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: Assessing QD-cell interactions for safer biomedical use in the microgravity environment.	
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.):** India
Organization legal name: Bubbles & Cafe Inc	
Organization status: ✔ U.S. Entity ☐ Non-U.S. Entity	**Organization address:** 990 Shoreline dr, Aurora, IL 60504
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: The project aims to investigate the interactions between Quantum Dots (QDs) and cells in a microgravity environment to assess their potential biomedical applications, with a focus on enhancing safety and efficacy. Rationale: Quantum Dots (QDs) are nanoscale semiconductors with unique optical properties that make them attractive for various biomedical applications, including imaging, drug delivery, and diagnostics. However, there are concerns about their potential cytotoxicity and safety in living systems. To address these concerns and unlock their full potential for biomedical use, the project proposes to study how QDs interact with cells in a microgravity environment.

- Space Exploration and Nanomedicine Synergy: Combining space exploration and nanomedicine enables understanding nanomaterial impact on cells for long-duration space missions.
- Methodology: Employ in vitro and possibly in vivo experiments with QDs in simulated microgravity using fluorescence microscopy, flow cytometry, and gene expression profiling.
- Interdisciplinary Collaboration: Collaborate across nanotechnology, biology, pharmacology, space sciences, and bioinformatics for comprehensive research.
- Potential Biomedical Applications: Unlock groundbreaking QD applications as targeted drug delivery, imaging agents, and sensors, revolutionizing healthcare.
- Ethical Considerations: Prioritize safety and ethical guidelines to responsibly experiment with potentially toxic nanoparticles.
- Broader Impact: Findings extend to other nanomaterials, contributing to the understanding of nanomaterial behavior in altered gravitational conditions.
- Unique Microgravity Environment: The ISS provides an unparalleled platform to study QD-cell interactions without terrestrial gravitational effects, leading to a more comprehensive understanding.
- Long-Term Studies: Extended experiments on the ISS allow for in-depth observation of cellular responses to Quantum Dots, improving the accuracy and reliability of results.
- Resource Availability: Access to specialized equipment and facilities on the ISS enhances the quality and scope of the research.
- Reduced Environmental Variability: Controlled conditions on the ISS minimize environmental factors, ensuring more reliable and replicable experimental outcomes.
- Space Commercialization and Biomedical Industry: Successful research can attract private sector interest, leading to collaborations and applications in medical technologies.

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

The test objective is to investigate QD-cell interactions in a microgravity environment for safer biomedical use. Starting TRL is at the basic research phase (TRL 1), and the ending TRL would likely be around 5 to 6, indicating significant laboratory testing and potential for real-world applications.

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

In-depth study without gravity-related effects; Elimination of terrestrial confounding factors for accurate data; Assessment of nanomaterial stability in space's harsh environment; Insights into altered cellular responses for biomedical applications; Encouragement for future space-based biomedical research; Gravitational independence for direct observation; Contributions to space-ready medical tools; Alignment with space exploration goals; Unique platforms for innovative research; Promotion of international collaboration and data

sharing; Validation of medical technologies for space applications; Minimization of terrestrial interference for cleaner results; Advancement in nanomedicine and space health research.

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

- Safer Biomedical Applications: Understand QD-cell interactions in microgravity for safer QD-based biomedical products.
- Enhanced Efficacy and Targeting: Optimize QDs for better therapeutic and imaging applications.
- Innovative Drug Delivery Systems: Inspire advanced drug delivery systems with QDs.
- Advanced Imaging Technologies: Revolutionize medical imaging with QDs' optical properties.
- Space Health Applications: Monitor astronauts' health and provide medical interventions in space.
- Space Commercialization Opportunities: Attract commercial interest in space-ready medical technologies.
- Earth-based Biomedical Solutions: Adapt QD-based products for improved healthcare on Earth.
- Economic and Societal Impact: Generate new markets and enhance healthcare outcomes.
- Regulatory Approvals: Streamline regulatory approval for QD-based medical products.
- Enhanced Nanomedicine Research: Stimulate further research in nanomedicine.
- Knowledge Transfer to Other Fields: Apply knowledge to other nanomaterials and biomedical applications.
- Education and Workforce Development: Foster education in specialized fields for future innovations. In conclusion, the project's outcomes can lead to safer and more effective QD-based biomedical products and solutions, driving technology development and commercialization opportunities in both space and terrestrial healthcare settings.

