CASIS™

THE CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE

THE ROLE OF CASIS

GREG JOHNSON,
EXECUTIVE DIRECTOR

MARCH 31, 2015

NRC SPACE SCIENCE WEEK
SPRING 2015 MEETING OF THE COMMITTEE ON BIOLOGICAL AND PHYSICAL SCIENCES IN SPACE

CASIS AND THE ISS NATIONAL LAB

Provide Opportunity for research & discovery targeted to a definitive

Impact on Earth

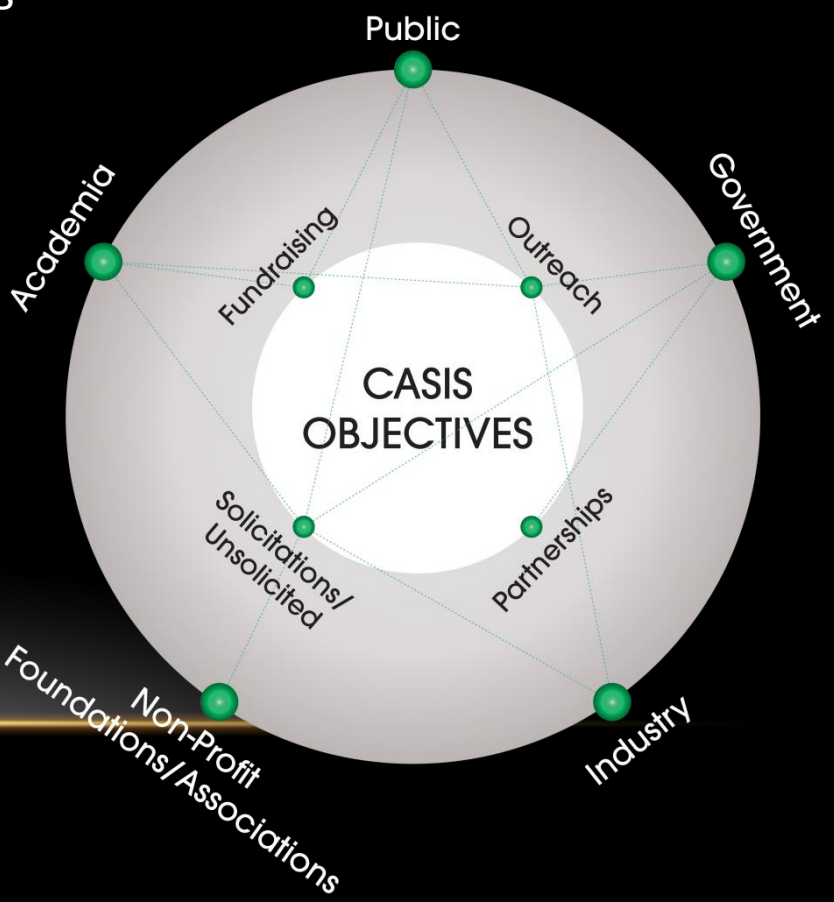
The Opportunities are Wide-Ranging:

