CASIS | ISS U.S. NATIONAL LABORATORY

FY16 SELECTED PROJECTS

EDUCATION | LIFE SCIENCES | PHYSICAL SCIENCES | REMOTE SENSING | TECHNOLOGY DEVELOPMENT

Tomatosphere

Ann Jorss, First the Seed Foundation • ALEXANDRIA, VA

Tomatosphere is an educational program started in 1999 in which students investigate how the space environment affects tomato plant growth. Each participating class is sent two packages of tomato seeds: one package of seeds that has been sent into space and one package of control seeds that have not been in space. Students and teachers compare the germination rates of the two groups of seeds, not knowing which seeds went to space and which are the control seeds. This project will provide transportation of 1.2 million seeds to and from the ISS (the seeds will remain in orbit between 10 and 60 days). The project will also include monitoring and data tracking (temperature, humidity, and pressure) for both the seeds sent to the ISS and the control seeds.

SPHERES Zero Robotics High School

Dr. Alvar Saenz Otero, Massachusetts Institute of Technology • CAMBRIDGE, MA

The Synchronized Position Hold, Engage, Reorient, Experimental Satellites: Zero Robotics (SPHERES-Zero-Robotics) investigation establishes an opportunity for high school students to design research for the ISS. As part of a competition, students write algorithms for the SPHERES satellites to accomplish tasks relevant to future space missions. The algorithms are tested by the SPHERES team and the best designs are selected for the competition to operate the SPHERES satellites onboard the ISS.

SPHERES Zero Robotics Middle School

Dr. Alvar Saenz Otero, Massachusetts Institute of Technology • CAMBRIDGE, MA

The Synchronized Position Hold, Engage, Reorient, Experimental Satellites: Zero Robotics (SPHERES-Zero-Robotics) investigation establishes an opportunity for middle school students to design research for the ISS. As part of a competition, students write algorithms for the SPHERES satellites to accomplish tasks relevant to future space missions. The algorithms are tested by the SPHERES team and the best designs are selected for the competition to operate the SPHERES satellites onboard the ISS.

Orions Quest-Student Research on the ISS

Peter Lawrie, Orions Quest • CANTON, MI

The Orion's Quest (OQ) program aims to challenge students to excel in math and science through active participation in research currently being conducted on the ISS. This project supports the joint participation of students, educators, and researchers on experiments currently manifested on SpaceX CRS-9 and SpaceX CRS-10. OQ develops an educational component in support of the investigators' research and provides a standards-based curriculum that covers pre-flight preparation to post-flight activities. During pre-flight preparation, students learn about NASA engineers, technicians, and administrators, and the role that each plays in the planning and tracking of the mission. For the mission phase, experiment support data is provided, and students take on the role of a Mission Specialist Astronaut. Students formulate their own hypothesis about microgravity's effect on the specimen (plants, seeds, cells, etc.). With digital images, data, and video provided through the OQ website, students record measurements and observations. In the post-flight phase, classroom findings are forwarded to the investigators for review and inclusion in databases (and publications), if appropriate.

The Virtual Astronaut

Amaresh Kollipara, Oculus • LOS ANGELES, CA

This project aims to bring the experience of being in space onboard the ISS to millions of students through two STEM education experiences. The Virtual Astronaut Experience uses proprietary 3-D virtual reality models of the inside and outside of the ISS and Oculus Touch controllers to allow students to move through the ISS just like astronauts do, by physically grabbing onto holds and propelling their body through microgravity. The Classroom in 360° Experience will consist of recorded "talks and lessons" from astronauts on the ISS combined with a recording of students from a classroom. The students will have a chance to ask questions that the astronaut(s) will answer in their filming. The astronaut and classroom portions will be seamlessly stitched together to produce an immersive 360° experience, featuring the simulation of students in a classroom interacting with astronauts on the ISS for the purposes of specific talks and lessons.

Genes In Space-2

Julian Rubinfien, The Boeing Company (sponsor) • NEW YORK, NY

This project aims to study genetic processes (specifically, telomere shortening in human organoids) that may lead to accelerated aging in space. This is a winning student experiment from the Genes in Space innovation challenge, which invites students to propose pioneering DNA amplification experiments using the unique environment of the ISS.

