
# Technology Advancement and Applied Research on the ISS National Lab

**National Lab Research Announcement** NLRA 2021-3

**Instructions to Offerors**

The Center for Advancement of Science in Space
6905 N. Wickham Road, Suite 500, Melbourne, FL 32940

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**End Date of Step 1 Phase: Feb. 25, 2021**

**Due Date for Step 2 Submission: Apr. 26, 2021**

*Note: For any updates regarding submission deadlines, please visit https://www.issnationallab.org/rfp2021-3. For general questions relating to this research announcement, please email info@ISSNationalLab.org.*

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## I. SUMMARY

The International Space Station (ISS) contains a one-of-a-kind laboratory that enables research and technology development not possible on Earth. As a public service enterprise, the ISS U.S. National Laboratory allows researchers to leverage this multiuser facility to improve quality of life on Earth, mature space-based business models, advance science literacy in the future workforce, and expand a sustainable and scalable market in low Earth orbit (LEO).

Through this orbiting national laboratory, research resources on the ISS are available to support non-NASA science, technology, and science, technology, engineering, and mathematics (STEM) education initiatives from U.S. government agencies, academic institutions, and the private sector. The Center for the Advancement of Science in Space (CASIS) manages the ISS National Lab, under Cooperative Agreement with NASA, facilitating access to its permanent microgravity research environment, a powerful vantage point in LEO, and the extreme and varied conditions of space.

As a U.S. taxpayer-funded organization, CASIS works only with U.S.-based organizations and researchers. This document will assist offerors in the development of quality proposals to use the ISS National Lab for applied research and technology development and demonstration.

## II. DESCRIPTION OF RESEARCH

This ISS National Lab Research Announcement (NLRA) is soliciting proposals for applied research and development, translational medicine, technology readiness level (TRL) maturation, and technology demonstration in a broad range of existing or emerging technology areas. Research concepts are desired for which space-based testing can uniquely enable technical solutions to known or new science and engineering challenges and the creation of new products and business opportunities. The objective is to use the unique ISS environment to develop, test, or mature products and processes that have a demonstrated potential to produce near-term, positive, direct or indirect economic impact.

The ISS National Lab enables long-term studies within the unique, persistent microgravity environment inside the ISS. When gravity is no longer a dominant physical force, myriad unique effects on physical and biological systems and phenomena are induced, enabling new capabilities of these systems that can be exploited to develop and demonstrate new technologies. Studies utilizing either the extreme conditions of the LEO environment, or the ISS as a remote sensing platform, may be conducted using facilities externally attached or within the ISS.

To be competitive, all responsive proposals must demonstrate sound rationale for use of ISS National Lab resources and must project pathways to industrial applications. Technologies proposed for testing should generally be beyond basic concept validation and seeking maturity through development and/or demonstration in the space environment. Proposed flight experiments should generally target raising the TRL from 4 or higher to 6 or higher. Ideally, it is desired that the results of flight experiments will rapidly enable a commercial offering of new technologies or products to end users.

Proposals within the areas of advanced materials and translational medicine are of particular interest. However, this NLRA is open to a broad range of additional proposal topics including but not limited to materials manufacturing techniques, crystal growth for organic and inorganic systems, translational medicine, biofabrication, quantum technology, high performance computing, artificial intelligence,

automation and robotics, remote sensing, and satellite technology.

*Background*

***Microgravity***

The ISS National Lab offers the opportunity to conduct long-duration experiments in persistent microgravity, where gravity-driven physical forces are nearly absent. Results of research inspired by microgravity-driven phenomena have been shown to provide new practical insights and tangible benefits to multiple, cross-cutting life science, physical science, and engineering fields and areas of industrial application.

*In the life sciences:*

- Long-term spaceflight is known to induce rapid physiological changes such as bone loss, immune dysfunction, cardiovascular deconditioning, and loss of muscle mass and strength-changes normally associated with aging and chronic human diseases. These effects (in humans, model organisms, and in some cases tissue constructs) can be used for disease modeling, development and evaluation of therapeutics, and other analyses. For more information, see Tissue Chips in Space: Modeling Human Diseases in Microgravity (Pharm Res 2020) and/or Modeling the Impact of Microgravity at the Cellular Level: Implications for Human Disease (Front Cell Dev Biol 2020).
- Spaceflight also has dramatic effects on fluid dynamics, providing a unique environment for studying nuanced and complex underlying factors associated with biomedical devices that involve fluids—particularly those at the nanoscale, where forces such as diffusion are critical to the function of the technologies. For an example, see Counteracting Muscle Atrophy on Earth and in Space via Nanofluidics Delivery of Formoterol (Adv Ther 2020).
- Crystallization experiments in space demonstrate the value of the ISS for improving molecular crystal growth. High-quality and/or larger crystals of organic molecules, grown in space, enable structural determination for efforts such as drug design and also can be used to improve drug formulation, manufacturing, and storage. For more information, see our web resources on Microgravity Molecular Crystal Growth.