- LIFE SCIENCES
- MATERIALS SCIENCES
- PHYSICAL SCIENCES
- TECHNOLOGY DEVELOPMENT
- EARTH OBSERVATIONS

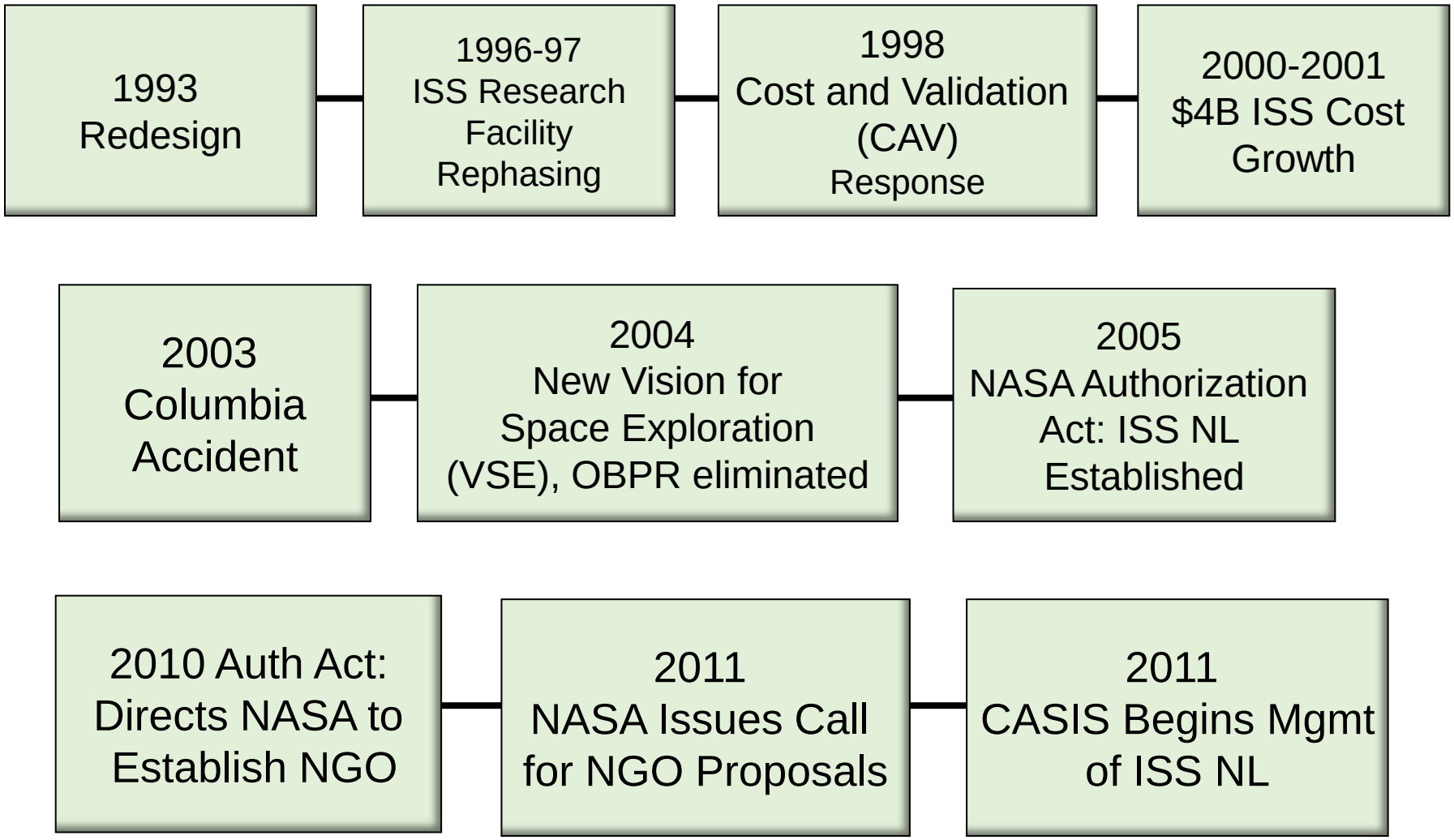
IMPROVE LIFE ON

CASIS OVERVIEW

- Nongovernment nonprofit organization, established to:
  - Develop & manage a diverse R&D portfolio
  - Stimulate & manage the use of ISS by OGAs, academic institutions, and commercial entities
  - Communicate the value of the ISS
    - Including STEM education
- $15M annually from NASA, ability to generate other sources of revenue
- NASA provides transportation and on-orbit logistics



Major Impact Points in Development of ISS National Lab

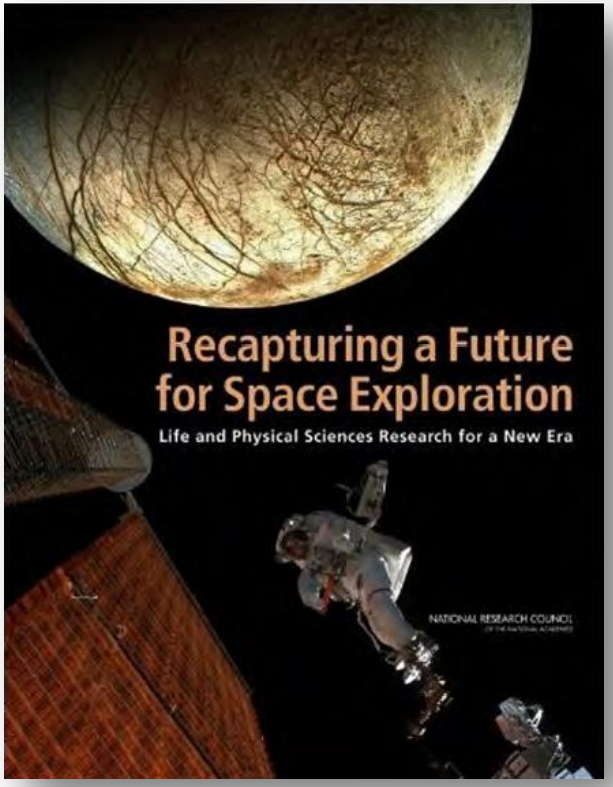


Stakeholders in ISS National Lab Research: One Destination, Multiple Pathways

- ***NASA Space Life & Physical Sciences (SLPS)*:** Discovery focused research in space biology and physical sciences
- ***NASA Human Research Program (HRP)* and the National Space Biology Research Institute (NSBRI):** Exploration related research and technology development to enable a long-term human presence in deep space
- ***Other Government Agencies*:** Discovery, applied, and translational research aligned with agency mission objectives (OGA use of ISS NL still early in development)
- ***CASIS***: Management of the ISS National Laboratory research portfolio to benefit the nation, and translate discoveries on the ISS National Lab into Earth benefits

