Carbon to Sea Initiative COVE

JUNE 2024

Halifax Ocean Alkalinity Enhancement Joint Learning Opportunity: Request for Proposal

Introduction

While society is making progress in advancing renewable energy, efforts to reduce carbon dioxide (CO_2) emissions are insufficient to protect our critical ecosystems from climate change and, consequently, active removal of CO_2 from the atmosphere is required. A portfolio of effective, safe, and affordable options for removing carbon from the atmosphere is needed to meet internationally recognized climate targets.

Ocean alkalinity enhancement (OAE) is a promising approach for removing and permanently storing atmospheric CO_2 in the ocean, primarily as bicarbonate (HCO_3^-), a stable form already present in large quantities in our oceans.

The theoretical effects of added alkalinity on ocean chemistry and the resulting CO_2 uptake by the ocean are understood, but the practical techniques required to perturb alkalinity, along with the attributed changes resulting from this perturbation, and the quantification of its impacts, need to

be demonstrated in small scale field trials to evaluate OAE's viability as a method of carbon removal.[1] [2] [3]

The Halifax region in Nova Scotia, Canada, offers a unique opportunity to advance OAE research due to its exceptional scientific research capacity, and its recent and planned field trials in Halifax Harbour, conducted by Planetary Technologies (Planetary), and associated academic research by scientists at Dalhousie University.

The goal of this Joint Learning Opportunity (JLO) is to increase the impact of ongoing trials by inviting additional scientific, technical, and social science teams to conduct research alongside already occurring research surrounding the alkalinity addition. This JLO provides: 1) logistical, operational, and permitting support and 2) research funding.

Participating researchers will contribute understanding towards scientific questions, develop and refine Measurement, Reporting, and Verification (MRV) instrumentation and techniques, and advance the community engagement and social license requirements of OAE during the alkalinity addition, **which runs from August to December 2024**, inclusive of two dosing phases (ramping and nominal) as well as planned and unplanned downtime.

Successful applicant(s) will demonstrate: scientific merit, articulate strategic fit with the research priorities shared in this Request For Proposal (RFP), provide a clear and pragmatic vision for executing the work, highlight appropriate qualifications needed to deliver on their vision, and *be ready to conduct the work this summer and/or fall.*

The award package will reflect the unique needs of the work and may include: in-kind services and support for research logistics, meeting rooms at COVE and logistics support from the COVE team, comprehensive alkalinity dosing data package, scientific collaboration, and research funding where the total budget allotted to this program is $250,000 divided amongst winning proponents. To learn more, please register for the OAE JLO Q&A Session here.

The JLO is delivered through a partnership between COVE and the Carbon to Sea Initiative, building on research being conducted by researchers from Dalhousie University and Planetary.

COVE is a high-tech industry-leading innovation hub that helps leaders develop solutions for a better and sustainable world. COVE's facilities, technology, programs, and services help innovators commercialize advanced products and services. COVE has a waterfront facility and is supporting this JLO through technical, logistical, and infrastructural support and coordinated access to materials and resources for JLO awardees.

[1] A Research Strategy for Ocean Carbon Dioxide Removal and Sequestration
[2] Best Practices in Ocean Alkalinity Enhancement Research
[3] NOAA's Ocean CDR Research Strategy

Carbon to Sea Initiative (C2S) is a nonprofit Research & Development (R&D) program to advance our understanding of the ocean's capacity to mitigate climate change. C2S provides funding and strategic alignment with OAE R&D goals.

Important Dates

OAE JLO Q&A Session Register Here	June 25, 2024 9:00 AM AST
Proposal submission deadline	July 13, 2024, 5:00 PM AST
Awardees notified	July 22, 2024
Alkalinity addition (dates approximate)	August - December 2024

Joint Learning Opportunity Strategic Objectives

The objective of this JLO is to advance the scientific, technical, and social understanding of OAE's viability and desirability as a method for climate change mitigation. By collaborating with planned field research, we can extend the impacts of this work to collect additional data or test novel methods. In addition, Carbon to Sea Initiative and COVE aim to use this effort to inform the value proposition of a longer term field research site in Halifax.

