoustic based; heterogeneous nodes bridging between RF and non-RF modes of communications.

    - Ultra-low power wake-up radios integrated with low power, long range radios and mesh networking
- MAC and networking layer
    - Low power mesh networking capable of scaling to cover 100's of km and 100's of hops.
    - Integrating low power wake-up radios integrated with mesh networking protocol definitions.
    - Energy harvesting constrained communications protocols to take into account the energy state of the devices when sensing and allocating RF resources.
    - Delay tolerant networking support to account for sensor/energy harvesting downtime among other problems
    - Heterogeneous network architecture including different types of communications between sensors, between sensors and gateways, and potential mesh of gateways to connect to cloud servers and analytics
    - Self-organizing networks – network formation/re-formation, autonomous operation
- Joint sensing and communications for low power optimization for sensors.
    - Compressive sensing and other mechanisms to reduce spatio-temporal sensor sampling rates and power consumption
    - Exploit sensing schedules and routing alternatives to jointly optimize sensor sampling, network routing and radio resource scheduling.

RV4: Distributed analytics and sense-making: The goal of this research vector is to develop analytics capabilities (edge-, gateway- and cloud-based) to enable an intelligent, low power, long lifetime/perpetual operation for the environmental quality monitoring wireless sensor network

- Online and incremental model building for better sense-making with sensor data, to efficiently identify the types and sources of pollution with an end-to-end compute infrastructure.
- Exploring efficient partitioning of sense-making, analytics and inferencing tasks between edge nodes, gateways and cloud analytics, within constraints imposed by power and latency requirements.
- Leveraging network-wide analytics to monitor health of sensor network – node failure, data inconsistency, loss of calibration etc.;
- Security and authentication of sensor nodes and data consistent with low power constraints
- GIS mapping and aggregation of sensor data

Program Structure

DST and Intel expect to award **Research, Development and Demonstration Projects** addressing multiple Research Vectors, integrated in a manner to develop complete technological solution(s) that can be demonstrated first through test-bed in controlled conditions, and subsequently in real-time deployment. Both these milestones have to be completed during the tenure of the project. Such projects would normally be supported for a duration of 5 years and at a cost of about INR 15 Crore. Two fully integrated projects with interdisciplinary teams - one for river water and another for air quality monitoring, are intended to be supported.

DST and Intel reserve the right, without qualification, to reject any or all applications received in response to this announcement and to select any application, in whole or in part, as a basis for negotiation and/or award.

Eligibility

National Laboratories, Academic Institutions and autonomous Research Organizations in India are eligible to apply for the Grant-in-aid. The participation of at least one U.S. entity is mandatory. Partnership of users and other stakeholders is desirable.

Note: Indian research groups are encouraged to collaborate with academic counterparts in U.S./EU. They are urged to leverage and integrate intellectual resources/skillset of a highly specialized nature from U.S./European Institutions into the proposal(s) with a clear indication of value enhancement, such that approximately 75% of the total grant is spent in India. The cost of international travel and user charges for sophisticated facilities/services to leverage international linkages can be factored into the overall budget of the proposal.

Intellectual Property

The final award terms are expected to follow one of the following two approaches - (a) the IP developed under this grant will be placed in the public domain, including offering software under an open source license; or, (b) the Intellectual Property generated as part of the program would rest with the Institution(s) that develop it and Intel would have the first right to refusal for non-exclusive royalty free licensing.

Evaluation Criteria

- The proposals would be evaluated based on soundness of 'proof of concept' and potential to address multiple research vectors, ideally delivering or substantially enabling an integrated end-to-end solution spanning all research vectors.
- Technical innovation, non-incremental potential, and relevance. The extent to which the proposal's problem formulation and key approaches are innovative, important, and relevant to the problem at hand.

- Clarity of overall objectives, intermediate milestones, and success criteria. Adequacy and feasibility of the applicant's technical approach, work plan, and management plan.
- Appropriateness of the division of the activities into logical phases, tasks, and subtasks necessary to accomplish the project's objectives.
- Demonstrated experience of the applicant and participating organization(s) in the technology areas addressed in the application and in managing similar projects.
- Appropriateness and extent of key personnel credentials, capabilities, and experience.
- Cost effectiveness and cost realism. The extent to which the proposed work is both feasible and impactful within the proposed resource levels.
- Potential for co-funding. Opportunity for matching grants and co-funding from other agencies will be given significant consideration.

Award Notices

The selected teams will be intimated through an *Award Letter* from the Indo-U.S. Science and Technology Forum (IUSSTF), along with a *Terms and Conditions document* stating the approved funds. The awardee(s) will sign an agreement contract, IPR sharing agreement amongst the partners and provide their acceptance to begin the fund disbursal. Organizations whose applications have not been selected will be informed as promptly as possible.

Proposal Format

Note: *The Proposal must not include any proprietary or sensitive business information as Intel or the Government of India may make it available to the public.*