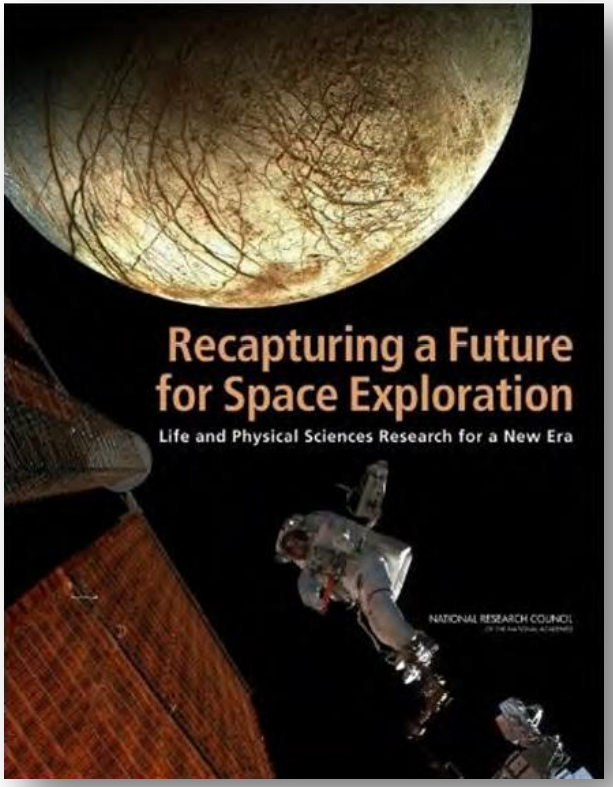
NRC Decadal Guides NASA and Prioritizes Exploration Research

NASA Space Life and Physical Sciences (SLPS)
NASA Human Research Program (HRP)
National Space Biomedical Research Institute



1. **Research that enables space exploration:** scientific research in the life and physical sciences that is needed to develop advanced exploration technologies and processes, particularly those that are profoundly affected by operation in a space environment.
2. **Research enabled by access to space:** scientific research in the life and physical sciences that takes advantage of unique aspects of the space environment to significantly advance fundamental scientific understanding.

NRC Decadal Informs the CASIS Research Portfolio for the ISS NL



CASIS MISSION TO THE ISS

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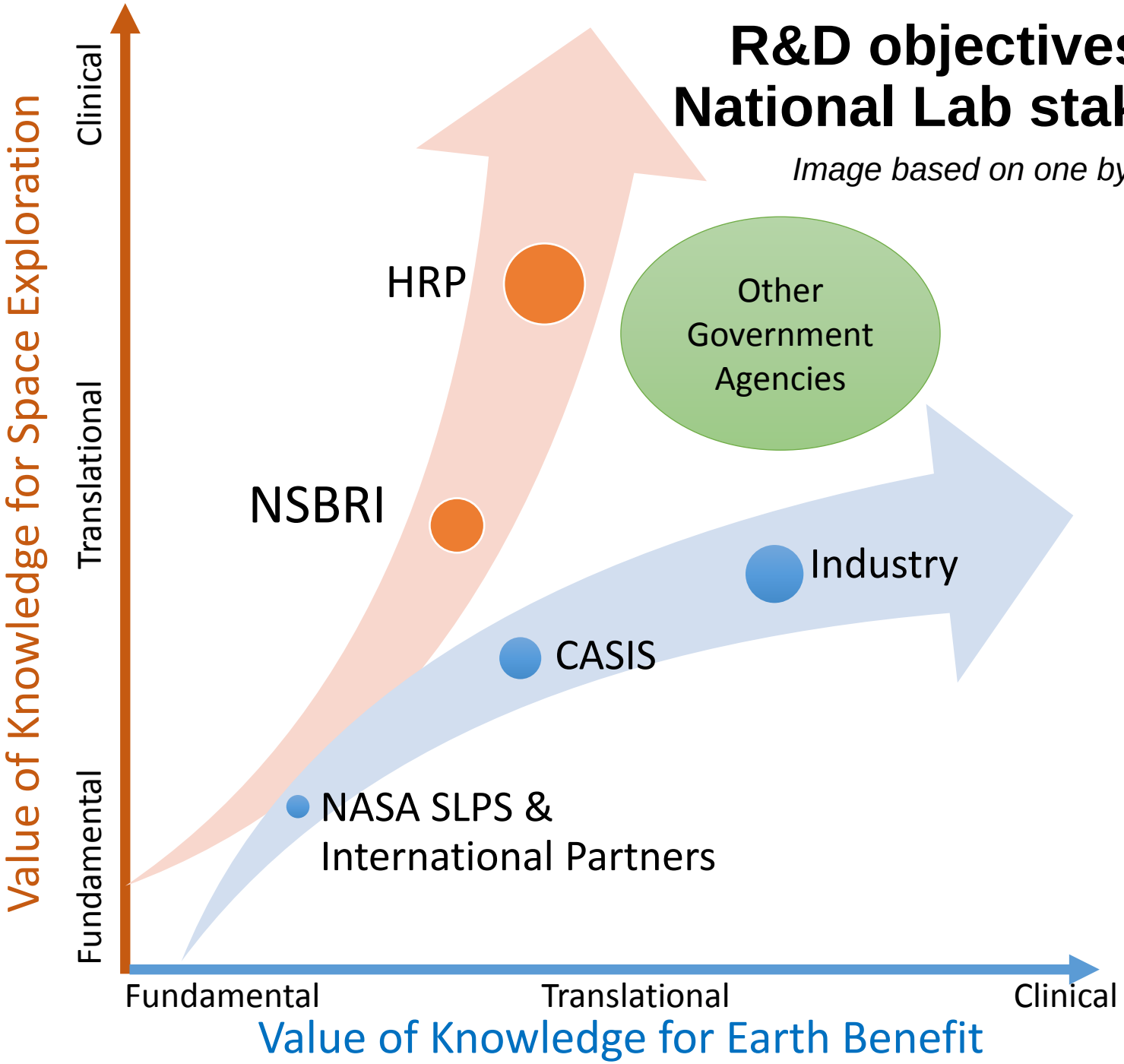
R&D objectives of ISS National Lab stakeholders