*In the physical sciences:*

- In microgravity, gravity-driven phenomena such as convection, buoyancy-driven fluid flows, and sedimentation are nearly negligible. This environment presents the opportunity to clarify different effects (such as diffusion, interfacial tension, and other atomic-scale phenomena) on the formation processes and properties of industrial materials. This can enable the synthesis and testing of novel materials and manufacturing methods for tailored applications, including but not limited to additive manufacturing. For more information, see NASA's A Researcher's Guide to Fundamental Physics and A Researcher's Guide to Microgravity Materials Research.
- Altered fluid dynamics in the functional absence of gravity also enable studies to improve the practical design and utility of fluid flow systems, particularly when involving phase separation or capillarity. For more information, see NASA's A Researcher's Guide to Fluid Physics.

***LEO Extreme Conditions***

In addition to microgravity, the extreme conditions of the space environment are demonstrably hostile to many materials. In LEO, these conditions include:

- Atomic oxygen, which is highly reactive with plastics and some metals, causing severe erosion.

- Ultraviolet radiation, which deteriorates and darkens many plastics and coatings.
- Vacuum conditions, which alter the physical properties of many materials.
- Impact from meteoroids and orbiting man-made debris, which can damage materials exposed in space.
- Continuous cycling between extreme high and low temperatures, which can result in accelerated thermal degradation of materials.

The ISS National Lab supports a variety of facilities and hardware to exploit the LEO extreme environment for development and testing of new materials, devices, and subsystems. Such testing provides a mechanism for rapid failure and analysis, thereby accelerating the qualification and commercial readiness of these new devices and products. Innovative concepts may also be proposed to specifically demonstrate the effective use of external LEO vacuum, radiation, and/or thermal cycling in a space-based industrial process, or to demonstrate and qualify new technologies involving robotic operation and assembly. For more information on the effects of these conditions of the space environment, see NASA's A Researcher's Guide to Space Environmental Effects.

***Vantage Point***

The ISS offers a vantage point in LEO with unique opportunities for technology development and demonstration in remote sensing:

- The ISS orbits at an average altitude of 400 km (250 miles), offering a wide range of Earth viewing geometries and spatial resolutions for sensors mounted on the externally attached platforms. Sensors may also be mounted inside the ISS with access to observation windows offering Earth-facing or other orientations.
- The orbital inclination of 51.6 degrees covers approximately 90% of Earth's populated area every 90 minutes and allows revisits of the same targets every 3-5 days.
- The ISS offers variable illumination conditions for Earth viewing and similar solar illumination conditions approximately every 63 days.
- The ISS provides power, communications, and data handling infrastructure to hosted payloads.
- Payloads may be returned for post-mission analysis; however, this is a heavily constrained resource, so payload return requests should include a strong rationale for this experiment requirement.

Sensors are either hosted on external platforms or mounted inside the ISS where targets on Earth or in space may be viewed through observation windows. Past and current remote sensing instruments include commercial-off-the-shelf (COTS) high-resolution cameras and prototypes of a variety of sensor technologies including hyperspectral, multispectral, and light detection and ranging (LIDAR). Sensor data have been used to demonstrate several commercial and practical applications, such as the monitoring and mitigation of environmental pollutants (methane and carbon dioxide) from chemical processing facilities; measurement of atmospheric carbon dioxide; monitoring of cloud and aerosol characteristics to aid understanding of climate and weather patterns; monitoring and optimization of agricultural practices; analysis of ocean and forest ecosystems; and assistance with disaster relief. Proposals for remote sensing should indicate novel features of new sensors to be tested and describe how the data acquired from new or existing sensors will be used to generate products of commercial value.

For more information on the remote sensing features of the ISS, see NASA's A Researcher's Guide to Earth Observations.

*ISS National Lab Implementation Partners, Facilities, and Capabilities*

Each offeror should be familiar with the capabilities of flight hardware for in-orbit studies that are relevant to their proposed technology development objective. The ISS National Lab partners with a variety of Implementation Partners, organizations that provide research, engineering, and technical services—and, in some cases, operate and maintain commercial payload facilities on the ISS, to support and facilitate research projects. For details about these providers and their specific hardware/services, visit our Implementation Partner database. Where applicable, the ISS National Lab encourages contact between offerors and Implementation Partners prior to concept or proposal submission in order to obtain information that may be useful for budget and schedule estimates. If requested, the ISS National Lab can facilitate contacts between Implementation Partners and offerors.