Concept of Operations:

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

In-Orbit Requirements:

- Spacecraft Access: The project requires access to a space station or a satellite with microgravity conditions for the duration of the experiments.
- Microgravity Environment: The primary in-orbit requirement is to conduct the experiments in a controlled microgravity environment. This can be achieved on a space station in Low Earth Orbit (LEO) or on a dedicated microgravity research platform.
- Safety and Containment: The experiments involving QDs and biological cells need to be conducted with utmost safety and containment protocols to prevent any accidental release of hazardous materials into the spacecraft's environment.
- Data Transmission: A reliable data transmission system is essential to relay experiment data and results back to the ground control station for analysis and monitoring.

Experimental Setup: Components of QD-Cell Interaction Experiment on ISS:

- QD Synthesis: High-quality, biocompatible QDs with tailored properties.
- Cell Culturing: Onboard cultivation of relevant biological cells.
- Microfluidics/Lab-on-a-Chip: Precise co-culturing of QDs and cells.
- Imaging & Analysis Equipment: Real-time monitoring with specialized tools.
- Environmental Control: Optimal conditions for cell viability and stability.
- Safety Measures: Containment and waste management protocols.
- Experiment Duration: Observing long-term cellular responses.

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

1. Lab-on-a-Chip or Microfluidics Device: A specialized lab-on-a-chip or microfluidics device will be required to co-culture the Quantum Dots (QDs) with biological cells. This device allows for controlled interactions between the QDs and cells in a microgravity environment.
2. Bioreactor: A bioreactor system might be utilized to culture and maintain the biological cells in a controlled environment, ensuring their viability and functionality during the experiments.
3. Spectrometers and Microscopes: High-resolution imaging equipment, such as fluorescence microscopes and spectrometers, will be needed to monitor and analyze the interactions between QDs and cells in real-time.
4. Environmental Control Systems: The experiment requires systems to control temperature, humidity, and gas exchange within the setup to create the desired conditions for cell growth and QD interactions.
5. Safety Containment Units: To prevent any accidental release of hazardous materials or contamination of the spacecraft environment, safety containment units will be incorporated in the experimental setup. **(The Quantum dots that are synthesized using microbial and green synthesis and non toxic materials are used in the experiment to minimize the safety concerns)**
6. Data Transmission System: A reliable data transmission system will be necessary to transmit experiment data and results back to the ground control station for analysis and monitoring.
7. QD Synthesis and Preparation Facilities: Prior to the mission, facilities for synthesizing and preparing biocompatible QDs with specific properties may be required on Earth.

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

Operations Lead: _____
Science Lead: _____

8. Cell Culturing Facilities: Onboard the spacecraft, facilities for cell culturing and maintenance will be needed to ensure the availability of viable biological cells for the experiments.
9. Waste Management System: A waste management system will be necessary to handle and store any biohazardous waste generated during the experiments.

Define the logistical support and payload return requirements: Logistical support for the project involves preparing and transporting equipment to the launch site, arranging the launch to the microgravity environment, installing the experiment, providing mission monitoring, and supporting data analysis. A payload return vehicle will safely transport hardware and data back to Earth. Post-mission debriefing and analysis will be conducted to assess the experiment's success and address any issues. Equipment disposal or refurbishment may be necessary.

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).

Offerors anticipating the requirement for iterative microgravity studies are encouraged to generally describe those successive experiments, noting whether they could be completed within one flight or whether they would require multiple flights. (Note: Only one flight project at a time will be funded.)