Image based on one by Julie Robinson (NASA)

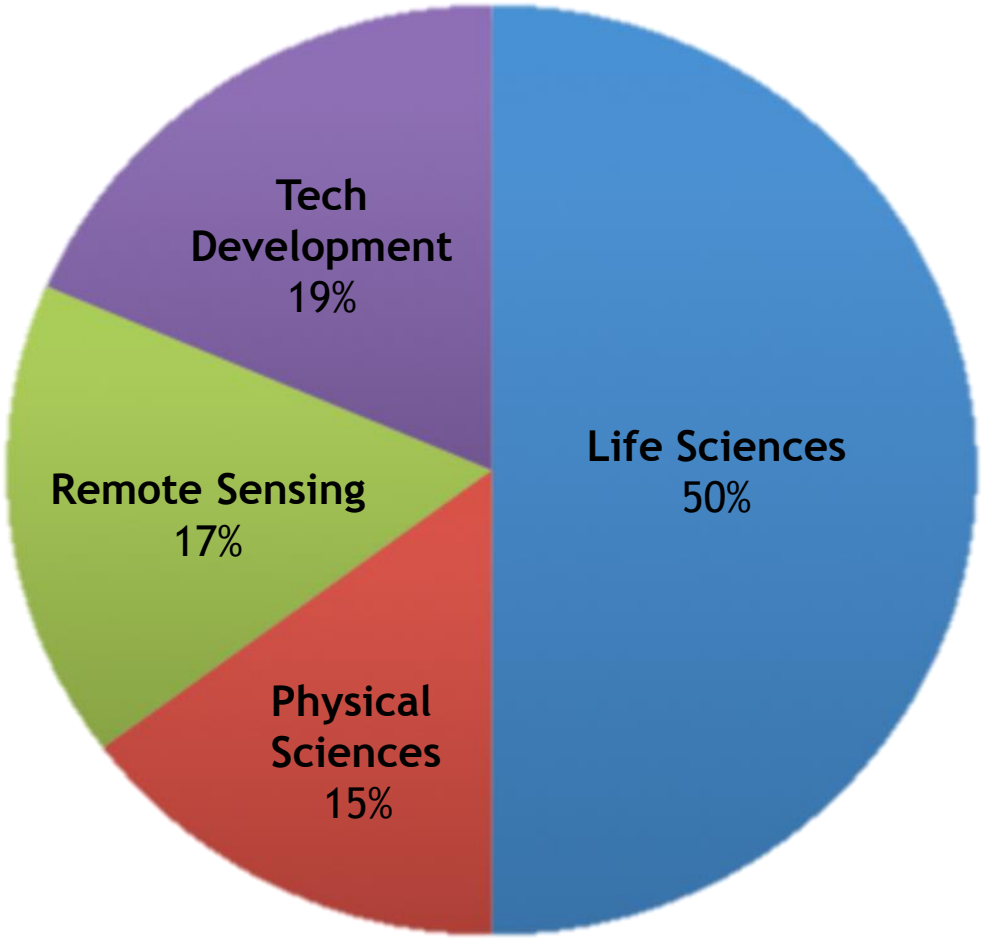


The CASIS Portfolio for ISS National Lab Utilization

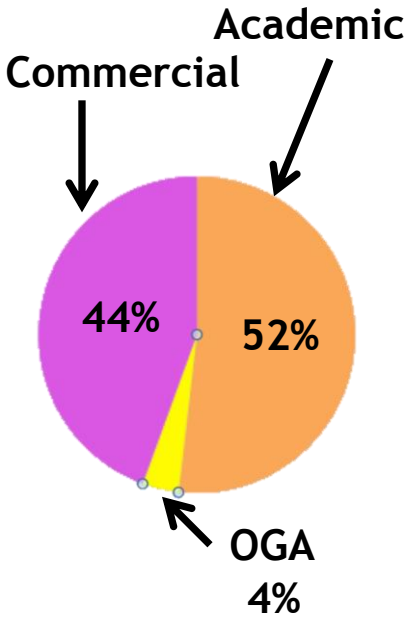
CASIS SPONSORED/NATIONAL LAB PAYLOADS IN FLOW			
Post Flight	Operational	Tactical/L – 6 months	Strategic/Early Development
40 Payloads	3 Payloads	9 Payloads	36 Payloads
CASIS SELECTED NATIONAL LAB PROJECTS IN FLOW			
Post Flight	Operational	Tactical/L – 6 months	Strategic/Early Development
23 Payloads	3 Payloads	6 Payloads	14 Payloads
Inc 37 thru 40	*Inc 41/42*	*Inc 43/44*	*Inc 45/46*

INCREMENT TIME LINE

CASIS Research Portfolio*



ISS National Lab



FY 2015 Focused Campaigns
- Good Earth
- Good Health

*thru FY14

CASIS Commercial Utilization

CASIS COOPERATIVE AGREEMENT

1.2 CASIS Purpose

1.2.1 CASIS Mission

CASIS will be responsible for maximizing the value of the ISS to the nation by developing and managing a diversified R&D portfolio based on U.S. national needs for basic and applied research and by using the ISS as a venue for Science, Technology, Engineering and Mathematics (STEM) educational activities.

