ISS NATIONAL LABORATORY PROJECT CONCEPT SUMMARY

Technology Advancement and Applied Research Leveraging the ISS National Lab

ISS National Lab Research Announcement 2023-8

(Do not exceed 3 pages when complete)

Proposed project name: Zero-G Lithium: Microgravity Magnesiothermic Reduction for Sustainable Manufacturing	
Principal investigator (PI): ILAKKUVASELVI MANOHARAN	**Project type:** ✔ Flight ✔ Ground ☐ Other
Email address: ilakk2023@gmail.com	**Space experience:** ☐ High ✔ Low ☐ None
PI citizenship status: ☐ U.S. citizen ✔ Permanent resident ☐ Non-U.S. Person	**PI country of citizenship (if non-U.S.):**
Organization legal name: Bubbles & Cafe Inc	
Organization status: ✔ U.S. Entity ☐ Non-U.S. Entity	**Organization address:**
Organization type: ✔ Commercial ☐ Academic ☐ Government ☐ Nonprofit	
Organization Unique Entity ID: C7Y5XP1FBXY7 / **Organization CAGE code:**	
Is this research or technology subject to U.S. export laws and regulations? ✔ No ☐ Yes, explain below	
How did you hear about this research announcement? ✔ ISS National Lab website ☐ Email ☐ News article ☐ Advertisement ☐ NASA ☐ NSF ☐ ISS Research and Development Conference ☐ Other conference ☐ Other (please describe):	

Objectives:

Vision: Revolutionize lithium manufacturing using microgravity and magnesiothermic reduction for sustainable and efficient production, supporting renewable energy and space exploration.

Rationale:

- Growing demand for lithium in EVs, renewable energy, and electronics.
- Environmental impact of terrestrial mining.
- Advantages of microgravity: improved purity and uniformity.
- Synergy with space exploration and resource utilization.
- Reduced energy consumption compared to conventional methods.
- Support global energy transition and combat climate change.
- Innovative manufacturing technique with broader applications.
- Contribute to space industry growth and collaboration.
- Ensure resource independence for lithium-dependent industries.
- Foster public-private partnerships for solving global challenges.
- Offer education and outreach opportunities to inspire future innovators.
- Effective Use of the International Space Station (ISS) National Laboratory: Zero-G Lithium Project

Goals:

- Develop innovative and scalable manufacturing process for lithium in microgravity.
- Address environmental concerns by promoting sustainable lithium production.
- Contribute to space exploration by exploring in-situ resource utilization.
- Optimize energy efficiency in the magnesiothermic reduction process.

Deliverables:

- Successful proof-of-concept for microgravity lithium production.
- Production protocol and operational guidelines for future space-based manufacturing.
- Dissemination of data and research findings through publications.
- Potential technology transfer and industry collaboration opportunities.
- Educational outreach and STEM engagement initiatives.
- Contribution to ISS research objectives.

State the test objective and the starting and ending technology readiness level (TRL).

Test Objective: Evaluate microgravity magnesiothermic reduction for lithium production in space, validating feasibility and resource utilization.

Starting TRL: TRL 2-3 (Concept formulated, untested in relevant environment).

Ending TRL: TRL 5-6 (Tested and validated in simulated or actual microgravity).

Describe how the project utilizes the conditions of a space-based laboratory or environment (e.g., extended access to microgravity, extreme environmental conditions).

Utilization of Space-Based Laboratory for "Zero-G Lithium" Project:

- Extended access to microgravity for studying magnesiothermic reduction process.
- Enhanced mixing and homogeneity due to reduced buoyancy-driven convection.
- Reduced settling and segregation of particles during the reaction.
- Study of thermodynamics and kinetics under microgravity conditions.
- Formation of novel alloy structures with unique properties.
- Exposure to extreme environmental conditions like vacuum and temperature variations.

Describe how the project's outcome will further technology development that will ultimately lead to a commercial product or solutions offering.

Technology Development and Commercial Product Outcome for "Zero-G Lithium" Project:

- Proof-of-concept validation for microgravity magnesiothermic reduction.
- Optimized manufacturing protocol for efficient and reliable production.
- Higher-purity and uniform lithium, appealing to battery and energy industries.
- Environmentally responsible process for eco-conscious markets.
- Cost-efficient approach for increased competitiveness.
- Potential for broader space industry applications and resource utilization.
- Attracting partnerships, investments, and funding opportunities.
- Scalability for meeting growing market demands.