- Baseline study on Earth to establish standard QD-cell behavior.
- Microgravity validation on ISS to compare results with baseline.
- Long-term effects study to observe cumulative impacts.
- Dose-response relationship exploration for varying QD concentrations.
- Cellular uptake mechanisms investigation for biomedical targeting optimization.
- Cellular stress responses assessment to mitigate adverse effects.
- Targeted drug delivery optimization using QDs in microgravity.
- Advanced imaging techniques development with QDs.
- Multi-cellular interactions study for complex cellular systems understanding.

Benefits/Business Case:

Why this proposed project is important:

Understanding QD-cell interactions in microgravity is crucial due to altered biological processes in space; It benefits future space missions and biomedical applications for astronauts; Ensuring safer biomedical use of QDs on Earth; Advancing targeted drug delivery systems with QDs; Enabling advanced imaging techniques for cellular processes; Assessing QD biocompatibility in microgravity; Optimizing biomedical treatments during space missions; Implications for space colonization healthcare; Contributing to fundamental research in nanomedicine; Fostering collaboration and innovation across disciplines.

How will this research in low Earth orbit will lead to a disruptive product or service?:

Safer space medicine through improved biomedical applications for astronauts; Innovative nanomedicine products and therapies targeting specific diseases; Advancements in medical imaging with enhanced cellular visualization; Precision drug delivery systems for targeted disease treatment; Encouraging space-based biotechnology industries; Multidisciplinary innovations at the intersection of space science, nanotechnology, and biology; Implications for terrestrial medical applications in precision medicine and targeted therapies; Technology transfer and commercialization in various industries; Driving space commercialization and private investment in biomedical technologies; Global impact on healthcare, biomedical technologies, and space exploration.

Who will use the product?:

- Astronauts and space agencies for safer biomedical applications in space missions.
- Biomedical researchers for QD-cell interaction insights and medical technology development.
- Medical professionals for improved drug delivery and imaging techniques.
- Pharmaceutical industry for enhanced drug development.
- Biotechnology companies for precision medicine innovations.
- Medical imaging companies for advanced imaging technologies.
- Space biotechnology startups for disruptive space exploration products.
- Healthcare providers for advanced treatments and diagnostics.
- Biomedical device manufacturers for incorporating QD-based technologies.
- Research institutions for enriching ongoing studies.
- Public health authorities for disease prevention and management.
- General public for improved healthcare and diagnostics.

The best estimates of how much revenue realistically will be generated from it, or as a result of it, and in what timeframe.

- Revenue from licensing research outcomes and patented technologies to biotech and pharma companies.
- Income generated through sales and royalties from novel biomedical products and therapeutics.
- Space medicine contracts and consultations with space agencies.

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

Operations Lead: _____
Science Lead: _____

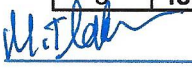
- Research and development grants from government and private organizations.
- Commercialization of improved imaging technologies for space exploration and remote sensing.
- Revenue from precision medicine and targeted drug delivery in healthcare.
- Incorporating QD-based health monitoring into space tourism experiences.
- Revenue-sharing partnerships with biotechnology companies for diagnostics and therapies.
- Revenue growth in nanotechnology applications across industries.
- Expected revenue generation in 5 to 10 years post-research success.
- Global revenue impact with increased demand for advanced biomedical technologies.

Budget and Funding Sources:

Budget Narrative:

- 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	N/A
2	Implementation Partner (Mission Integration & Operations) Costs	350K
3	**Total Project Funding Required (1 + 2)**	350K
FUNDING SOURCES		
4	Funds Provided by PI's Organization	N/A
5	Funds Requested from CASIS (5a + 5b)	350K
5a	Project Funding Requested from CASIS	N/A
5b	Implementation Partner (Mission Integration & Operations) Funding Requested from CASIS	350K
6	Funds Provided by Other Sources	N/A
7	In-Kind Contributions	N/A
8	**Total from All Funding Sources (must equal Item 3)**	350K

Signature: 

Prepared By: ILAKKUVASELVI MANOHARAN

Title: CEO, BUBBLES & CAFE, INC

Date: 08/09/2023