*Additional ISS Facilities*

Multiple additional facilities for research and technology development are available on the ISS. Detailed descriptions of facilities are provided in NASA's ISS Researcher's Guides Series.

For life sciences investigations, a listing and descriptions of current or soon-to-be available facilities on the ISS can be browsed on NASA's Space Station Research Explorer web tool.

For materials research and engineering, current or soon-to-be available facilities include but are not limited to the following:

- Microgravity Science Glovebox
- Pore Formation and Mobility Investigation Apparatus
- Solidification Using a Baffle in Sealed Ampoules
- Materials Science Research Rack

Additional information on materials science flight investigations sponsored by NASA to utilize these and other physical science platforms is available in the NASA Physical Sciences Informatics System.

*Research and Technology Development Objectives and Priorities*

Applied research and technology development on the ISS National Lab is intended to validate technological breakthroughs and rapidly advance the development of new Earth- or space-based products to bring value to our nation and drive a robust, sustainable, and scalable LEO economy. These objectives will be achieved by successfully executing flight experiments utilizing microgravity, the extreme conditions in LEO, or the vantage point of the ISS. Responsive proposals must describe how successful space-based experiments will quickly advance the technology or product toward a viable market offering. The ISS National Lab strongly recommends obtaining and submitting letters of support from commercial partners and/or potential users of new technologies or products to demonstrate feasibility or commercial interest, when applicable.

Proposals in advanced materials and translational medicine are of particular interest, but this NLRA is open to a variety of proposal topics. These other topic areas include but are not limited to manufacturing techniques for crystal growth for organic and inorganic systems, biofabrication, quantum communications, high performance computing, artificial intelligence, automation and robotics, remote sensing, and satellite technology.

Additionally, emphasis will be placed on proposals for testing and space-qualification of hardware prototypes and on advancing process improvements. Suggested concepts under these areas are described below:

- Advanced materials: Current advanced materials research addresses the development of next-generation production methods, the synthesis and testing of novel materials, and the exploitation of mechanisms involved in material transformations for production of new materials with unique characteristics. Potential topic areas of interest under this NLRA include but are not limited to material bonding (e.g., soldering, brazing, or welding); biomaterials; soft materials (e.g., emulsions, foams, or liquid crystals); metamaterials; granular materials; and hard, functional materials with unique microstructure (e.g., metal alloys, semiconductors, ceramics, glassy alloys, metallic foams, or composites).
- Translational medicine: Potential topics for consideration in translational medicine include validation of accelerated disease models, analyzing macromolecular structures for structure-based drug design, and demonstration of novel drug delivery and diagnostic devices.
- Hardware prototype testing: Innovations addressing hardware product development gaps and emerging technology proliferation in the following areas: computing, electronics, nanotechnologies, robotics, sensors, communications, space-based quantum communication, remote sensing, and satellite technology (assembly, inspection, refueling, operations, and in-orbit servicing). Proposals of interest in this area will typically feature ground-tested, ready-to-fly hardware prototypes that require space qualification to capture new market opportunities.
- Process improvements: Use of the ISS as a test bed for advancing development of facilities for high-throughput investigations; use of spaced-based data to facilitate modeling or operations of industrial systems; and demonstrating new methodologies for spaceflight research and development (e.g., combinations of ISS edge computing and Earth-based cloud computing), including the use of robotics/automation and artificial intelligence.

## III. SUBMISSION AND SELECTION PROCESS

This research announcement will follow a two-step proposal submission process. Before being invited to submit a full proposal, all interested investigators must first complete and submit a Step 1 Concept Summary for review. The purpose of Step 1 is an initial evaluation of the offeror's concept for operational feasibility, scientific or technological scope, compliance, and alignment with the NLRA scope.

*Step 1 Concept Summary Submission*

- Concept summaries must use the template provided on the NLRA webpage.
- Concept summaries may be submitted and will be received, evaluated, and potentially approved continuously during the NLRA open period.
- A CASIS internal review team with representatives from science, business, operations, and compliance will evaluate each concept summary. Approved concept summaries will be invited to submit a full proposal.
- Concepts approved based on Step 1 evaluation will proceed to Step 2 by invitation only.
- Concepts not invited to submit a full proposal will receive feedback.