Concept of Operations:

Provide a basic description of the project's in-orbit requirements and experimental setup.

In-Orbit Requirements:

- Microgravity Environment
- Extended Experiment Duration
- Safe and Controlled Environment
- Data Transmission and Telemetry

Experimental Setup:

- Microgravity Chamber or Furnace
- Reaction Vessel and Reactants
- Temperature and Pressure Control
- Heating and Cooling Systems
- Sensors and Data Acquisition Systems
- Safety Measures and Contingency Plans
- Sample Collection and Preservation
- Integration with Spacecraft Systems
- Experimental Procedures and Protocols
- Ground Control Support

Describe any specific hardware or in-orbit facilities necessary to support this project, if known.

Specific Hardware or In-Orbit Facilities for "Zero-G Lithium" Project:

- Microgravity Laboratory or Chamber
- Experiment Rack or Furnace
- Reaction Vessel
- Temperature and Pressure Control System
- Heating and Cooling Mechanisms
- Data Acquisition and Sensor Systems
- Safety Features and Contingency Plans
- Sample Collection and Preservation System
- Ground Control Support and Data Transmission
- Spacecraft Integration
- Extended Experiment Duration

Logistical Support and Payload Return Requirements for "Zero-G Lithium" Project:

Logistical Support: Pre-launch preparations: Integration, safety checks, compliance; Mission planning: Launch opportunity, orbital parameters; Ground control team: Monitoring, data analysis, communication; Payload return vehicle: Suitable for safe return.

ISS National Lab Use Only:
Complexity: R C A S
IP Portal Needed: Y N

Operations Lead: _____
Science Lead: _____

Payload Return Requirements: Sample preservation and containment; Reentry and landing safety: Safe vehicle reentry and landing; Sample handling and transport: To research facilities.; Data and result dissemination: Sharing experiment findings.
Return Cargo Space and Capacity: Payload size and weight assessment; Spacecraft and cargo integration.
Return Logistics Timeline: Return window planning; Return vehicle scheduling.
Safety and Contingency Planning: Contingency procedures for unexpected events; Sample and data redundancy.
Post-Mission Disposition: Handling of returned samples; Equipment and hardware recovery.
Identify any preliminary discussions the offeror has had with an Implementation Partner, including evidence that the Implementation Partner can meet the proposed technical and schedule requirements.
If known, provide an in-orbit operations timeframe (i.e., desired launch date and flight duration).
Successive Experiments for Iterative Microgravity Studies - "Zero-G Lithium" Project:

- Proof-of-Concept: Validate microgravity magnesiothermic reduction for lithium production.
- Reaction Kinetics and Rate Optimization: Study reaction kinetics and optimize rate in microgravity.
- Purity and Impurity Analysis: Assess lithium purity and identify impurities in microgravity.
- Alloy Formation and Material Properties: Investigate novel lithium alloys and their properties in microgravity.
- Scaling and Upscaling: Test scalability of the reduction process in microgravity.
- Process Optimization: Optimize the reduction process in microgravity.

Benefits/Business Case:

Importance of "Zero-G Lithium" Project:

- Sustainable lithium production with reduced environmental impact.
- Advancement of microgravity research for unique material studies.
- Resource independence in space for future celestial body missions.
- Development of advanced lithium alloys for energy storage.
- Fostering space-based manufacturing and the space economy.
- Technological innovations with broader applications.
- Support for global clean energy transition with lithium batteries.
- Inspiration for scientific exploration and STEM fields.

Disruptive Product or Service from "Zero-G Lithium" Research in Low Earth Orbit:

- Sustainable lithium source, reducing reliance on conventional mining methods.
- Enhanced purity and quality of lithium materials.
- Discovery of novel and advanced lithium alloys.
- Development of high-performance lithium-based batteries.
- Green energy storage solutions, accelerating renewable energy adoption.
- Paradigm shift in space resource utilization.
- Efficient and lightweight power systems for spacecraft and satellites.
- Energy storage solutions for long-duration space missions.
- Fostering space-based manufacturing and industry growth.
- Commercialization of space resources and new business opportunities.
- Positive environmental impact, promoting sustainability.
- Market disruption and increased competitiveness.