There are three primary categories of activities key to advancing the research and implementation of OAE and establishing a strong community of practice in the field. These include:

1. **Scientific:** Understanding the ecological impacts of OAE on marine environments and the new chemical balance resulting from alkalinity addition, including throughout the water column, within sediments, and along the air-sea interface. The aim is to gather comprehensive data and build skillful models to learn more about the effects of OAE and inform strong scientific practices for activities performed by others.
2. **Technical:** Developing and refining methodologies and technologies to produce measurements to assess the alkalinity additionality effects, thus reducing uncertainty in estimating the OAE-associated carbon removal.
3. **Social:** Engaging with interested and affected parties about their perceptions about climate change, perceived risks and benefits, and details of the proposed ocean research. The aim is to seek feedback and explore and advance ongoing methods of engagement, public outreach, and collaboration.

Knowledge gaps and strategic research priorities

This JLO invites researchers to submit proposals on any topic that advances the existing body of knowledge of OAE in the region. Priority will be given to projects that provide research that helps close knowledge gaps beyond the scope of the existing, planned field trial activities. (Please note: applicants are not expected to address all of the below.)

In addition to the robust analysis conducted by the parties to the field trials,the following are a range of research areas that would be most *additional and/or complementary* to the planned OAE field trial activities:

1. **Biological Impacts:** Study the responses of the biological community to changes in water or sediment quality that result from OAE (e.g. particle load, light environment, chemical composition) in terms of growth and production rates, abundance, physiology and feeding behaviour, community composition and diversity, impacts on commercially, ecologically or culturally important species, or additional properties.
2. **Impacts of Feedstock Accumulation:** Seabed analysis using sediment sampling to investigate feedstock accumulation and the impacts associated with it.
3. **Trace Metals:** Monitoring of trace metals in the water and sediment, and the associated biological and geochemical impact.
4. **Advancing MRV:** Technologies for MRV, including intercomparison exercises and the application of novel technologies to OAE monitoring and assessment of effectiveness and accuracy.
5. **Sensor Deployment:** Optimization of sensor deployment, including platform integration (customization of sensor mounts and interfaces to fit different platforms), duty cycle maintenance (efficient power management systems to extend sensor operational life) and anti-fouling (exploration of coatings, cleaning mechanisms, and/or regular maintenance protocols to reduce biofouling and maintain sensor accuracy), and the development of low-cost, fit-for-purpose sensing equipment and platforms.
6. **In-situ Particle Dynamics and Dissolution Kinetics:** In-situ assessment of particle dynamics and dissolution, including examining which factors impact those behaviours (such as water turbulence, stratification, temperature, pH, particle size, surface area, season, tidal cycle etc.).
7. **Community Participation, and Co-creation:** Explore topics with focus on co-creating a sustainable framework for ongoing community participation, ensuring that local knowledge and values are integrated into the OAE JLO and future climate initiatives.

8. **Community Engagement:** Exploration of public perceptions, beliefs, and attitudes about climate interventions through educational outreach, workshops, and/or traditional or Indigenous systems for shared study and decision-making.

9. **Community Experience:** Prototype innovative methods of public education, awareness-building, and/or community involvement where possible.

Summary of Planned Field Trial Activity

Field research for OAE is a highly collaborative effort, bringing together researchers from different disciplines in academia and the private sector, weaving together data from vessel-based sampling, innovative sensor technologies, and modelling studies, as well as conducting the necessary analyses to derive meaning and insight from the results. Alkalinity release is scheduled throughout August - December. Dates are subject to change due to uncontrollable factors such as weather or unforeseen circumstances. Any changes will be communicated via email from the JLO Management Team to all JLO applicants as soon as possible. A more detailed overview of Planetary Technologies' alkalinity release, dosing, and data package can be found here - 2024 Trial Activity Overview - and in the reference section of this RFP.

The table below provides a summary of the planned scientific activities, leaders, and dates for this year's fieldwork. This table has been provided so that applicants are aware of the OAE activities scheduled to take place in Halifax Harbour, minimize research overlap, and identify areas in which their activities can complement or benefit from those already scheduled.

Table 1: Summary of planned field trial activities for the 2024 Halifax OAE project.

