

## Liquid Crystal – Thailand (LC-T)

### BACKGROUND

The Liquid Crystal – Thailand investigation (Study Of Structures & Dynamics Of Inclusions On 2-Dimensional Freely Suspended Smectic Liquid Crystal Films In Microgravity) will explore fundamental non-equilibrium fluid interfacial phenomena in ultra-thin liquid films. Smectic liquid crystals make the thinnest possible stable films and exhibit a combination of physical characteristics that make them uniquely exciting systems for the study of equilibrium and out-of-equilibrium phenomena in reduced dimensionality, for example liquid crystal ordering and fluctuations in two dimensions, and the effects of finite size on liquid crystal phase transitions. This unique characteristic enables specific scientific research objectives with free standing liquid crystal films in microgravity environment on board the ISS resulting in extraordinary opportunities for the study of fluid dynamic and thermodynamic behavior in reduced dimensionality.

This investigation is being worked as part of an agreement between NASA Science Mission Directorate and Kasetasart University in Thailand. They will be responsible for developing the experiment and providing the samples to NASA for the investigations. The investigators will receive support from the Thai Geo-Informatics and Space Technology Development Agency (GISTDA). The initial investigations will be done utilizing the Blue Origin sub-orbit launch vehicle (New Shepard) to determine some minimal science, overall characterization of the samples, and obtain support for an ISS focused investigation. The samples will be modified (if needed) by the Kasetasart University to be manifested and flown to the ISS. Currently the samples are being developed to be tested in the Keyence Research Microscope Testbed (KERMIT) microscope that is integrated into the Materials Science Research Rack-1 (MSRR-1) rack on the ISS.

KERMIT is a commercial off-the-shelf Keyence microscope (BZ-X800E) that provides researchers with fundamental microscope capabilities, including state-of-the-art imaging and analysis modules. Additional information on the Keyence microscope can be found at:

[https://www.keyence.com/products/microscope/fluorescence-microscope/bz-x700/models/bz-x800e/?search\\_dl=1](https://www.keyence.com/products/microscope/fluorescence-microscope/bz-x700/models/bz-x800e/?search_dl=1)

KERMIT provides the ability to perform advanced microscopy on the ISS and is operated remotely from the ground after the crew installs the sample.

### TASK DESCRIPTION

The contractor shall be responsible for providing Mission Integration and Operations for these liquid crystal investigations utilizing the Blue Origin New Shepard test capability and the KERMIT system on the ISS. This will involve determining the best method to image the samples on the Blue Origin vehicle, along with assisting the investigators in properly developing and integrating their samples in the KERMIT system on the ISS. This task consists of four subtasks consisting of:

- (1) Blue Origin manifesting, integration and operations;
- (2) ISS KERMIT manifesting and integration;
- (3) Safety assessments and integrated safety reviews;
- (4) ISS Console Operations.

## **SCOPE OF WORK**

The SOW Performance Work Statement 4.7 and 4.8 are applicable to this task. The contractor shall provide mission integration and operations support to the LC-T project to assist the Thailand investigators to properly integrate and operate their mission on the Blue Origin New Shepard vehicle and the International Space Station. The specific activities are sub-divided into a series of tasks that support systems engineering and integration, operations, and safety and mission assurance for the investigation. The work shall be performed in the following tasks:

### **1) Blue Origin New Shepard manifesting, integration, and operations**

The contractor shall provide the investigator team the Blue Origin New Shepard interfaces and environments that are defined by Blue Origin between the payload and the New Shepard vehicle and the testing/safety requirements for payloads. The contractor shall support the science team's identification and refinement of the engineering/science requirements by reviewing their experiment requirements and the Blue Origin capabilities. The contractor shall determine the best approach to meet their science objectives. This should also include determining an approach of "simulating" the KERMIT system for this investigation to avoid multiple set of diagnostics equipment to be developed.

To achieve these objectives, the Contractor will have to define and develop appropriate interfaces with the Blue Origin vehicle. This may require proof-of-concept assessments and potential risk mitigation recommendations. The contractor shall assume the experimental package would then be used for a series of flight-campaigns consisting of up to six partial gravity flights.

### **2) ISS KERMIT Integration**

The contractor shall provide the investigator team the ISS KERMIT interfaces and associated ISS requirements to allow for safe operation by the crew in handling the samples and operating in KERMIT. The contractor shall be responsible for working with the ISS Program and the KERMIT team to provide the necessary documentation to support planning and verification for manifesting and utilization of the experiment.

It is important and crucial for the ISS Program to understand the experiment readiness for: a) final delivery, b) launch/return c) on-orbit ISS integration, and d) operations. The contractor shall keep the ISS Program informed of the experiment readiness along with verification submittals and all associated documentation for manifest and operations on the ISS.

### **3) Safety assessments and integrated safety reviews**

The contractor shall work with the experiment development team to define the safety requirements and process that will need to be met for operation on the Blue Origin New Shepard and the ISS. The contractor shall define the hazards associated with the experiment based on the experiment design and planned operations, along with the required verifications required to be provided to the ISS and Blue Origin for control of the hazards. The contractor shall provide the proper required safety package and hazard reports to the ISS. Proper documentation shall also be developed and provided to Blue Origin for manifesting the experiment for those series of flights. The contractor shall hold appropriate safety reviews and technical interchange meetings with ISS and Blue Origin, as required.

#### 4) ISS Console Operations

The contractor shall provide a LC-T console operator support to communicate with the KERMIT operations team along with providing ISS crew interactions during the preparation and install of the samples during utilization of the KERMIT microscope. The contractor shall assume that the experiment will consist of 10 samples with each requiring crew interaction for preparing it to operate properly in the microscope. An Operations Readiness Review (ORR) shall be completed prior to the start of operations. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

The contractor shall coordinate with the KERMIT team during the checkout of the LC-T hardware on orbit. The contractor shall perform the work required to resolve the anomalies on orbit and complete the additional operational requirements/tasks requested by PI/science team.

### **GOVERNMENT PROPERTY**

- No Government Property is provided for this Task.

### **DELIVERABLES AND REVIEWS**

#### 1) Deliverables

- LC-T/New Shepard vehicle Utilization Assessment
- Applicable LC-T/New Shepard vehicle Interface and Safety Requirements
- Applicable ISS/KERMIT Interface and Safety Requirements
- LC-T Safety Package (New Shepard and ISS) with Hazard Reports
- Verification Documentation Submittals to ISS

#### 2) Milestones

- Kickoff Meeting with LC-T Team
- New Shepard Safety Review
- New Shepard Operational Readiness Review
- ISS Flight Safety Review TIM (Phase 0/I/II)
- ISS Phase-III Flight Safety Review
- ISS/KERMIT Operations Readiness Review