*Step 2 Full Proposal Submission*

- The process for developing full proposals is outlined below and set forth in greater detail within the Proposal Instructions published on the NLRA webpage.
- Full proposals will undergo a peer review in accordance with proposal evaluation documents provided as attachments.
- At the end of Step 2, the proposals recommended for selection will be presented for final determination to the CASIS executive director, who is the selecting official.

Further details and requirements for the concept summary and full proposal submission, including instructions and templates, can be found in the Proposal Instructions document available on the NLRA webpage at *https://www.issnationallab.org/rfp2021-3*.

*Award Information*

CASIS may award a funded or unfunded agreement for a selected proposal. All awarded proposals will receive ISS National Lab sponsorship of ISS resource utilization, payload launch to the ISS, in-orbit ISS crew time, data return, and payload return, if required. Grant funding is not available for ground-based efforts.

***Funds Availability:*** The obligation of CASIS to make an award is contingent upon the availability of funds from which payment can be made. The number of grants awarded and the amount of grant funding for each award will depend on the number of meritorious applications.

***Funding for this NLRA:*** Total set aside funding for this NLRA is approximately $1 million, with an expectation to make up to four awards. CASIS funding is to be allocated to support Implementation Partner costs only. It is anticipated that CASIS will execute task orders and/or subcontracts directly with the Implementation Partner on behalf of the awarded principal investigator. No funding will be granted to cover the offeror's internal project costs. Requesting funding for cost elements not covered by this NLRA is grounds for disqualification. CASIS reserves the right to refuse award of grant if no meritorious offers are received.

***Notice of Award:*** For selected proposals, a CASIS officer will contact the principal investigator named in the proposal. Offerors have the right to be informed of the major factor(s) that led to the acceptance or rejection of their proposal.

***Period of Performance:*** It is anticipated that the period of performance will be no longer than three (3) years from date of award.

CASIS assumes no liability (including bid and proposal costs) for cancelling this NLRA or for any entity's failure to receive notice of cancellation.

## IV. PROPOSAL PREPARATION AND CONTENT

Step 1 Concept Summary instructions and the Step 2 Full Proposal submission guidelines can be found in the Proposal Instructions available on the NLRA webpage.

**Before finalizing proposals, offerors are strongly encouraged to consult with the CASIS Payload Operations team** (Ops@ISSNationalLab.org) for feedback regarding feasibility and compliance with flight requirements and capabilities. Please include reference to NLRA 2021-3 in the subject line and note that questions and answers will be posted on the ISS National Lab website. Offerors are also encouraged to work with an Implementation Partner—organizations that work with the ISS National Lab to provide services related to payload development. There are two ways to do this:

- Visit www.ISSNationalLab.org/Implementation-Partners to browse, select, and contact an Implementation Partner.
- Contact the CASIS Payload Operations team for guidance.

*Offeror Qualifications*

Proposals must be submitted by a principal investigator or an authorized official of the proposing organization. Any individual business entity or institution capable of executing the proposed research may submit a proposal. However, CASIS will **NOT** consider proposals requiring funded or unfunded agreements between CASIS and any non-U.S. entity (business or individual), as defined below.

## V. PROPOSAL EVALUATION FACTORS AND PROCESS

Proposals will be evaluated under the ISS National Lab's review and selection criteria for its Technology Development line of business, which covers applied research and development, technology demonstration, and TRL maturation to validate or improve technologies, products, and/or processes in preparation for commercial use. All proposals submitted must include an expressed commercial purpose or intent. Proposals that are determined to better fit other CASIS lines of business (Commercial Service Provider Utilization, Fundamental Science, In-Space Production Applications, and STEM Engagement and Educational Outreach) will be redirected to those areas.

Please note that CASIS will not accept or consider proposals submitted by NASA and/or NASA civil servants.

For further information on proposal evaluation criteria and processes, refer to the ISS National Lab Proposal Evaluator Instructions in the information package linked to the NLRA webpage.

The proposal review is guided by an overall assessment of expected project impact upon successful completion of proposed objectives. CASIS has overall responsibility for conducting and facilitating reviews, presenting information for final determination, and ensuring compliance with CASIS-defined processes.

## VI. CONTRACTING AND COMPLIANCE

To be considered, proposals must be received from U.S. persons and U.S. entities as defined in the Code of Federal Regulations (CFR) and be compliant with ISS National Lab export control programs and policies.

Award recipients will be required to enter into a User or Grant Agreement with the ISS National Lab. A

representative list of mandatory flow down provisions contained in the agreement can be accessed via the ISS National Lab's Contracts and Compliance webpage.