Activity	Lead	Description	Dates
Baseline Data Collection	Dr. Ruth Musgrave (Dalhousie University)	Monthly vessel-based surveys at 5 stations (surface, bottom samples, water column profiles). Underway profiling sensors: CTD, oxygen. Surface sensors: pCO_2, pH, CTD, oxygen (tbd). Water samples at surface and depth: DIC, ^{13}C, TA, pH, nutrients, S, total suspended solids, total metals. Profiling sensors: pH, T, depth, S (since April 2024), and turbidity and light (since June 2024) sediment metals (at two stations only).	TBD
Baseline Data	Dr. Dariia Atamanchuk	Bi-weekly sampling at 10 stations (surface only).	(Every two weeks,

Activity	Lead	Description	Dates
Collection	(Dalhousie University)	Surface sensors: pCO_2, pH, CTD, Oxygen (tbd). Water samples: DIC, ^{13}C, TA, pH, nutrients, S.	alternating with monthly sampling)
Baseline Data collection	Planetary Technologies	Boat sampling at 4 stations. Profiles: CTD, DO, PAR, Turbidity, pH. Surface and bottom samples: total suspended solids (TSS), total metals (2 stations only). Sediment grabs: total metals (2 stations only). NOTE: boat surveys are conducted jointly with Dalhousie University (Atamanchuk lead).	Monthly
Sediment core	Dr. Chris Algar (Dalhousie University)	Sediment core collection prior to addition.	June
Benthic	Dr. Ramon Filgueira (Dalhousie University)	Moored array or benthic transect for mussel valvometry close to discharge point.	Deployment ~15 days before first release
ADCP	Dr. Alex Hay (Dalhousie University)	1000 kHz ADCP mooring at ~10 m depth shoreward of the current buoy.	Deployment for ~ a month
ADCP & HADCP Moorings	Dr. Alex Hay and Dr. Ruth Musgrave (Dalhousie University)	3 ADCP Moorings: Year long deployments of 500kHz ADCP moorings with CTDs along the Narrows and into Bedford Basin. 1 HADCP Mooring. Year long deployment of 300 kHz looking sideways across the Narrows.	July ‘24 - ‘25
Thermistor string	Dr. Ruth Musgrave (Dalhousie University)	Ongoing deployments of thermistor/CTD string mooring in the Narrows (20m).	July ‘24 - ‘25
Community Engagement	Planetary	Ongoing outreach to Indigenous and local communities to engage in two-way discussions about the conditions under which OAE trials and scaled deployments would be of benefit to	Continuous and Ongoing

Activity	Lead	Description	Dates
		communities using Planetary's approach.	
Dye tracer experiment	Dr. Dariia Atamanchuk and Dr. Ruth Musgrave (Dalhousie University)	3-4 day-long dye release studies throughout the summer/fall to study near-field plume dynamics (within 500 m from outfall) at different tidal phases.	TBD
Alkalinity release field trials	Planetary Technologies	Release of alkaline material ($Mg(OH)_2$) from Nova Scotia Power effluent pipe at Tufts Cove. Dosing rate ranging from 7 to as high as 40 kg/min, with a ramp up period, followed by constant additions.	August - December
Trial sampling	Dr. Dariia Atamanchuk and Dr. Ruth Musgrave (Dalhousie University)	Discrete carbonate and nutrient sample collection and surface carbon-sensor measurements on a bi-weekly basis. Frequency: biweekly (baseline, ongoing), twice weekly, flexible (trials) location: 5 stations during monthly surveys (surface, bottom samples and water-column profile), 10 stations during bi-weekly sampling (only surface measurements) Underway profiling sensors: CTD, oxygen Surface sensors: pCO_2, pH, CTD, oxygen Surface and deep water samples: DIC, ^{13}C, TA, pH, nutrients, salinity	August - December
Trial sampling	Planetary Technologies	Boat sampling at 4 stations. Profiles: CTD, DO, PAR, Turbidity, pH Surface and bottom samples: total suspended solids (TSS), total metals (2 stations only) Sediment grabs: total metals (2 stations only) NOTE: boat surveys are conducted jointly with Dalhousie University (Musgrave and Atamanchuk lead)	every two weeks, June - December
Biogeochemical moorings	Dr. Dariia Atamanchuk (Dalhousie University)	2 x 30.0" moored data buoys with the sensors measuring: CTD, dissolved oxygen, pCO_2 (air and sea on one mooring), TA (on one mooring), pH and 3–3-channel fluorometer Location: Near the Tufts Cove plant and in the	August