1.2.2 CASIS Goals

- Stimulate, develop and manage the U.S. national uses of the ISS by other U.S. government agencies, academic institutions and private firms.
- Develop tools and techniques to communicate the value of uses of the ISS National Laboratory ("ISS NL") and increase the return on the U.S. investment in the ISS.

CASIS COOPERATIVE AGREEMENT

2.1 CASIS Responsibilities

2.1.1 Stimulate Interest and Use of the ISS National Laboratory

CASIS will stimulate interest in and use of the ISS NL as a platform for basic and applied research for other U.S. government agencies, academic institutions, and private firms.

2.1.2 Develop the ISS National Laboratory

CASIS will determine the research objectives that provide the most value to the nation across the breadth of research disciplines and across the range of basic to applied research.

2.1.3 Manage the ISS National Laboratory

CASIS will prioritize the entire NL research portfolio of technology demonstrations, basic, and applied research using a fair, transparent, and impartial selection process that maximizes value of the ISS investment made by the Nation.

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WHAT ARE THE GUIDING PRINCIPLES BY WHICH CASIS SELECTS RESEARCH PATHWAYS FOR UTILIZATION OF THE ISS NATIONAL LAB?

MICHAEL ROBERTS, PH.D.,
SENIOR RESEARCH PATHWAY MANAGER

CASIS Approach to Define Research Objectives for ISS National Laboratory

Set Initial Research Priorities:

- Engaged with NASA & Professional Organizations to conduct:
  - Literature reviews
  - Expert interviews
  - Market research
  - Market analysis
- Recommendations from the Decadal informed CASIS research priorities for both solicited and unsolicited proposals.

Establish & Manage Research Pathways:

- Produced key recommendations:
  - Biosciences Opportunity Map
  - Physical Sciences Opportunity Map
- Opportunity maps reviewed by interim CASIS science “collegium” (2012)
- Established CASIS Science and Technology Advisory Panel (2013)

CASIS Science and Technology Advisory Panel (STAP)

CASIS STAP Overview

- Comprised of academic and commercial experts:
  - Professional scientists
  - Engineers
  - Physicians
    - Areas of expertise map to key topic areas identified in Decadal
- Meet quarterly (three via teleconference and one meeting in person)
- Rotating membership

Role of the CASIS STAP

- Advise and support CASIS in developing ideas that underpin future solicited proposals (i.e., RFPs) and shape the portfolio of unsolicited proposals.
- Provide contacts to new users and communities for the ISS NL
- Broaden knowledge and talent base.
- Core areas of STAP expertise - Life Sciences, Physical Sciences, Remote Sensing, and Technology Development.

MAPPING THE DECADAL TO THE CASIS PORTFOLIO

ID	Recommendation
Plant and Microbial Biology	
P1	Establish a microbial observatory program on the ISS to conduct long-term, multigenerational studies of microbial population dynamics.
P2	Establish a robust spaceflight program of research analyzing plant and microbial growth and physiological responses to the multiple stimuli encountered in spaceflight environments.
Animal and Human Biology	
AH2	The preservation/reversibility of bone structure/strength should be evaluated when assessing countermeasures.
AH3	Bone loss studies of genetically altered mice.
AH4	New osteoporosis drugs should be tested in animal models.
AH5	Conduct studies to identify underlying mechanisms regulating net skeletal muscle protein balance and protein turnover during states of unloading and recovery.
AH13	Multiple parameters of T cell activation in cells should be obtained from astronauts before and after re-entry to establish which parameters are altered during flight.
AH14	Both to address the mechanism(s) of the changes in the immune system and to develop measures to limit the changes, data from multiple organ/system-based studies need to be integrated.
AH16	Studies should be conducted on transmission across generations of structural and functional changes induced by exposure to space during development.
Crosscutting Issues for Humans in the Space Environment	
CC7	Conduct longitudinal studies of astronauts for cataract incidence, quality, and pathology related to radiation exposures to understand both cataract risk and radiation-induced late tissue toxicities in humans.
CC8	Expand the use of animal studies to assess space radiation risks to humans from cancer, cataracts, cardiovascular disease, neurologic dysfunction, degenerative diseases, and acute toxicities such as fever, nausea, bone marrow suppression, and others.
CC10	Expand understanding of sex differences in adaptation to the spaceflight environment through flight- and ground-based research, particularly potential differences in bone, muscle, and cardiovascular function and long-term radiation risks.
Fundamental Physical Sciences in Space	
AP5	Experiments on the ISS to understand complex fluid physics in microgravity, including fluid behavior of granular materials, colloids and foams, biofluids, non-Newtonian and critical point fluids, etc.
AP7	Combustion processes research, including reduced-gravity experiments with longer durations, larger scales, new fuels, and practical aerospace materials relevant to future missions.
AP9	Reduced-gravity research on materials synthesis and processing and control of microstructure and properties, to improve the properties of existing and new materials on the ground.