Assessing Osteoblast Response to Tetranite(TM)

Nikolaos Tapinos, MD, PhD, LaunchPad Medical • BOSTON, MA

The goal of this investigation is to explore the ability of Tetranite, a synthetic bone material capable of adhering bone to metal within minutes, to accelerate bone repair. It is well known that microgravity affects bone cell growth and healing, mimicking the symptoms observed in osteoporosis. The investigators seek to evaluate the response of osteoblasts (a bone cell subtype responsible for renewing bones) to Tetranite. Understanding bone cell-Tetranite interactions could provide insight into the post-fracture bone healing response and assist in the development of more effective treatments for patients with osteoporosis. In addition, this cell culture project should provide the basis for follow-on studies of the bone healing response in small rodents.

Combined Evaluation of Mouse Musculoskeletal Data

Dr. Virginia Ferguson, University of Colorado Boulder • BOULDER, CO

This ground project aims to analyze, normalize, and consolidate bone data from rodent research experiments in space for open source distribution as standardized control data to aid future researchers working on novel musculoskeletal disease treatments. Although rodent research on the ISS has already led to major discoveries in musculoskeletal disease models, such experiments would benefit from more robust control datasets.

Rodent Research-Wound Healing

Dr. Rasha Hammamieh, Department of Defense and Indiana University Research • FORT DETRICK, MD

This project is part of a broader effort to understand the effects of spaceflight on tissue healing. Studies suggest that microgravity likely impairs the wound healing process, and microgravity has been shown to have negative effects on skin quality in astronauts. This project seeks to identify the molecular foundations of cutaneous (skin) wound healing that are vulnerable to spaceflight-induced stress, potentially revealing biologically relevant pathways for the next generation of wound healing therapies. Samples from mice will be collected over a time course of wound healing, both in spaceflight conditions and in ground controls. In addition, the team will attempt to identify surrogate biomarkers from the blood, which if validated in humans, could eventually provide clinically useful diagnostic markers for the state of skin wounds. This project will mark the first time a comprehensive systems biology approach has been used to understand the impact of spaceflight on wound healing.

Conversion of Adipogenic Mesenchymal Stem Cells into Mature Cardiac Myocytes in the ISS National Laboratory

Dr. Robert Schwartz, University of Houston • HOUSTON, TX

This project seeks to evaluate a new approach, which has proven practical in ground-based simulated microgravity, to growing human tissue for transplant. This project will exploit microgravity onboard ISS to improve cell growth and development and 3-D tissue formation, enabling discoveries that will advance translational disease treatments. Specifically, this project will further refine tissue growth processes and identify the role of several cell proteins in growth, development, and disease (specifically, ischemic heart disease).

Implantable Nanochannel System for the Controlled Delivery of Therapeutics for Muscle Atrophy (RR-6)

Dr. Alessandro Grattoni, The Methodist Hospital Resesarch Institute • HOUSTON, TX

An implantable drug delivery system that circumvents the need for daily injections will be tested in a rodent model with microgravity-induced muscle atrophy. Specifically, the drug formoterol (an adrenalin substitute) will be administered by controlled release from a nanochannel implant to achieve a constant and reliable dosage. If successful, this system could serve as a universal technology for drug delivery and animal testing. In collaboration with Novartis and NanoMedical Systems, this validated system may rapidly translate into a commercial product.

Comparative Real-Time Metabolic Activity Tracking for Improved Therapeutic Assessment Screening Panels

Dr. Gary Sayler, 490 BioTech, Inc. • KNOXVILLE, TN

490 Biotech's reporter-gene system for substrate-free bioluminescent human cell lines is an enabling technology for evaluation of drug safety and effectiveness. Cellular response to drug samples is observable via visible data acquisition in both tissues and small animal models. The microgravity environment onboard ISS promotes superior 3-D cell growth conditions, enabling evaluations (using this cell line) that may better mimic the cellular response of human tissues. This investigation will specifically examine anti-cancer therapeutics with downstream applications to other drugs.