- **Cover page {1 page}:**
  i. Title of proposal
  ii. Lead Indian Partner
    a. Organization (Contact Details including Website)
    b. Contact Person (Name, Designation, Phone Numbers, Email Id)
  iii. Other Partners:
    a. Organization (Contact Details including Website)
    b. Contact Person (Name, Designation, Phone Numbers, Email Id)
  iv. Funds requested
  v. Amount of cost share (if any).
- **Executive Summary {1 page}:** Define the problem/challenge that this research will address specific technical objectives and success criteria, and the basic proposed approach to realize them.
- **Relevance and Impact Claims {1 page}:** This section is the centerpiece of the proposal. It should succinctly describe the uniqueness and non-incremental benefits of the proposed objective and approach relative to the state-of-the-art and current approaches.
- **Detailed Technical Plan {2-3 pages}**: Details of proposed research. Proposals should address key issues along one or more of the above research vectors (or another topic still addressing program objectives and goals), and the rationale should include a basis of confidence for meeting the program metrics.
- **Statement of work, schedule, milestones, success criteria and deliverables {2-3 pages}:** Outline the scope of the effort including tasks to be performed, schedule, milestones, deliverables, and success criteria. It is understood that this is an exploratory research effort and schedules/deliverables reflect intentions rather than a firm commitment.
- **Team {2-3 pages}**: Summarize the members of the program team, their qualifications, and their level of participation in the project.
- **Additional Documents:**
  i. Detailed CV of Lead and Other Investigators.
  ii. Budget {to be prepared as per format provided as ***Annexure I***}.
  iii. References {unlimited}.
  iv. If multiple Principal Investigators will be designated, provide a *Coordination and Management Plan* {**1 page**} that describes the organizations structure of the project as it pertains to the designations of multiple Principal Investigators. This plan, at a minimum, must describe the process for making decisions on scientific/technical direction, publications, and intellectual property issues. The plan must also describe Principal Investigators' roles and administrative,

technical, and scientific responsibilities for the project; communication plans; and procedures for resolving conflicts. IPR sharing agreement amongst the partner must be worked out.

v. Organizational *letters of commitment* {to be prepared as per format provided as ***Annexure II***} are required from each organization participating as a team member. Each letter of commitment from an organization participating as a team member must be signed by the person authorized to commit the organization to a legally binding agreement.

ANNEXURE I

Budget Format

Please Note:

- All figures mentioned in the Budget table should be in Indian Rupee (INR) only.
- The grant-in-aid would be released in equal installments over a 5-year period. Applicants are therefore advised to prepare the budget accordingly.
- Milestone of the project must specify significant point of achievement or development during the implementation phase of the project.
- Milestone duration to be either 6 months or 12 months only.
- Only reasonable manpower cost with respect to the overall project cost must be budgeted.
- **All Tables under Section D** to be provided ***separately for each Partner***.

A. Project Duration (in Months):

B. Milestones :

Year	**Milestone**	**Role of Lead Partners** *(List key activities to be performed)*	**Role of Other Partners** *(List key activities to be performed)*
Year 1	Milestone 1		
	Milestone 2		
Year 2	Milestone 3		
	Milestone 4		
Year 3	Milestone 5		
	Milestone 6		
Year 4	Milestone 7		
	Milestone 8		
Year 5	Milestone 9		
	Milestone 10		

C. Total Budget of the Project:

S. No.	**Budget Head**	**Partner I (in INR)**	**Additional Partners (in INR)**		**Total Cost (in INR)**
			Partner II	**Partner III**	
Non-Recurring					
1.	Equipment				
Recurring					
2.	Manpower				
3.	Consumables				
4.	Contingencies				
5.	Domestic Travel				

6.	International Travel[1]				
7.	Institutional Overheads				
8.	Any Other Cost (Please specify with justification)				
Grand Total					

D. Budget- Break-up for Each Partner:

S. No.	Budget Heads	Year I	Year II	Year III	Year IV	Year V	Total Cost (in INR)
Non-Recurring							
1.	Equipment						
Recurring							
2.	Manpower						
3.	Consumables						
4.	Contingencies						
5.	Domestic Travel						
6.	International Travel						
7.	Institutional Overheads[2]						
8.	Any Other Cost (Please specify with justification)						
Grand Total							

Table D(i): Justification for Equipment:

S. No.	Particulars of Equipment(s)	Quantity	Cost per unit	Total cost (in INR)	Justification

[1] Only in case of collaborative proposals with formal linkages with Institutions outside India.

[2] For projects costing up to INR 100 Lakhs, 10% of total cost for Educational Institutions and 8% for National Laboratories and autonomous Research Organizations. For projects costing more than INR 100 Lakhs and up to INR 500 Lakhs, 10% of total cost or INR 15 Lakh, whichever is lesser.

Table D(ii): Justification for Manpower:

Name (s)	Designation/ Position	Monthly Remuneration	Total Cost	Role in the project and Justification

Table D(iii): Justification for Consumables:

S. No	Particulars	Amount (INR)	Justification

Table D(iv): Justification for Domestic & International Travel:

Travel	Justification
Domestic Travel	
International Travel	

Table D(v): Justification for Other Cost(s), if any:

E. Total Budget of the Project including Additional funding (if any):

S. No.	Particulars	Total Cost (in INR)
1.	Overall cost of the project	
2.	Funding Expected from the **Research Initiative for Real Time River Water and Air Quality Monitoring Program**	
3.	Funding from other sources (Please specify the Agency and Amount)	
4.	Cost share from Institutional Partners	

ANNEXURE II

Format for Organizational Letter of Commitment

(*To be typed on the letterhead of the Organization*)

Project Title:

1. Certified that ……. (*Name of the Organization*) welcomes the participation of Dr/Mr/Mrs .....as the PI and Dr/Mr/Mrs.....as the Co-PI for the project and that in the unforeseen and legitimate event of discontinuation by the PI, the Co-PI will assume full responsibility for completion of the project. Information to this effect, endorsed by me, will be promptly sent to IUSSTF.

2. Certified that the equipment, other basic facilities and other administrative facilities as per the terms and conditions of the award of the Project, will be extended to the investigator(s) throughout the duration of the project.

3. The ……. (*Name of the Organization*) shall ensure financial and purchase procedures are followed as per the prevailing norms of the organization, within the allocated budget.

4. The ……. (*Name of the Organization*) shall provide timely the Statement of Expenditure and the Utilization Certificate of the grant as required by the DST in the prescribed format.

(Head of the Institute)
Seal/Stamp

Date:
Place: