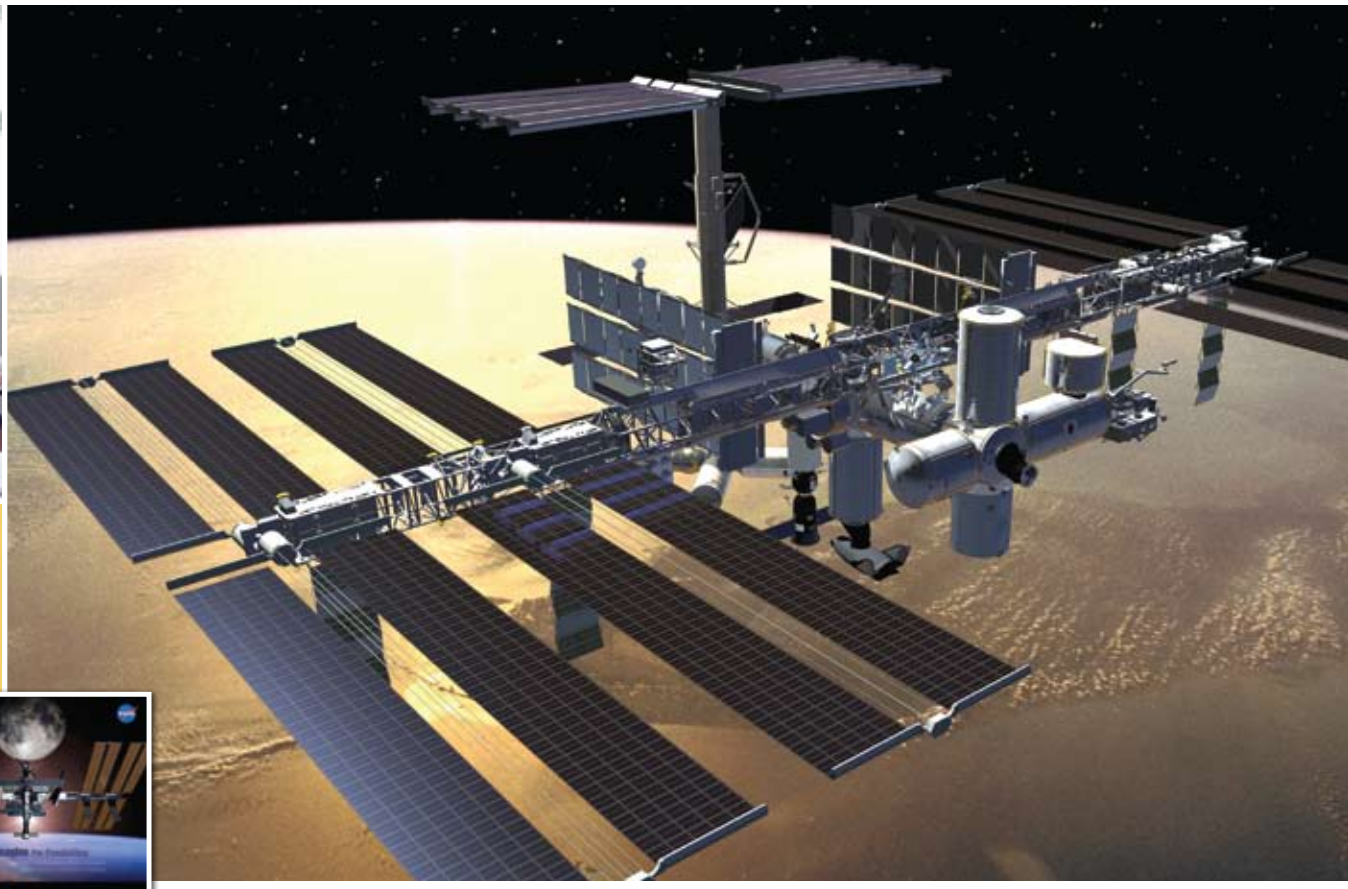
National Aeronautics and Space Administration



An Opportunity To Educate:

International Space Station National Laboratory

Reviewers' Praise for the National Laboratory Education Project

NASA's first spinoff is education. Even before a mission flies, learning about the mission is often inspiring, causing bored students to suddenly pay rapt attention to science and math and technology as the opportunity to explore realms beyond Earth has them reaching for the sky. For those lucky students who actually participate hands-on in a mission, it is a life-changing event.

—Dr. Russell Hancock, President and Chief Executive Officer, Joint Venture: Silicon Valley Network

For countless generations, humankind could only dream what it would be like to travel and work in space. Now the ISS National Laboratory Education Project offers the wonderful opportunity to enable students of all ages to turn dreams into reality as they are engaged in educational opportunities that involve them in doing experiments aboard the ISS or being able to increase their knowledge of STEM subjects from the lessons they receive from this unique laboratory in space.

—Dr. R. Lynn Bondurant, Aerospace Educator

Because the International Space Station embodies 21st-century values of global cooperation and collaboration, the ISS National Laboratory is a unique resource for promoting international understandings and for cultivating youth as emerging leaders of a global society. It provides opportunities for the youth to investigate significant, real-world issues; to communicate with inspiring NASA ISS role models; and to practice applying the 21st-century global competencies they need to invent the future.

—Dr. Ronnie B. Lowenstein, President, Lowenstein & Associates, Inc.