Interrogating the Unfolded Protein Response in Microgravity-Induced Osteoporosis and Sarcopenia

Dr. Imran N. Mungrue, Louisiana State University Health Science Center • NEW ORLEANS, LA

This study examines the role of the unfolded protein response (UPR) as an important contributor to osteoporosis and muscle atrophy. Untangling this cellular pathway's connection with musculoskeletal disease will provide important knowledge for developing targeted therapies. Previous experiments have shown UPR's increased activity in microgravity, making this phenomenon more accessible for investigation in a spaceflight rodent model. In addition to musculoskeletal diseases, over-activation of UPR has also been implicated in neurodegenerative disorders such as Alzheimer's, Parkinson's, and Huntington's diseases.

3D Neural Microphysiological System

Dr. Michael Moore, AxoSim Technologies • NEW ORLEANS, LA

This project will demonstrate the utility of a human nerve-on-a-chip as a model for studying disorders affecting myelin (a substance that surrounds the axon of nerve fibers, forming an insulating layer). This model could be useful not only for studying tissue behaviors associated with myelin disorders (e.g., multiple sclerosis) but also for accelerating preclinical drug development (e.g., toxicity testing). This ground-based study will lay the foundation for a follow-on flight project.

Investigation Of The Effects Of Microgravity On Controlled Release Of Antibiotics And Curing Mechanism Of A Novel Wound Dressing

Dr. Elaine Horn-Ranney, Tympanogen, LLC • NORFOLK, VA

This project seeks to improve the process of antibiotic release from a novel patch that can treat military combat wounds and reduce the occurrence and severity of sepsis, or systemic inflammation. This novel patch contains a hydrogel with inherent antimicrobial properties that can promote healing of a wound while acting as a scaffold for regenerating tissue. Reduced fluid motion in microgravity will allow for more precise studies of this hydrogel behavior and its controlled release from the patch.

Neutron Crystallographic Studies Of Human Acetylcholinesterase For The Design

Andrey Kovalevsky, Oak Ridge National Lab • OAK RIDGE, TN

This project seeks to produce crystals of suitable size and quality for macromolecular neutron crystallography (MNC) analysis of the medically important enzyme acetylcholinesterase. In humans, this enzyme is responsible for degrading a specific neurotransmitter in the brain, and malfunction of the enzyme leads to a fatal increase of this neurotransmitter. Analysis using MNC has the unique ability to locate the position of hydrogen atoms within a crystal structure, providing essential insights into how an enzyme functions in the human body and how it might be altered by nerve agents to become toxic. However, even with recent advances in instrumentation, MNC still requires very large crystals for analysis, the production of which may be enabled by microgravity, which allows for more uniform crystal growth.

Development And Validation Of A Microfluidic Lab-On-A Chip

Dr. Siobhan Malany, Micro-gRx, Inc. • ORLANDO, FL

A fully automated, multifunctional cell culture platform called Lab-on-a-Chip, which was previously validated in bacterial and crystal growth studies, will now be extended to study human skeletal muscle cell growth. This project expands on recent ISS stem cell studies and provides a model for microgravity-induced muscle atrophy, with downstream implications for additional research efforts in micro-scale modeling of musculoskeletal disease.

3D Organotypic Culture System

Dr. Rocky S. Tuan, University of Pittsburgh • PITTSBURG, PA

A microphysiological system (MPS, a micro-scale system that models the detailed physical structure of human tissue) will be used to evaluate potential therapies for the treatment and prevention of osteoporosis and other musculoskeletal disorders. Unlike animal models of bone loss, which can be confounded by species-specific responses (i.e., bone pathways in mice differ from humans) and require significant resource input even for limited sample sizes, MPS models can use human bone cells in high throughput microfluidic platforms. This project will validate an MPS platform for bone in microgravity to confirm the protective role of bisphosphonates (a class of drugs currently used to treat osteoporosis) for protection during long-term microgravity exposure.

Intraterrestrial Fungus Grown in Space (iFunGIS)

Dr. Heath Mills, Space Technology and Advanced Research Systems Inc. (STaARS) • SAN ANTONIO, TX

This project has two objectives: Goal 1 seeks to validate a fast-track hardware capability for molecular biology projects; Goal 2 will determine at a molecular level the response of a deep subsurface fungus, Penicillium chrysogenum, to growth in microgravity. This fungal species produces a novel penicillin-like antibiotic natural product, giving the fungus high commercial value. Organisms respond to environmental changes by altering their metabolic processes in an effort to regulate internal biochemical conditions. Previous results have shown that organisms have different metabolic responses to microgravity, including alterations in growth rate and virulence. Thus, the aim of this project is to determine the metabolic impact of spaceflight on this novel fungal species. The production and effectiveness of the novel penicillin-like antibiotic produced by the fungus will also be characterized following exposure to microgravity.

Implantable Glucose Biosensors

Dr. Michail Kastellorizios, Biorasis, Inc. • STORRS/MANSFIELD, CT

This project seeks to improve the accuracy of a wireless medically implantable continuous glucose biosensor (Glucowizzard) for day-to-day diabetes management. Slow glucose transport within human tissue (through the capillary walls and surrounding tissue toward the sensing site of the biosensor) can create delays of up to 20 minutes in real-time monitoring of glucose levels. This delay can be detrimental in achieving tight glycemic control, which has been linked to serious secondary complications in patients with diabetes. The ISS provides a microgravity environment in which reduced fluid movement allows precise monitoring of the role of diffusion in glucose transport, thus improving the mathematical models that determine the accuracy of the Glucowizzard continuous glucose monitoring biosensor.

Mutualistic Plant/Microbe Interactions

Dr. Gary W. Stutte, SyNRGE, LLC • TITUSVILLE, FL

This project, a re-flight of the SyNRGE3 payload flown by NanoRacks on SpX-4, seeks to study mutualistic plant-microbe interactions in microgravity. Most land plants establish physical interactions with fungi that increase uptake of nutrients and improve stress resistance. This process is directly or indirectly responsible for producing 20% of the protein consumed in the human diet. Previous SyNRGE experiments performed on STS-135 demonstrated that the symbiosis between plant and bacterial partners is affected by microgravity, potentially increasing the ability for infection to occur. SyNRGE3 sought to determine if certain changes in this mutualistic relationship were associated with molecular changes that could be exploited to identify and select more effective plant strains for use on Earth. (The initial flight of SyNRGE3 suffered several technical issues on orbit, so the primary objectives of the experiment were not completed.)

Droplet Formation Studies in Microgravity

Garry Marty, Delta Faucet • INDIANAPOLIS, IN

This project seeks to evaluate the water droplet formation, water flow, and pressure of Delta Faucet's current H2Okinetic shower head technology versus the industry-standard use of jet nozzles. H2Okinetic technology allows better control of droplet size and increases the speed of the drops (fewer water drops are used, but the droplets are larger and are moving faster), which creates a feeling of increased pressure for the end user. The study will evaluate how best to control the output of water droplets to create a better performing shower device that provides an improved experience for the end user while also conserving water and energy. The full effects of gravity in the formation of water droplet size (with a standard jet nozzle or H2Okinetic technology) are unknown. By conducting research in microgravity, Delta Faucet seeks to gain a better understanding of the upper limit of what can be achieved with the H2Okinetic technology and determine if and how the technology can be improved.

Inertial Spreading and Imbibition of a Liquid Drop Through a Porous Surface

Dr. Michel Louge, Cornell University • ITHACA, NY

This project will utilize the microgravity environment on the ISS to improve understanding of imbibition, a process in which water is absorbed by solids. Measuring and observing this process is significantly easier to achieve on the ISS, due to the suppression of gravitational forces.

Unmasking Contact Line Mobility and Inertially-Spreading Drops

Dr. Paul Steen, Cornell University • ITHACA, NY

This project is focused on the study of the behavior of drops pinned on a vibrating surface. The investigators hope to develop a theory to predict conditions for how and when the drops oscillate, while conducting experiments to verify the theoretical model in microgravity conditions. Results from this work can potentially be applied to medical, agricultural, manufacturing, and other industrial processes.

Kinetics of nanoparticle self-assembly in directing fields

Dr. Eric Furst, University of Delaware • NEWARK, DE

The number of advanced materials manufactured by the assembly of colloidal particles is growing. Assembly can be controlled by applying external fields (such as a magnetic field) that affect the motion of the particles and their organization during assembly. Performing this research in microgravity is advantageous because on Earth, the particles sediment due to gravity with a sedimentation rate that increases as they form large and complicated structures. The colloidal particles examined in this project could serve as building blocks for advanced materials that control the propagation of sound and heat in electronics.

Quantifying Cohesive Sediment Dynamics for Advanced Environmental Modeling

Dr. Paolo Luzzatto-Fegiz, University of California, Santa Barbara • SANTA BARBARA, CA

This project is focused on the study of forces between particles that cluster together. The physical system studied consists of sediments of quartz and clay particles. By conducting the research on the ISS, it is possible to separate the forces acting on the particles over a short range (adhesive forces) versus those acting over a long range (cohesive forces). In microgravity, investigators can observe how particles cluster over long time scales without gravitational settling, which complicates measurements taken on Earth. The quartz/clay system is commonly found in a wide variety of environmental settings (such as rivers, lakes, and oceans) and plays an important role in technological efforts related to deep sea hydrocarbon drilling and carbon dioxide sequestration.

Constrained Vapor Bubbles of Ideal Mixtures

Dr. Joel Plawsky, Rensselaer Polytechnic Institute • TROY, NY

This project will examine gas/liquid interfaces of various organic mixtures used in heat pipes. Heat pipes are heat transfer devices that are used routinely for cooling a variety of electronic equipment, including laptop computers. Heat pipes use fluid to transfer heat. An essential feature of these devices is that the fluid undergoes a phase change from liquid to vapor. The detailed motion of the liquid and vapor, and the motion and dynamics of the interface between the two phases, can strongly affect the performance of heat pipes and similar systems.

Tropical Cyclone Intensity Measurements from the ISS (CyMISS) – Season 3

Dr. Paul Joss, Visidyne, Inc. • BURLINGTON, MA

This project seeks to improve intensity measurements, and subsequently, path predictions of strong tropical cyclones (also known as hurricanes or typhoons) through improved modeling using a measurement technique from the low Earth orbit vantage point of the ISS. Improving intensity measurements requires accurate measurements of the altitude of eyewall clouds (the clouds surrounding the eye of a storm). For tropical cyclones of interest, a camera is mounted on a selected Cupola window and programmed to capture high-resolution exposures of the storm. The resulting sequence of digitally processed images allows Visidyne to develop algorithms necessary to determine the altitude of the eyewall clouds in a storm.

GRASP

Robert Carlson, JAMSS America, Inc. • HOUSTON, TX

Global Receive Antenna and Signal Processor (GRASP) is an enabling technology facility that provides affordable recovery of terrestrial radio frequency (RF) data using the ISS. Remote RF data is vital to commercial entities, governmental entities, and the research community for reasons as diverse as tracking ships at sea, studying animal migrations, improving agricultural yields, and monitoring the health of assets and health of the environment. The GRASP facility consists of an internally-mounted signal processing unit and an externally-mounted nadir-pointing antenna array. A key feature of GRASP is that it can be simultaneously used by multiple users, each targeting unique frequencies of interest. The GRASP facility on the ISS will increase access to and use of terrestrial RF signal data, which is currently constricted due to limited access to and high cost associated with recovering terrestrial RF signals using satellites.

Space Development Acceleration Capability (SDAC)

Philip Bryden, Craig Technologies • CAPE CANAVERAL, FL

This project aims to accelerate flight hardware development and test schedules utilizing additive manufacturing technologies and a Flight Test Platform (FTP) to support low Earth orbit and ISS missions and experiments. The FTP will integrate into the MISSE or NREP external platforms and provide new capabilities to support the evaluation of materials and subsystems all focused on additive manufacturing. This project aims to transition into a marketable capability that will increase the opportunity for multiple industries to develop, test, and fly hardware and experiments on the ISS or low Earth orbit spacecraft at reduced cost and schedule.