Users of the "Zero-G Lithium" Product:

Battery manufacturers; Renewable energy sector; Electric vehicle (EV) industry; Aerospace and satellite companies; Space exploration agencies; Energy storage projects; Technology and electronics companies; Materials and chemical industries; Innovative startups and entrepreneurs; Resource-independent space colonies; Research and academic institutions; Environmental and sustainability advocates

Estimated Revenue Generation from "Zero-G Lithium" Project:

- Short-Term (Within 5 Years): Research Partnerships and Government Grants.
- Medium-Term (Within 5-10 Years): Initial Product Sales; Space Missions and Contracts.
- Long-Term (Beyond 10 Years): Mass Adoption of Advanced Batteries; Space Resource Utilization Contracts; Space-Based Manufacturing.
- Commercial Space Applications (Beyond 10 Years): In-Orbit Manufacturing.

Budget and Funding Sources:

Budget Narrative:

ISS National Lab Use Only:
Complexity: R C A S
IP Portal Needed: Y N

Operations Lead: _____
Science Lead: _____

- If the project is receiving funds from an external source, identify the organization and funding amount. Fundraising ongoing.
- Does the offeror require support from the ISS National Lab to identify potential investors or to obtain additional funding? Yes
- Does the offeror or any funding partners have the intent, resources, or experience to develop and/or commercialize project outcomes? Yes

Item	Description	Amount ($K)
1	Project Costs	500K
2	Implementation Partner (Mission Integration & Operations) Costs	N/A
3	**Total Project Funding Required (1 + 2)**	500K
FUNDING SOURCES		
4	Funds Provided by PI's Organization	0
5	Funds Requested from CASIS (5a + 5b)	500K
5a	Project Funding Requested from CASIS	500K
5b	Implementation Partner (Mission Integration & Operations) Funding Requested from CASIS	N/A
6	Funds Provided by Other Sources	N/A
7	In-Kind Contributions	
8	**Total from All Funding Sources (must equal Item 3)**	500K

Signature: M. Ilam

Prepared By: ILAKKUVASELVI MANOHARAN

Title: CEO, Bubbles & Cafe, Inc

Date: 08/06/2023

Guidelines and Helpful Links (Do not include this page in the Concept Summary submission)

All offerors must complete and submit for review a Step 1: Concept Summary form. The purpose of Step 1 is to evaluate an offeror's concept for operational feasibility, scientific, technological, and economic/business merit, compliance with the CASIS Cooperative Agreement, and alignment with the scope of the solicitation. Concept summaries must use the template provided in this document, and all sections must be completed. As funding is limited for this research announcement, the level of funding requested will be a factor in concept approval.

Offerors are strongly encouraged to begin now during Step 1: Concept Summary preparation to identify and consult with an Implementation Partner—organizations that work with the ISS National Lab to provide services related to payload development. For more information, see the Instructions to Offerors for this research announcement.

The U.S. General Services Administration (GSA) has officially transitioned the System for Award Management (SAM.gov) to no longer use data universal numbering system (DUNS) numbers from Dun & Bradstreet (D&B) and instead use government-issued Unique Entity IDs. GSA implemented the change effective April 4, 2022. The new ID can be found on the offeror's SAM.gov profile.

It can take several weeks or longer to apply for and receive a Commercial and Government Entity (CAGE) Code. If an offeror is unable to obtain this code in time for submission of the concept summary, indicate the date one was applied for on the concept summary form. To obtain a CAGE code, go to https://cage.dla.mil/request or apply to the System for Award Management Registration at https://sam.gov/content/home. Before one can register with SAM or obtain a CAGE code, he or she will need to first obtain a Unique Entity ID.

Offerors should note that CASIS funding is to be allocated toward Implementation Partner costs only. All other costs will be covered by the principal investigator. Concerning the In-Kind Contribution line item in the budget table, this value should include the estimated value of any facilities, hardware, or support services provided by the offeror's institution to support the project.

Useful Links:

ISS National Lab Project Overviews: www.issnationallab.org/projects
ISS National Lab Implementation Partner Database: www.issnationallab.org/implementation-partners
NASA's Export Control Program: www.nasa.gov/oiir/export-control
NASA Designated Countries: www.nasa.gov/oiir/export-control
Click here for Frequently Asked Questions