Knowledge of mathematics is fundamental to the legion of science professionals who have designed, built, and installed the International Space Station (ISS) in orbit as well as the astronauts and scientists who work in the ISS. The NASA ISS National Laboratory Education Project is an ideal way for students to personally experience the important relationship between mathematical literacy and scientific progress.

—Dr. Michael C. Hynes, Chair, Teaching and Learning Principles, University of Central Florida

The International Space Station National Laboratory Education Project provides a compelling, powerful, and inherent opportunity to strengthen how our Nation's students learn vital STEM topics. Bringing new thresholds of knowledge to society, the resources of the ISS also provide unparalleled aerospace education opportunities for our students. The true benefit of this project is that it will create a more scientifically literate society while opening new frontiers in education.

—Kenneth L. Huff, Chair,
National Science Teachers Association (NSTA) Aerospace Advisory Board

The scientists and engineers who work at the Department of Energy's national laboratories have inspired many students to become involved with world-class scientific investigations and to use cutting-edge research facilities. The ISS National Laboratory Education Project will extend these opportunities into space, vaulting the process of learning beyond the boundaries of Earth and sparking the imaginations of young scientists.

—Jeffery Dilks, Program Manager,
Department of Energy

The NASA ISS National Laboratory Education Project places a focus upon astronautics and space education for educational decision makers. It provides leadership to the STEM education movement that is needed by educators to follow NASA's work. The National Laboratory Education Project is a continuation of a long line of NASA projects and activities further establishing the role that NASA plays in leading educational directions to improve teaching and learning.

—Kendall N. Starkweather, Executive Director,
International Technology Education Association (ITEA)

Education multiplies one's options and opportunities in life. Why limit your possibilities, when there is an exciting world out there waiting for your brainpower?

—Dr. Shirley Ann Jackson, President, Rensselaer Polytechnic Institute, New York

March 2008

A Message from the

Assistant Administrator for Education

In 2006, the National Aeronautics and Space Administration (NASA) requested a range of Federal agencies with responsibilities in education to join the International Space Station (ISS) National Laboratory Education Concept Development Task Force charged with developing a strategy for utilizing the ISS as an educational asset. Two years later, as NASA celebrates 50 years of exploration and discovery, its Office of Education is prepared to endorse the ISS National Laboratory as a viable mechanism to help future generations continue the journey into the true space age.

An Opportunity To Educate: ISS National Laboratory presents an approach to validate the cross-agency task force's strategy for using ISS resources and accommodations to inspire, engage, and educate students, teachers, and faculty in the areas of science, technology, engineering, and mathematics (STEM). With new concepts developed in response to the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (America COMPETES) Act of 2007, this approach aims to demonstrate the versatility and power of the ISS National Laboratory to inspire and train the Nation's future STEM workforce, in addition to meeting our exploration and research needs.

This document showcases many such innovative ideas, including student experiments to be conducted aboard the ISS, ways to involve students in the development of new ISS hardware, and new strategies for utilizing ISS data in classroom activities. The task force has also outlined challenges to implementing this strategy, along with the specific assistance needed for success. The foundation is in place for opportunities across the Government, industry, and the education community to collaborate in support of this initiative.

The ISS has the potential to become a novel resource for education, with the untapped capability to contribute to all three major education goals of the Agency: strengthening the future workforces of NASA and the Nation, attracting and retaining students in STEM disciplines, and engaging Americans in NASA's mission. Experience has shown that NASA's compelling mission inspires the next generation in a unique and powerful way, and the Agency views the ISS National Laboratory as an invaluable educational investment whose potential to teach and inspire will continue into the foreseeable future.

Cordially,

Dr. Joyce L. Winterton
NASA Assistant Administrator for Education

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Michael Wiskerchen Director, California Space Grant Consortium

We must believe that we are gifted for something, and that this thing, at whatever cost, must be attained.

—Marie Curie, Nobel Prize Laureate in Physics and Chemistry

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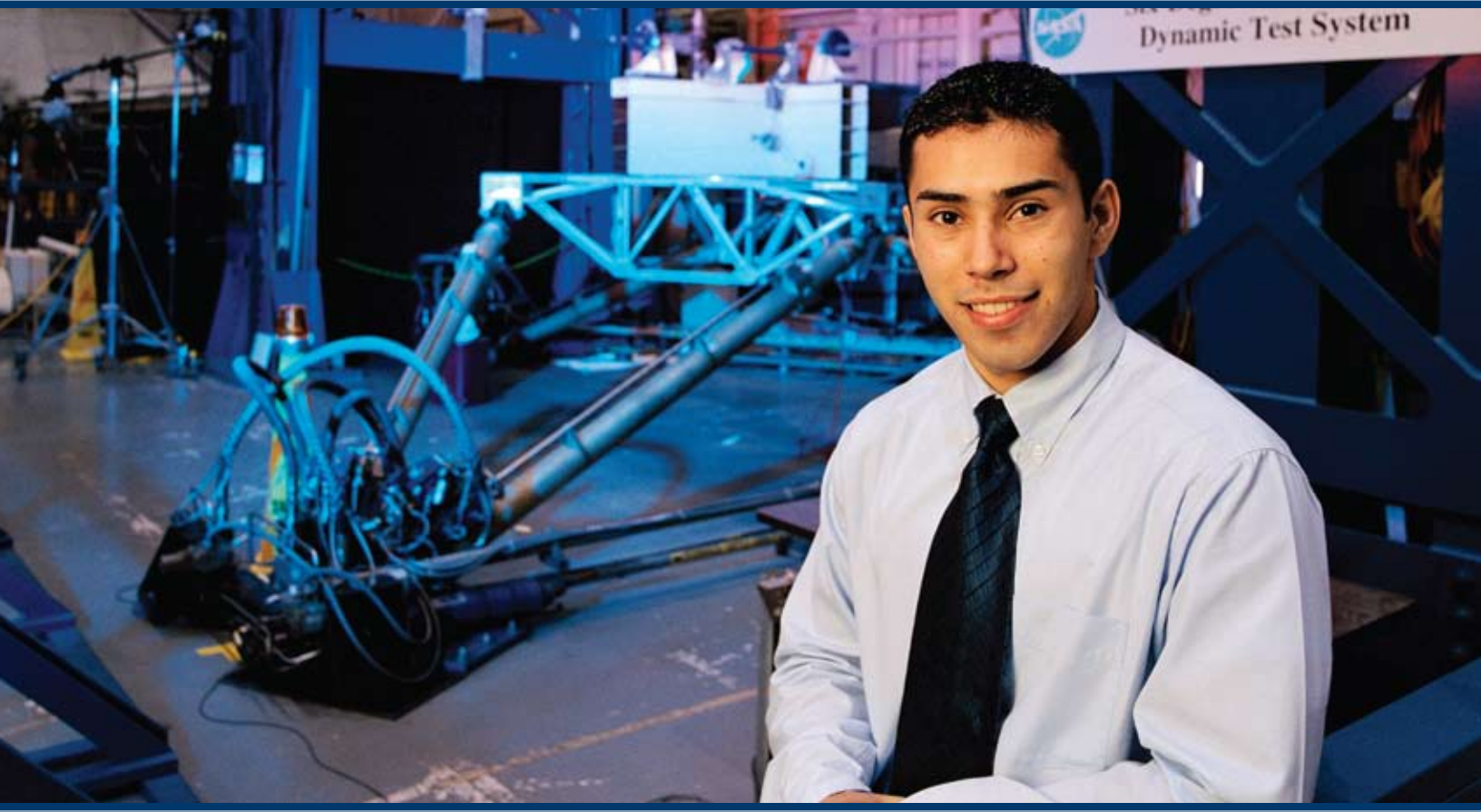


If I find 10,000 ways something won't work, I haven't failed. I am not discouraged, because every wrong attempt discarded is often a step forward.

—Thomas Edison, Inventor

Executive Summary

The America Competes Act of 2007 highlights the importance that national policy makers place on the role of education in ensuring the Nation's future economic health. The Act reflects a broad consensus that sustaining the Nation's high standard of living in a globally competitive environment will require a workforce equipped with the best possible education, an education that will prepare our children to take part in a technology-driven economy. Access to high-quality education is also recognized as a key to the door of economic opportunity for all Americans in an era when global competition challenges our workers to operate at world-leading standards of productivity.

The Act directs various agencies of the Federal Government to take actions to enhance their contribution to the national educational enterprise, particularly in science, technology, engineering, and mathematics (STEM) education. Among other actions, Congress directed NASA to develop a plan to conduct one or more education projects that utilize resources of the International Space Station. This report presents an approach to the plan. This report also continues the work of the International Space Station National Laboratory Education Concept Development Task Force, an interagency group convened by NASA in response to a provision in the 2005 NASA Authorization Act designating the U.S. segment of the ISS as a national laboratory and directing NASA to develop a plan to "increase the utilization of the ISS by other Federal entities and the private sector through partnerships, cost-sharing arrangements, and any other arrangements that would supplement NASA funding of the ISS." The initial report of the task force concluded that the ISS represented a unique opportunity for educational activities and that there was significant interest on the part of Federal agencies and other entities in using space and the resources of the ISS to help achieve their program objectives. This report takes the next step, identifying a number of candidate projects, defining a process to select projects for implementation, describing a concept of operations for educational flight projects, and offering metrics by which to assess the effectiveness of these demonstration projects. Developing these projects, which will use the ISS to bring new agencies and users into the space flight community, will be an important step for NASA and will be a new experience for the participating agencies. Although NASA has carried out educational projects in space for many years, from the perspective of the external community, this effort in many respects served as a pilot project for the exciting educational experiences that will be available in the future and that will utilize the ISS as a national laboratory. Through the implementation of selected demonstration projects, NASA and the participating external organizations will learn lessons that will allow the ISS National Laboratory to operate more efficiently when the assembly of the ISS is complete and full operations begin.

A journey of a thousand miles begins with the first step.

—Lao Tzu, Chinese Philosopher

Introduction

The successful integration of the European Columbus Module and the anticipated docking of the Japanese Experiment Module (JEM) with the International Space Station (ISS) are drawing more worldwide attention to space. Although the principal purpose of the ISS is to host research that is requirements-driven and exploration oriented, it clearly has the potential to support broader objectives as well, such as education. As a national laboratory, the ISS has sufficient accommodations and resources to meet NASA's needs for exploration and research, as well as contribute to the broader U.S. Government need for developing and training a domestic workforce in science, technology, engineering, and mathematics (STEM). This workforce is important to the economic competitiveness of the United States. The ISS has the potential to become a unique resource for education—a national education center accessible to teachers, students in kindergarten through postdoctoral studies, informal education institutions like science centers and museums, and university/college faculty.

Background

To better enable the effective utilization of the resources of the ISS, the assets of the United States Operating Segment were designated as a National Laboratory in the 2005 NASA Authorization Act.

In 2006, NASA asked a range of Federal agencies with responsibilities in education to participate in a task force charged with developing a strategy for using the ISS as an educational asset. The initial report from the task force, delivered in December 2006, affirmed that there was a serious interest on the part of Federal agencies in use of the ISS. Following the completion of this report, NASA was directed in August 2007, through section 2005 of Public Law 110-69, the America Competes Act, to submit to Congress a plan for "implementation of 1 or more education projects that utilize the resources offered by the International Space Station." The act specifically directs NASA to respond to the initial report of the task force: "In developing any detailed plan . . . the Administrator shall make use of the findings and recommendations of the International Space Station National Laboratory Education Concept Development Task Force."

This document presents an approach to validate the task force's strategy for using ISS resources and accommodations as a venue to engage, inspire, and educate students, teachers, and faculty in the areas of science, technology, engineering, and mathematics.

Objectives

The focus of this approach is to demonstrate the versatility and power of the ISS National Laboratory to encourage men and women to acquire skills in STEM fields; to engage, educate, and train learners of all ages for employment in STEM fields; and to reach students of all ethnic, racial, and economic backgrounds in accordance with the 1980 Science and Engineering Equal Opportunity Act. These candidate demonstration education projects represent the future: student-managed and -controlled space instrumentation and tools, curriculums that engage the interest and participation of students, inspirational stories that lead students to STEM fields of study, and widespread participation by underrepresented and underserved segments of society. The candidate demonstration education projects outlined in this report are an important first step in successfully planning educational activities after the Station's assembly is complete.

To accomplish its mission, NASA will provide a strategy to aid individuals and organizations unfamiliar with space projects and operations. Planning and executing space projects requires expertise in areas not traditionally found in the education community, and the assistance of NASA's experienced personnel will be needed to implement many project concepts.

Too often we give children answers to
remember rather than problems to solve.

—Roger Lewin

Minds are like parachutes. They only function when they are open.

—Sir James Dewar, Physicist and Chemist

Concept of Operations

The ISS National Laboratory will have approximately one-half of the ISS/U.S. utilization capability available for U.S. users outside NASA. The education community will use the novelty of working in space to stimulate science, technology, engineering, and mathematics education in the United States. Before our eyes, the ISS National Laboratory will be transformed into a learning center. The center will take advantage of available resources to develop the workforce and stimulate scientific and technical innovation in the United States.

Various components of the Federal Government are joining forces to increase the pool of qualified STEM workers. Federal agencies are taking the opportunity to develop experiments using ISS data, people, and facilities to train their workforce. Federal agencies will be responsible for soliciting, selecting, and submitting education payload instrumentation and/or activity recommendations to the space-based ISS National Laboratory payload manifesting process. Federal agencies will serve as sponsors/points of contact for these education flight payloads and activities. Ground-based projects and activities that meet specific criteria need not flow through the NASA payload manifesting process for approval. The ISS Education Coordination Working Group (IECWG), composed of representatives of Federal agencies having an interest in the educational uses of the ISS National Laboratory, will review and prioritize requests from organizations that would like their activities or experiments to be included in the ISS National Laboratory payload complement. All ISS National Laboratory projects and activities will be evaluated initially to make sure that they meet task force primary objectives. A summative evaluation will be conducted annually to determine whether the ISS National Laboratory Education Project is successfully promoting scientific and engineering literacy, is positively impacting learning, is improving the quality and quantity of students available to the STEM workforce, and is equally accessing men and women of all ethnic, racial, and economic backgrounds.

ISS National Laboratory Education Flight Project Selection Process

The IECWG will oversee candidate flight demonstration project assessments and evaluations and assign each project a priority on a scale to be determined. The ISS Program will estimate the on-orbit resources required by each project and assess the feasibility of any required payload development efforts. Using the task force priority rating and the estimate of resources and feasibility, the Associate Administrator of the Space Operations Mission Directorate will select flight projects for implementation. Selected projects will be scheduled for flight with the expectation that projects should be executed within a window of 1 to 3 years to allow a timely evaluation of the merits of further engagement by the Federal education community.

Participation

The ISS National Laboratory Education Project has great potential for accelerating the Nation's education and workforce goals using the best processes, exciting material, and strong partnerships. The Nation can successfully inspire the next generation of explorers and reach new segments of the population using the ISS as a new education venue.

NASA's education partnership strategy now includes a targeted effort to develop new linkages with the education community within Federal agencies, the corporate/nonprofit communities, education associations, informal education institutions like science centers and museums, and academia to improve science, technology, engineering, and mathematics education at all levels. Education partnerships are the Nation's only hope for meeting its education and workforce goals. Partnerships and alliances multiply the impact of individual education programs by sharing knowledge and program resources and identifying additional target audiences and organizations.

Educators see the value of the project. Participation, therefore, is plentiful and varied. Ideas stretch the imagination and will go far beyond educational demonstrations of the past. Participation is limited only by the availability of resources. Dr. Russell Hancock, president and chief executive officer of a Silicon Valley network group, believes that "NASA's first spinoff is education. Even before a mission flies, learning about the mission is often inspiring, causing bored students to suddenly pay rapt attention to science and math and technology as the opportunity to explore realms beyond Earth has them reaching for the sky. For those lucky students who actually participate hands-on in a mission, it is a life-changing event."

Planning National Laboratory Education Project Demonstrations

The International Space Station Program provides standard NASA payload services for payload development, integration, and operations, including the basic ISS payload integration and operations support infrastructure (people and facilities). The NASA ISS Payloads Office will provide specific functions for National Laboratory Education payloads that will guide chosen proposals through development, integration, and flight. These functions include the following:

- Manage all aspects of ISS payload planning and operations.
- Prioritize and oversee the execution of science/education objectives to ensure results.
- Integrate National Laboratory partner requirements into executable missions.
- Balance critical National Laboratory objectives with existing NASA missions.
- Establish flight manifests and allocate on-orbit resources.
- Perform hardware/software Station-to-payload interface testing.
- Conduct crew training.
- Carry out the day-to-day monitoring and operations of on-orbit payloads and support crew operations through the Payload Operations Integration Center in Huntsville, AL.

- Deliver all products (science samples, data) to payload developer.
- Provide interface and safety requirements for the facilities and crew-related operations.
- Share packing information and lessons learned for commercial transportation.

Formative and Summative Evaluation

The ISS National Laboratory Education Project will have two distinct, but linked, evaluation phases. The first phase will essentially be the development of a roadmap (logic model) for the evaluation of candidate projects. The second phase will consist of the collection and analysis of the education projects and activity data as prescribed by the roadmap. The first phase will take 3 to 4 months. The roadmap is a series of steps designed to analyze and highlight candidate demonstration projects and activities with the greatest potential to inspire, engage, and educate students. Also, it identifies the kinds of data needed to evaluate project success. Short- and long-term successes are based on the analysis of data. Even though evaluation processes occur during programmatic operation, it is essential to have evaluation design in concert with the program planning and development. This ensures that project/activity designs allow for the collection of appropriate information and data. Finally, an external evaluation team of experts must be used, both initially and throughout the project life cycle, to ensure third-party evaluative objectivity.

Candidate Demonstration Projects

Candidate demonstration projects are varied and cover science, technology, and engineering as depicted in the Appendices. These candidate activities, depicted in the chart on the following page, show possibilities. As more teachers and students become aware of this new venue for discovery, adventure, problem solving, and learning, there will be an abundance of new and innovative educational uses of ISS resources and accommodations. The International Space Station National Laboratory Education Project will usher in an era of exploration by all people, of all ages and of all ethnic, racial, and economic backgrounds. Ten Federal agencies, along with several university and education organizations, expressed interest in the International Space Station National Laboratory Education Project. Eleven organizations proposed candidate projects and activities for the demonstration phase.

Exploration Week

To promote the ISS National Laboratory Education Project, a week long event, will showcase projects and activities to educate and train students for employment in STEM fields. Exploration Week, tentatively scheduled for October 2009 on the National Mall, will be heralded as the most futuristic educational show on Earth. Pavilions featuring space wares, gadgets of the future, speakers, robots, books, new technologies, habitats, scientific experts in areas from oceans to space, and other related themes will blanket the Mall. Activities on the Mall will expose students

Candidate Demonstration Projects

ACTIVITY NAMES	TEACHING LEVELS						RESEARCH THEMES				
	Elementary School	Middle School	High School	Undergraduate	Graduate	Teacher/Faculty Training	Space Science	Earth Science	Biological Science	Space Operations and Exploration	Engineering and Technology Development
U.S. Department of Agriculture (USDA) Agriculture and Natural Resources Geospatial Education for K–12 Youth		✓	✓					✓			
Astronaut Access Plus (A+)	✓	✓	✓							✓	
Global NetGeneration of Youth (NGY) Cyberjournalists: Investigating Careers of NASA International Space Station Leaders Shaping the Future			✓							✓	✓
Preparation of a New Generation of Science Teachers				✓		✓	✓	✓	✓	✓	✓
National Defense Education Program (NDEP) Systems Engineering Challenge		✓	✓							✓	✓
The RosettaSpace Project			✓	✓	✓	✓			✓	✓	✓
Coastal Water Imager Demonstration and Evaluation			✓	✓	✓			✓			✓
Water Resources Management Using a Passive Microwave Radiometer (WatRad) on the International Space Station			✓	✓		✓		✓			✓
Student Experiments for the ISS To Support Extravehicular Activity (EVA) and Closed-Loop Life-Support Technology				✓							✓
Exploration Week	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HDMAX™—QuadHD™ Images from the ISS	✓	✓	✓	✓	✓	✓		✓		✓	
Fisk University Student Rocket Team	✓	✓	✓	✓	✓					✓	✓

to skills, tools, and equipment, as well as the knowledge needed to have a future in space, and will highlight the availability and accessibility of the ISS as a venue for education. The team will share Mall space with the Department of Energy (DOE)-sponsored Solar Decathlon.

Sample ISS National Laboratory Accomplishments

It is anticipated that during each year of operation of the ISS National Laboratory, thousands of teachers and students will be creatively involved in many of its lessons, activities, and projects. The results of each year's accomplishments will be captured in an annual report that will highlight the great successes, tell stories, describe the lessons learned, and give a brief glimpse of planned additions to the educational initiatives for the ISS National Laboratory during the next program year.

Never doubt that a small group of thoughtful,
committed citizens can change the world.
Indeed, it is the only thing that ever has.