Activity	Lead	Description	Dates
		basin.	
Shore tethered mooring at Tufts Cove	Planetary Technologies	Moored instrument cage, tethered to the seawall at NSPI Tufts Cove plant, and located nominally within the alkaline dosing plume. Surface sensor package (continuous measurements): TA, water and air pCO_2, pH, turbidity, Chl *a*, temperature, salinity	August - December
Air-sea flux	Dr. Ruth Musgrave (Dalhousie University)	Testing and short deployments of air-sea flux chamber close to outfall	July - December
Environmental Impacts	Dr. Julie LaRoche (Dalhousie University)	[Biological impact of OAE throughout the release in the water column and the sediments]. Development of environmental monitoring approaches for OAE Parameters: eDNA, flow cytometry, nitrogen cycle, light profiling, ecosystem approach. Participation in monthly transects of Dr. Ruth Musgrave.	July - December
Physical-biogeochemical simulations	Dr. Katja Fennel (Dalhousie University)	Semi-operational 10-day forecasts available at https://memg.ocean.dal.ca/memg/forecasts. Pairs of realistic and counterfactual simulations for OAE trials with the capability to run tailored scenario simulations.	July - December
Benthic analysis	Dr. Chris Algar (Dalhousie University)	Sediment cores and surface sampling for alkalinity, DIC, metals, $CaCO_3$, organic matter	Monthly during release
AUV	Dr. Dariia Atamanchuk (Dalhousie University)	SeaBer YUCO underwater profiling vehicle with a combination of C/T, pH, turbidity, Chl *a* sensors. To be deployed in the Basin and the Narrows.	Monthly
Blue Boat	Dr. Dariia Atamanchuk and Dr. Sean Morgan (Dalhousie University)	Autonomous surface vehicle measuring air-sea pCO_2 levels, CTD, pH. Travels at a speed of up to 5 m/s. Will be deployed in different parts of the Harbour to study CO_2 flux distribution.	Weekly, biweekly
Blue Boat	Planetary	Opportunistic surveys with uncrewed surface vehicle, transiting in/out of alkaline plume around	Weekly, bi-weekly,

Activity	Lead	Description	Dates
		Tufts Cove. Planned at weekly to bi-weekly frequency. Surface sensor package (underway measurements): water and air pCO_2, pH, turbidity, Chl *a*, temperature, salinity	August - December
ADCP	Dr. Alex Hay (Dalhousie University)	ADCP and multi-frequency sonar transects across plume using a small surface vessel.	During ADCP mooring deployment