MAPPING CASIS PROJECTS TO THE DECADAL

SUBSET OF CASIS PROJECTS CORREPSONDING TO DECADAL PRIORITY RESEARCH AREAS			DECADAL PRIORITY RESEARCH AREAS
Projects Awarded in Previous Quarter			
Project Title	**Organization**	**Project Description**	**Recommendation ID**
The Effect of Microgravity on the Co-crystallization of Membrane proteins and on-orbit crystallographic study of medically-relevant protein-ligand complexes as an orthogonal approach to facilitating structure-based drug design	Eli Lilly and Company	A series of experiments examining the effects of microgravity on the co-crystallization of several protein-ligand complexes, which have been either difficult to crystallize and/or difficult to obtain diffraction data of sufficient resolution by Earth-based crystallization methods	**AP9**
The Effect of Microgravity on the Dissolution of Hard to Wet Substances	Eli Lilly and Company	Seeks to understand the role microgravity on the wettability and ultimate dissolution rate to better understand the fundamental physical properties to involved in mixing solids and liquids.	**AP9**
Lyophilization in Microgravity: Impact on Physical Properties and Critical Quality Attributes	Eli Lilly and Company	Develop an understanding of the fundamental properties that impact the physical characteristics of lyophilized materials to improve processes for lyophilization in pharmaceutical and related industries.	**AP9**
Effect of Myostatin Antibody on Murine Muscle Mass and Function during Spaceflight	Eli Lilly and Company	Experiments in the microgravity environment of space provide the ability to determine the impact of an anti-myostatin antibody on muscle wasting in the absence of artificial constraints or co-morbidities that might interfere with the interpretation of results.	**AH2; AH5**

MAPPING CASIS PROJECTS TO THE DECADAL

SUBSET OF CASIS PROJECTS CORREPSONDING TO DECADAL PRIORITY RESEARCH AREAS			DECADAL PRIORITY RESEARCH AREAS
Projects Awarded in Previous Quarter (continued)			
Project Title	**Organization**	**Project Description**	**Recommendation ID**
Crystal Growth of Cs2LiYCl6:Ce Scintillators in Microgravity	Radiation Monitoring Devices, Inc	Conduct a series of experiments on the ISS to grow scintillator crystals. Scintillators excite when exposed to certain types of radiation. They can be used in detectors, primarily for homeland security applications.	**AP5**
Detached Melt and Vapor Growth of InI in SUBSA Hardware	Illinois Institute of Technology	Synthesize new types of semiconductor crystals on the ISS. They will show this material can positively compare with other semiconductor materials, in how it is non-toxic, and can be grown at a much faster rate.	**AP5**
Controlled Dynamics Locker for Microgravity Experiments on ISS	Controlled Dynamics Inc.	Seeks to develop an insert for existing ISS hardware that will provide research payloads with a “controlled dynamic acceleration environment”—in other words, a technology that will dampen fluctuations/disturbances in the microgravity environment that occur onboard moving spacecraft.	**AP5; AP9**
Osteocyte response to mechanical forces	Massachusetts General Hospital	Seeks to identify cellular and molecular mechanisms of mechano-sensation and mechano-transduction in osteocytes, the bone cells deeply embedded into the mineralized tissue.	**AH2**
T-Cell Activation in Aging	Northern California Institute for Research and Education (NCIRE)	Seeks to find how exposure to microgravity can mimic aging for immune cells and to reveal the biochemical mechanisms that underlie immune system dysfunction. This knowledge may be applied to develop treatments not only for immune suppression but also for inflammatory diseases in which the immune system misbehaves by overreacting rather than failing to act.	**AH13**

MAPPING CASIS PROJECTS TO THE DECADAL

SUBSET OF CASIS PROJECTS CORREPSONDING TO DECADAL PRIORITY RESEARCH AREAS FLIGHT DEVELOPMENT PHASE			DECADAL PRIORITY RESEARCH AREAS
Project Title	**Organization**	**Estimated Flight Date**	**Recommendation ID**
Decoupling Diffusive Transport Phenomena in Microgravity	The Methodist Hospital Research Institute	Orb-4; NET 10/1/2015	AP5
COBRA PUMA GOLF Microgravity Electrodeposition Experiment	Cobra Puma Golf	SpX-4; 9/21/2014	AP5
Novartis Rodent Research	Novartis Institute for Biomedical Research	SpX-4 9/21/2014 SpX-6 4/9/2015	AH3; AH4; AH5
Baylor College of Medicine-Dept. of Molecular & Cellular Biology OMICS seed grant (original)	Baylor College of Medicine	TBD	AH14
Longitudinal Assessment of Intracranial Pressure During Prolonged Spaceflight	Baylor College of Medicine	TBD	CC7
Impact of Increased Venous Pressure on Cerebral Blood Flow Velocity Morphology	Neural Analytics	TBD	CC7
Optimizing Jammable Granular Assemblies in a Microgravity Environment	Benevolent Technologies for Health	TBD	AP5
Synthetic Muscle: Resistance to Radiation	Ras Labs	Orb-4 4/1/2015	CC8
Microbead Fabrication using Rational Design Engineering	Quad Technologies	TBD	AP9
HNu Photonics - Ultra-Portable Remote-Controlled Microfluidics Microscopy Microenvironment	HNu Photonics	TBD	P2
Magnetic 3D Cell Culture for Biological Research in Microgravity	Nano3D Biosciences	Orb-6 4/1/2016	P2
BCM Dept Molecular/Cellular Biology OMICS	Baylor College of Medicine	TBD	AH16
Using the International Space Station to Evaluate Antibiotic Efficacy and Resistance	University of Colorado Boulder	N/A - Data Anaylsis	P1
Evaluation of a Corrosion Inhibitor Exposed to the Extreme Environments in Space	A-76	TBD	AP9
Systemic Therapy of NELL-1 for Spaceflight-Induced Osteoporosis	UCLA, School of Medicine	TBD	AH4
Flame retardant behavior of modified cellulose vs. meta-aramid (Nomex) in microgravity	Milliken & Company	TBD	AP7