—Margaret Mead, Anthropologist

A Novel Resource for Education

Despite NASA's best efforts, education organizations are still faced with high costs and complex operations, which hinder their ability to use the International Space Station as a resource for education. Alternatives are needed in order for NASA to keep its promise to students. The education community does not have the resources to complete this mission successfully. The ISS National Laboratory Project faces the following challenges:

- Space on transportation vehicles going to the ISS.
- Payload integration and operations resources to accommodate projects and payloads from the education community.
- ISS National Laboratory Education Project administrative resources to market, integrate, manage, and oversee the evaluation of educational activities and products.
- Appropriated funds available to Federal agencies for ISS utilization.
- Complimentary, NASA-provided technical advice and integration support for Federal agencies wishing to include ISS activities as a component of their education portfolios.

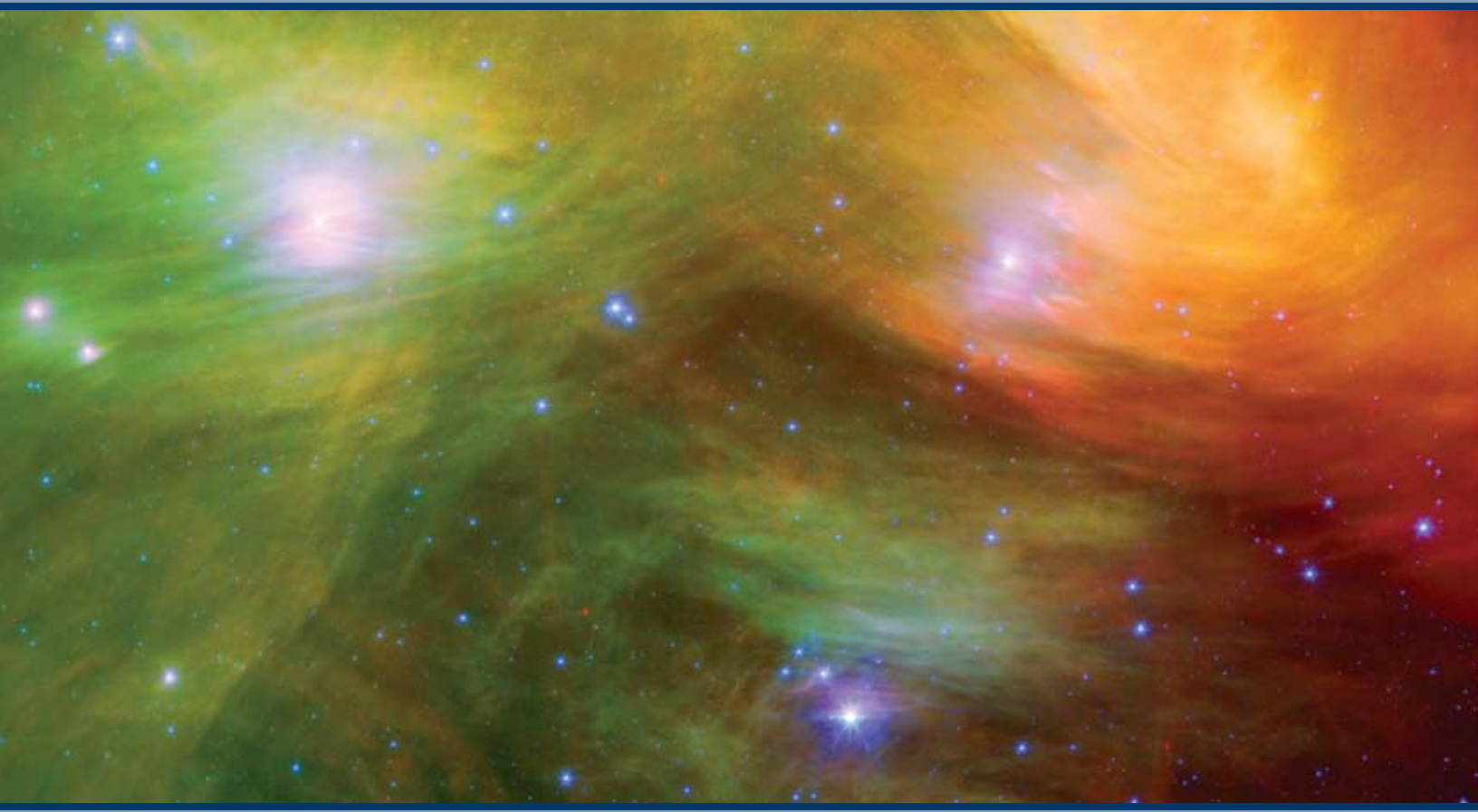
Tell me and I'll forget. Show me and I'll remember. Involve me and I'll understand.

—Confucius, Chinese Philosopher and Reformer

Summary

The education community is ready. The Federal Government is ready. Industry is ready. The education community, now empowered with new techniques and methods for learning, has a burning desire to teach. Its members meet students with the yearning to learn. Additionally, the Nation has access to one of the greatest instruments of learning, a remarkably capable spacecraft, by significant margins the largest and most complex space vehicle ever built. This is a prescription for success.

The people of the ISS National Laboratory will engage learners of all ages in acquiring skills in STEM fields. ISS National Laboratory information, equipment, and facilities will be used to educate and train students for employment in STEM fields. The ISS National Laboratory itself, the “school in outer space,” has the drawing power to reach students of all ethnic, racial, and economic backgrounds. Furthermore, teachers and faculty will use the ISS as a learning and research tool that will take students’ curiosity and interest in space to new levels and produce the skilled workforce necessary for the U.S. to prosper as a nation.



Nothing in life is to be feared. It is only to be understood.

—Marie Curie, Nobel Prize Laureate in Physics and Chemistry

Appendix A: Candidate Demonstration Projects Overview

U.S. Department of Agriculture (USDA) Agriculture and Natural Resources Geospatial Education for K–12 Youth

Students in Ag in the Classroom, 4-H, and other youth-serving organizations could use ISS images to learn about hotspots in their region such as pollution and diseased trees and plants. The students could identify and visit the exact locations in or near their community, where they would investigate and report on actual conditions that they found on the ground. Students could learn the power of remote sensing data to help them observe, track, and understand the importance of ground-level conditions that affect soil, water, and biological matter. Observations by the students, working with remote sensing experts and other geospatial-savvy adults, could lead the participating youth into important career tracks of science, technology, engineering, math, geography, and agriculture. This work could build on a foundation of geospatial learning to be launched in more than 500 counties Nationwide.

Astronaut Access Plus (A+)

NASA is now structured to be more flexible and responsive to others wishing to gain access to ISS resources. One such process is Astronaut Access Plus (A+), a means of direct access to and collaboration with the astronauts through the NASA Teaching From Space (TFS) Office. Under the umbrella A+ payload, NASA would work with partner agencies to capture short (roughly 15 minutes), unedited video filmed by astronauts aboard the ISS. Agencies could develop one or several content-driven lessons containing key curriculum requirements. The video captured would be delivered to the requesting agency for editing and incorporation into educational products. This proposed umbrella payload for National Laboratory education is ready for implementation.

The model for A+ is the Education Payload Operations (EPO) Demonstrations, NASA's cornerstone education payload that designs curriculum-based educational activities demonstrating basic principles of STEM. These onboard activities are videotaped, downlinked, and then incorporated into educational products for use by students and educators. Completed projects have explained topics as diverse as lab safety, garbage in space, water recycling, the International Polar Year, and toys in space. Some of the activities cover physical properties, such as Newton's Laws of Motion or Bernoulli's Principle for air pressure, and others are specific to life in space, such as activities that explain power generation on the ISS (how the ISS solar panels work) or demonstrate extra-vehicular activities. EPO educational outreach products meet national educational standards for scientific and technical literacy; they introduce students to scientific concepts and help them build a stronger understanding of the unique environment of microgravity and how humans can live and work in space. For more information, visit *http://www.nasa.gov/mission_pages/station/science/experiments/EPO.html.*

Global NetGeneration of Youth (NGY) Cyberjournalists: Investigating Careers of NASA International Space Station Leaders Shaping the Future

The International Space Station National Laboratory presents a unique opportunity for youth to connect with NASA ISS scientists, researchers, inventors, engineers, astronauts, and policy makers (ISS role models), whose lives and stories can inspire students to pursue careers in STEM fields. The Global NetGeneration of Youth Cyberjournalists Project is a collaboration of three high schools in the United States and Canada (pilot schools) with corporate, government, and community-based partners committed to STEM education.

Specific goals of this multisite project are to (1) demonstrate the efficacy of providing youth with a robust science and technology learning environment using state-of-the-art collaborative and interactive technologies, as well as an inquiry-based curriculum that inspires youth to aspire to and attain 21st-century skills and global competencies; (2) cultivate multinational teams of students as cyberjournalists who investigate the lives and careers of NASA ISS role models and then design and create multimedia content (e.g., photo essays, PowerPoint slides, press releases, PSAs, videos, and DVDs [digital portfolios]) that conveys their discoveries; (3) foster the creation of a multinational Web site to archive NGY digital portfolios; (4) extend public outreach and increase public understanding of NASA and the ISS by further disseminating their digital portfolios to peers, educators, and adults around the globe via multimedia channels including print, radio, television broadcast, Internet, online collaborations, videoconferencing, and onsite presentations; and (5) define a sustainable and scalable model that can be replicated worldwide.

Preparation of a New Generation of Science and Mathematics Teachers

Both California and the Nation face a critical shortage of science and mathematics teachers, and these shortages threaten the preparation of a future workforce of scientists and engineers. Collaboration among the California State University (CSU), the largest producer of science and mathematics teachers in the Nation; California Polytechnic State University; San Francisco State University; NASA Ames Research Center; NASA Dryden Flight Research Center; and the Jet Propulsion Laboratory can significantly enhance the recruitment, preparation, and retention of science and mathematics teachers for California and serve as a model partnership for the Nation. To the extent that resources are available, the collaboration proposes to do the following:

(1) Develop and conduct a summer research program that enables future science teachers prepared by the California State University to participate on NASA Ames research teams before earning a teaching credential and also offers them the possibility of continuing to work as members of NASA Ames research teams during their initial years of teaching.

(2) Cooperate in the conduct of the NASA Ames Spaceward Bound program, organized in partnership with the Mars Society and supported through the Exploration Systems Mission Directorate at NASA Headquarters, toward the goal of enabling future science teachers prepared by the California State University to participate in the exploration of scientifically remote and extreme environments on Earth as analogs for human exploration of the Moon and Mars.