Additional Background & Reference Material

Halifax Harbour Key Areas of Interest

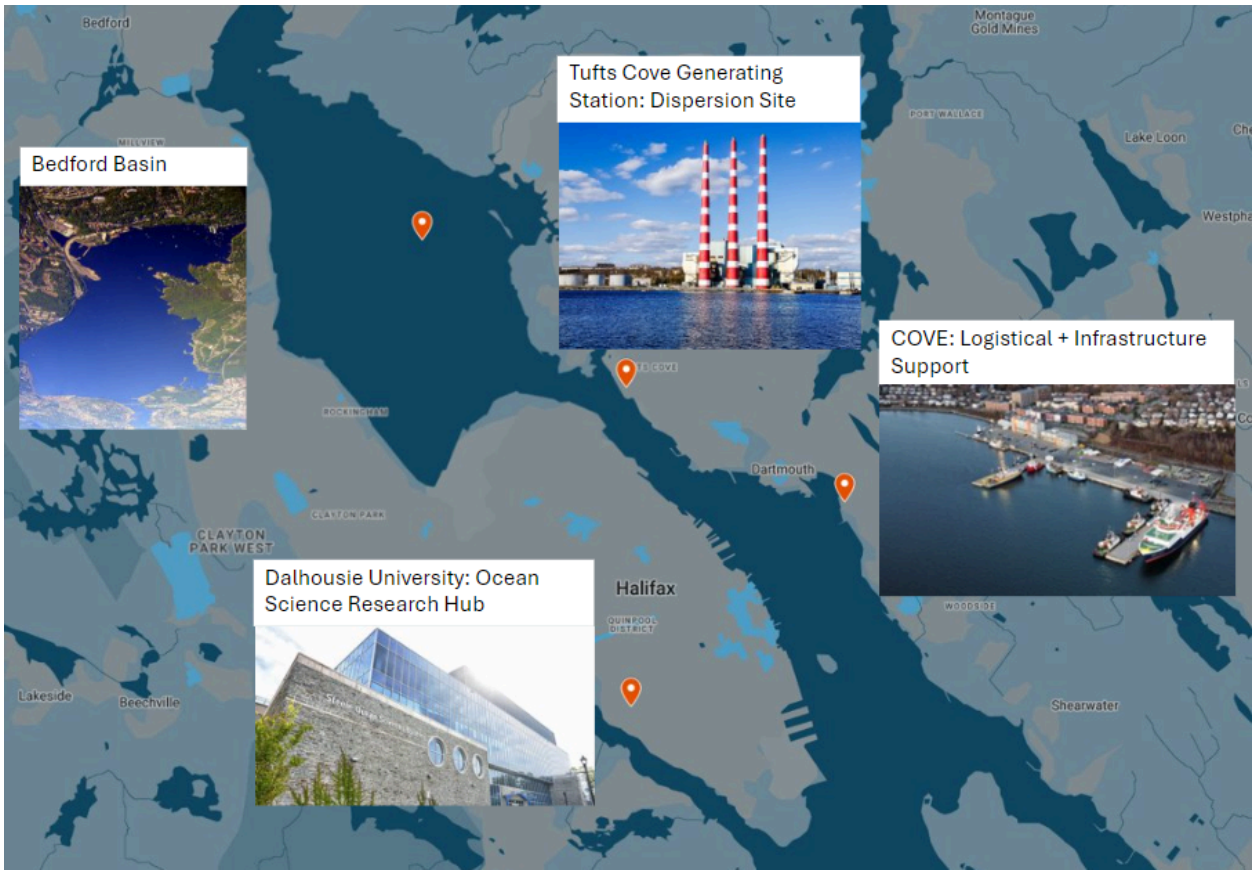

Figure 1: Halifax Harbor and key areas of interest.

2024 OAE Field Research Trial Detail

This document provides a high level overview of the planned OAE activities in the summer and fall of 2024. The purpose of the document is to provide context against which applicants to the Halifax OAE JLO may plan their research proposals. This does not comprise the full extent of their research, technology, or decision-making process and is intentionally simplified for clarity and reference.

Halifax Asset Inventory

The Halifax Asset Inventory provides proponents with a list of potential assets available for a cost to use during trials. While the JLO Management Team cannot guarantee asset availability, they will facilitate access and support wherever possible. The Halifax Asset Inventory is intended to simplify

logistics planning for awardees. Please reach out to the JLO Management Team if you require additional information about a specific asset, including renting or buying cost and procurement processes. Please cite the corresponding asset ID in your request. The cost of renting or purchasing assets must be present in the project budget of all submitted proposals when applicable. The inventory includes:

1. **Research vessels:** Capabilities, equipment, and schedules.
2. **Laboratory facilities:** Fabrication, chemical, and biological analysis laboratories and services.
3. **Rentable marine technology:** Instruments for rent, such as ROVs, sensors, and water quality tools.
4. **Logistical support:** Storage, transportation, desk and meeting room rental, and bay areas.

The inventory will be updated throughout the JLO period. Applicants should review it thoroughly to enhance their proposals. For questions about listed or additional assets, contact the JLO Management Team.

Public Data Sources

Public data sources provided include available environmental data, spatial data, and other data potentially relevant to the 2024 Halifax Harbour OAE trials. This spreadsheet is accessible through the hyperlinked Public Data Sources section title.

2023 OAE Field Research Summary

Relevant news and photos related to the 2023 OAE field trials. Relevant research outputs are available through the Ocean Alk-align Project Website.