DexMat CASIS CNT Cable Project

Dr. Alberto Goenaga, DexMat, Inc. • HOUSTON, TX

Carbon nanotube (CNT) technology allows for lighter weight cables that have electromagnetic interference (EMI) benefits over conventional metallic coaxial cables that use a tin-copper shielding braid. Research in low Earth orbit will accelerate the near-term insertion of CNT cables in satellite systems, with a long-term potential for a two-thirds weight savings for CNT coax cables and power harnesses. Exposing this experiment to the extreme conditions on the ISS will provide long-term performance data and showcase DexMat's ability to design and implement the technology on spacecraft. The successful completion of this in-orbit testing will raise the Technology Readiness Level of the products (a Department of Defense requirement for adoption of new technologies by the aerospace industry).

High Data Rate Polarization Modulated Laser Communication System

Dr. Eric Wiswell, Schafer Corporation • HUNTSVILLE, AL

This project involves development of a laser communications system for transmitting very large data files— in the range of 10 Gbps to 40 Gbps—from space to the ground. Earth-sensing instruments produce large amounts of data that are currently constrained by the slow uplink and downlink rates of antiquated radio frequency technology, which severely limits space-based operations. Schafer's next-generation laser communications technology will help increase the uplink rate 10- to 200-fold and the downlink rate 1,000- to 20,000-fold, improving transmission of high-quality remote sensing data from satellite constellations back to the ground. This preflight development project will involve designing and producing of a form fit unit, including all external system interfaces, to support ground and airborne testing. Pending success of this ground demonstration, a future ISS flight project is planned.

Additive Manufacturing Operations Program

Michael Snyder, Made In Space, Inc. • MOFFETT FIELD, CA

The Additive Manufacturing Operations Program will allow ISS user communities to use the Made In Space Additive Manufacturing Facility. Through this program, objects for experiments and technology demonstrations will be produced onboard the ISS in a fraction of the time currently required to have such objects manifested and delivered to the ISS using traditional ground preparation and launch. Made in Space hopes to use this program to develop a commercial market for in-space manufacturing.

Demonstration and Exploration of the Effects of Microgravity on Production of Fluoride-Based Optical Fibers for Science, Technology, Education and Commercialization on the International Space Station

Michael Snyder, Made In Space, Inc. • MOFFETT FIELD, CA

High-performance optical fiber has been extensively used for efficient and compact ultraviolet, visible, and infrared fiber lasers due to its low intrinsic loss, wide transparency window, and small phonon energy. This technology enables advances in many different sectors, including medical devices such as laser scalpels and endoscopes, sensors for the aerospace and defense industry, and telecommunications applications. The optical fiber ZBLAN has the potential to far exceed the performance of other fibers in common use. Despite this, the terrestrially produced fiber suffers from glass impurities and microcrystal formation which contribute to scattering and absorption loss, reducing performance. Microgravity has been shown to significantly reduce these imperfections, and production of fibers in space may enable not only improved materials but also a new frontier in manufacturing and space utilization.

Validation of WetLab-2 System for qRT-PCR capability on ISS

Julie Schonfeld, NASA ARC • MOFFETT FIELD, CA

WetLab-2 is an ISS National Lab suite of scientific instrumentation that provides improved research capabilities for ISS investigators. The WetLab-2 system enables investigators working with cell cultures or animal and plant tissues to process samples and extract purified high-quality RNA (a nucleic acid involved in gene expression), which can then be returned to Earth for analysis or directly analyzed in orbit using a technique called quantitative Real Time Polymerase Chain Reaction. WetLab-2 tools also provide individual experimental capabilities for a variety of other research-enabling improvements related to sample preparation and analysis for both biological samples and fluids systems.

Fiber Optics Manufacturing in Space (FOMS)

Dr. Dmitry Starodubov, FOMS, Inc. • SAN DIEGO, CA

This project seeks to demonstrate the technical and commercial feasibility of in-orbit manufacturing of optical fibers for data transmission. Fluoride optical fibers have demonstrated a 10- to 100-fold signal loss reduction compared with traditional silica optical fibers, which could dramatically improve the cost and efficiency of communications systems and the internet. However, imperfections that occur during manufacturing on Earth prevent fluoride optical fibers from achieving this reduction in signal loss. Such imperfections appear to be reduced in microgravity, and this project will test ISS capabilities for in-orbit production of ZBLAN optical fibers, a type of fluoride optical fibers.