MAPPING CASIS PROJECTS TO THE DECADAL

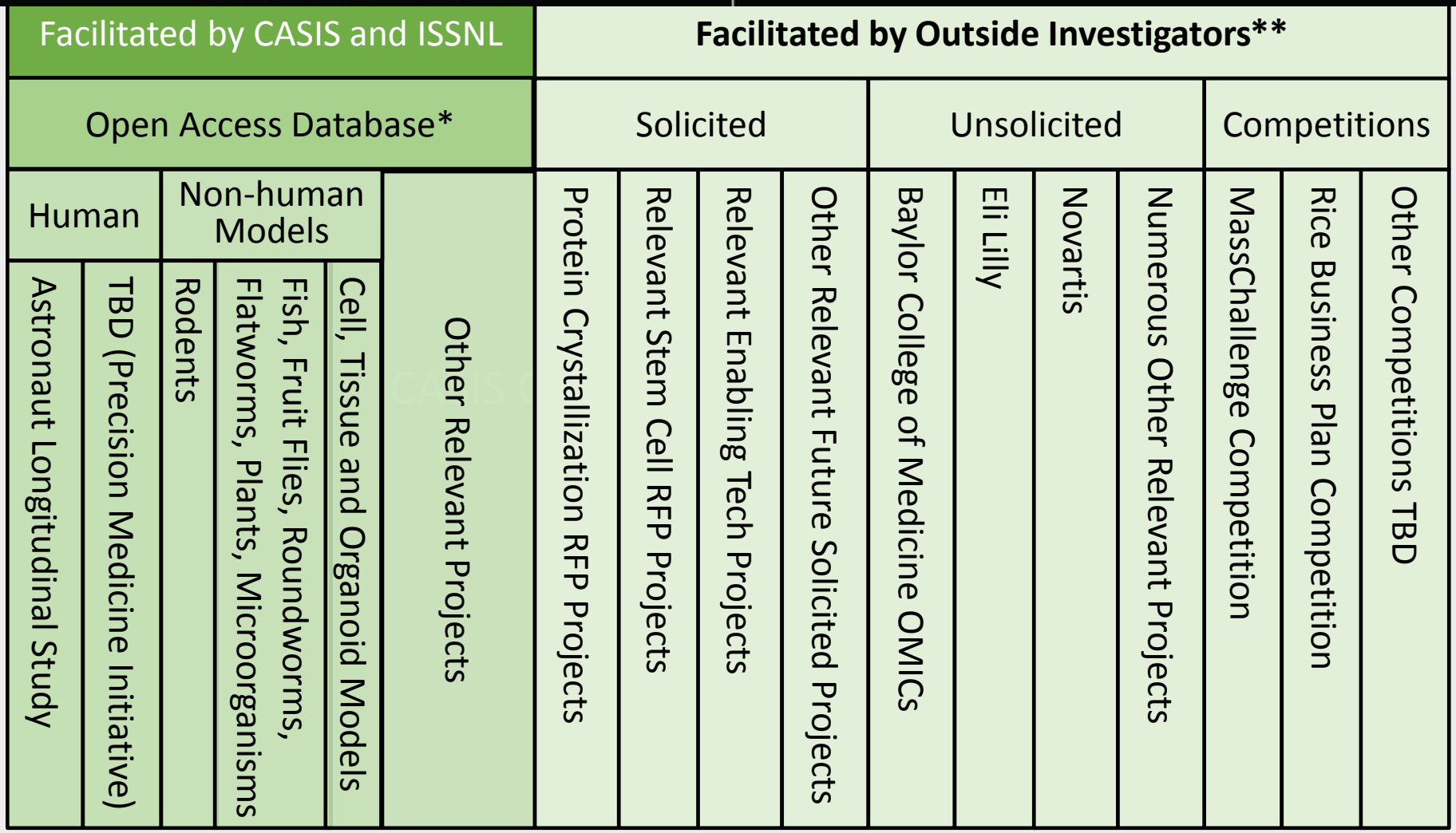
SUBSET OF CASIS PROJECTS CORREPSONDING TO DECADAL PRIORITY RESEARCH AREAS			DECADAL PRIORITY RESEARCH AREAS
Projects Onboard ISS			
Project Title	**Organization**	**Estimated Return Date**	**Recommendation ID**
Deployment of a bone-density scanner for on-orbit animal research	Techshot	N/A	**AH16**
Binary Colloidal Alloy Test – Low Gravity Phase Kinetics Platform	Zin Technologies, Inc.	7/15/2015 (SpX-7)	**AP5**
Returned Projects			
Project Title	**Organization**	**Results**	**Recommendation ID**
Molecular Biology of Plant Development in the Spaceflight Environment (Petri Plants)	University of Florida	Seed germination was excellent and all experiment objectives were met. First time use of LMM for life science research paid off; images of tissue-specific gene expression data was obtained for the first time. PI team also had several lessons learned regarding LMM, which will be of tremendous benefit for their follow-on NASA flight on SpX-5.	**P2**
Antibiotic Effectiveness in Space-1 (AES-1)	University of Colorado Boulder	Preliminary results: Growth was note in flight samples cultured in antibiotic concentrations that were inhibitory on Earth, including in the highest antibiotic concentrations tested. Cell populationn density and antibiotic concentration are generally correlated within predicted trends. Clustering of cells was noted in flight samples with the highest Gentamicin concentration, which is suggestive of a protective mechanism similar to what occurs in biofilm formation.	**P1**