Mooring and Sample-based Monitoring Station Map

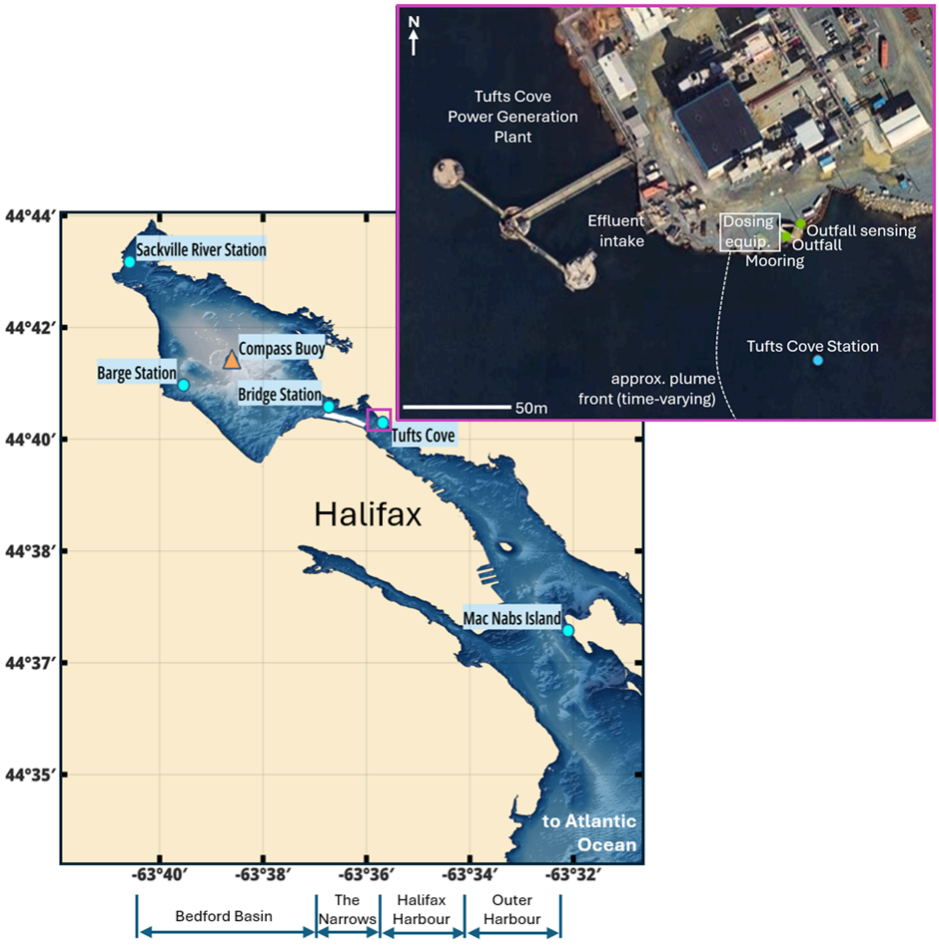

Figure 2: Locations of monitoring stations. Blue markers represent the regularly sampled ocean monitoring stations. Green markers (right panel) represent the on-shore effluent monitoring stations. Additional sampling stations are located at Sackville River and Compass Buoy.

Eligibility, Evaluation, and Submission Instructions

Eligibility Criteria:

Proposals must be submitted by individuals or teams affiliated with established organizations or research institutions that are legally recognized and capable of conducting research or conservation activities between August and December, 2024. Applicants should have a strong track record in marine science, environmental research, marine technology, social research, or related fields. While the JLO is based in Halifax, international proposals are welcome.

Additional participation requirements for proposals and core values in our candidate selection process are as provided in the Terms and Conditions.

Proposal Evaluation

Proposals for the JLO initiative will be independently evaluated by an experienced and technically proficient review committee, inclusive of researchers at Dalhousie University, COVE, Planetary and Carbon to Sea Initiative. This RFP is working on a fast timeline; applicants should be ready to convey how they are equipped to move quickly. In addition to considering the thoroughness and completeness of the proposal, and the cost-benefit of the award, the proposals will be evaluated against the criteria below:

1. **Scientific merit**: Proposed research demonstrates scientific excellence, originality, and rigor within the field of OAE.
2. **Strategic research fit:** Proposed research addresses key opportunity areas and provides significant and *additional* learning beyond the scope of existing research.
3. **Clarity and technical feasibility:** Proposed approach is feasible and has a high likelihood of successful outcome.
4. **Expert qualifications:** Team has the necessary experience, qualifications, and capacity to deliver the proposed activities.

Application Process

Applications must be submitted directly to the JLO Management Team at Innovation@COVEocean.com with the title of your project as the subject line by July 13, 2024, by 5:00 PM AST using the Proposal Application Guidelines.

For additional questions related to the JLO, the proposal process, or questions surrounding the OAE community of practice in Halifax, NS, please contact the JLO Management Team directly, or raise questions at the OAE JLO Q&A Session hosted on June 25, 2024, 9:00 AM - 10:00 AM AST. Please register for the event here.