Moving Forward: Campaign Good Health

- **Good Health:** An over-arching CASIS initiative to translate observations in microgravity to health benefits on Earth
- **Goals and Objectives:**
  - Understand the mechanisms that underpin the transition from wellness to disease—a process in many cases accelerated by microgravity—so that interventions can be designed to preserve health on Earth.
  - Leverage data and resources produced by other agencies alongside our own to ensure the highest probability of success.
  - Integrate all possible sources of biological and molecular data from human and non-human subjects using a systems biology approach.

GOOD HEALTH INITIATIVE

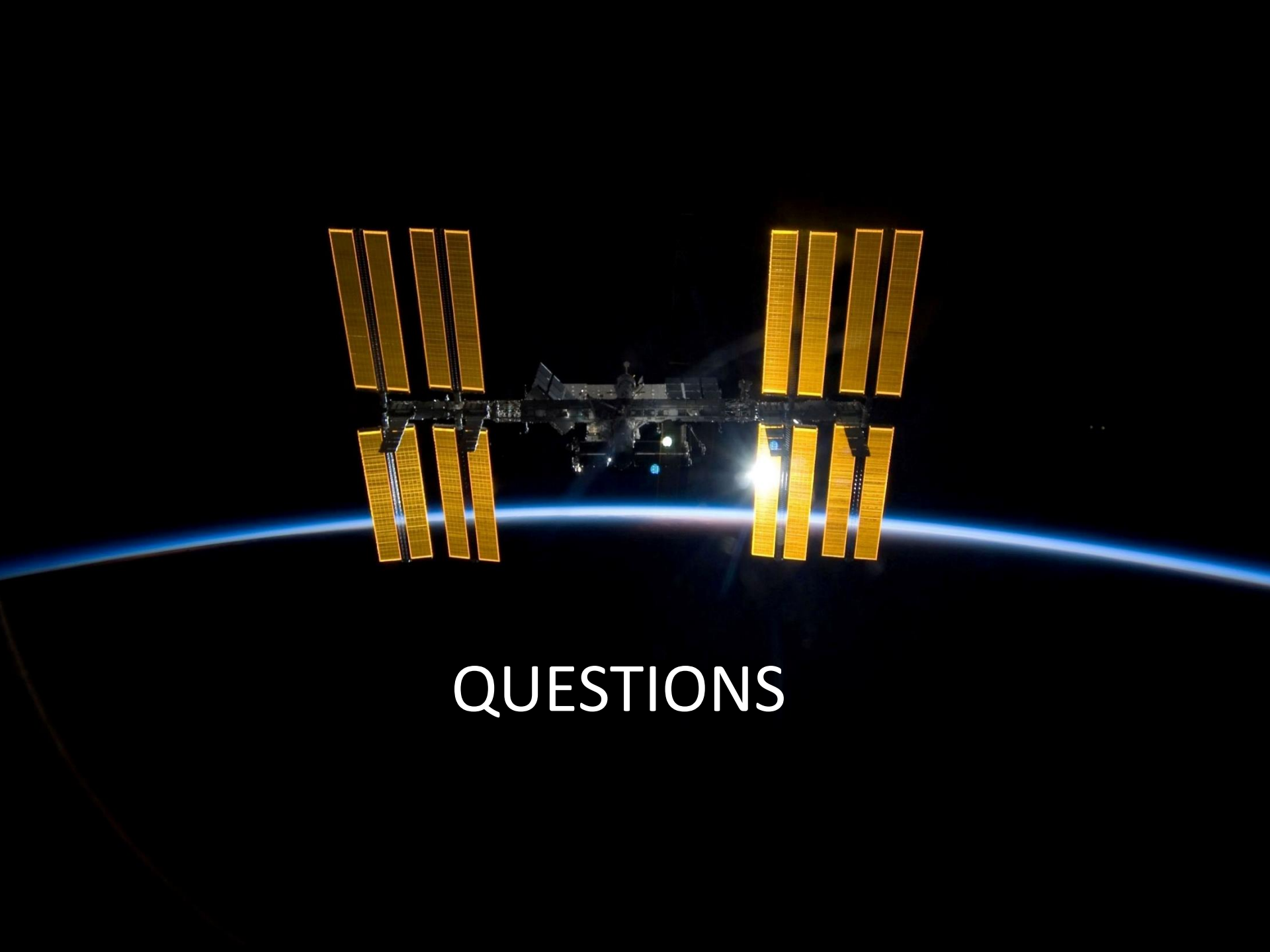
TRANSLATE DISCOVERY IN MICROGRAVITY INTO HUMAN WELLNESS AND DISEASE TREATMENT ON EARTH



STEM component of Good Health Campaign projects

* CASIS collaboration with NASA HRP, NSBRI, and NASA SLPS (GeneLab)

**Includes PI-directed research by investigators from academic, commercial, and other government agency institutions


QUESTIONS