(3) Partner in the NASA Ames Pre-service Teacher Institute, designed to model and promote the use of scientific inquiry through problem-based learning and integration of technology in the curriculum.
(4) Expand participation of CSU campuses in NASA Ames programs, including research programs for undergraduate and graduate students and for faculty, designed to increase the participation of minority-serving institutions in NASA research and development and to increase the number of minority students pursuing higher education in STEM fields.
(5) Collaborate in the development of preservice teacher education curriculum materials in order to strengthen the preparation of future teachers in the use of instructional strategies utilizing scientific inquiry and problem-based learning and to focus curriculum development on programs such as the ISS that represent high priorities for NASA Headquarters and NASA Ames Research Center.

National Defense Education Program (NDEP) Systems Engineering Challenge

The Department of Defense (DOD) proposes to sponsor a series of regional engineering design challenges for middle and/or high school students leading to an NDEP-supported national challenge, with the winning team getting the green light to put its project on the ISS the following year. Scholarships may be given out to teams that make it to the top tier but do not make it to the ISS level. The top team would work with a group of DOD, NASA, and industry scientists and engineers to take a systems engineering approach to the final design of its winning project so that it would function as designed when launched into the space environment.

The RosettaSpace Project

The RosettaSpace Project proposes to provide students with the opportunity to make primary discoveries about life beyond Earth through hands-on research that culminates in a flight experiment aboard the ISS. In addition to inspiring students to pursue education in the lucrative field of biotechnology, RosettaSpace would demonstrate the utility of the ISS National Laboratory for biotech innovation and medically relevant research by characterizing, for the first time, the biology of key organisms in space using the latest research techniques. Through the National Space Grant's state-based Space Grant Consortia, each state would select one of the benign microorganisms in the groundbreaking Human Genome Project as the focus of its student projects. New studies on these organisms would be implemented annually, thus expanding the knowledge base and providing additional skill development in cutting-edge biotech research tools. In later years, students and states could follow NASA's exploration trail throughout the solar system by extending their research to investigations on the Moon and beyond. The Space Grant Consortium competitively selected in each state would be responsible for designing the ground studies and space flight experiments, analyzing the results, and publishing the data both in peer-reviewed publications and on international databases. Participating students would have the advantage of hands-on experience in the rapidly developing area of space biotechnology.

Coastal Water Imager Demonstration and Evaluation

The National Oceanic and Atmospheric Administration (NOAA) Cooperative Center for Remote Sensing Science and Technology (CREST) at City College of the City University of New York (CUNY) proposes an inexpensive proof-of-concept experiment for a four-channel, high-resolution imaging sensor optimized for coastal water observations and retrievals of bio-optical parameters, including chlorophyll and its fluorescence, as well as the detection of harmful algal blooms. Since many of the U.S. and, indeed, the world's centers of population are concentrated in coastal areas, the status and health of coastal waters is critical and drives a strong need for an effective satellite coastal water imager for monitoring the health and bioactivity of coastal waters and for assessing anthropogenic influences. Unfortunately, the only dedicated ocean color sensor (the Sea-viewing Wide Field-of-view Sensor, or SeaWiFS) is optimized for open ocean conditions and is not optimized or effective for coastal water monitoring.

Though other remote sensing instruments, such as the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Medium Resolution Imaging Spectrometer (MERIS), have observation channel bands that can be used for ocean monitoring, they are not effective for coastal waters. The proposed nadir-pointing imager on the ISS tests and validates a new approach for coastal water monitoring using channel selections optimized for retrievals of coastal water properties including chlorophyll concentration, fluorescence, and suspended solids that are based on extensive theoretical analysis and laboratory and field studies by NOAA CREST and others. Students from 12th grade through graduate school would participate in all aspects of the work and come to understand and appreciate the importance of critical proof of concepts, including the selection of optimized observation bands, near infrared (NIR) retrieval algorithms, and fluorescence height models for use in future missions to extend satellite observation capabilities to coastal waters as well as oceanic waters.

Water Resources Management Using a Passive Microwave Radiometer (WatRad) on the International Space Station

The NOAA CREST scientific team proposes to lead the development of the WatRad, which is to be mounted on the ISS. WatRad is a tool for water resources management using passive microwave images taken from a radiometer. Students would be involved in the design and monitoring of the sensor. K–12 teachers and high school and undergraduate students will be more interested and motivated to learn when they are engaged in the planning, development, operation, data collection, publishing, and reporting of results from a new remote sensing instrument. Students will be energized and excited about the prospect of work at NASA and NOAA.

It is important to mention that images can be received at NOAA CREST's new Satellite Receiving Station. The reception of these images will expose hundreds of students, teachers, and faculty to different aspects of space science, including instrumentation design and calibration, image acquisition, data processing and analysis, and result analysis. To achieve these objectives, a receiving module will be developed as a part of the satellite receiving station. Several students of

the City College of the City University of New York are currently involved in the implementation of the new receiving station. Furthermore, a Web template will be developed to make the acquired images, as well as derived products, available for the scientific community. It is worth mentioning that given the lower altitude of the International Space Station (approximately 360 kilometers) compared to that of the current passive microwave satellites (approximately 800 kilometers), there is an interesting potential to improve the spatial resolution and develop new applications for these images. Collected images will allow students to observe the dynamics of phenomena related to hydrology and climate, such as floods, droughts, encroachment on wetlands, and heavy rains. These resources can be easily integrated into the curriculums of several departments, such as civil engineering, geography, and Earth science.

Student Experiments for the ISS To Support Extravehicular Activity (EVA) and Closed-Loop Life-Support Technology

Purdue researchers propose two student-built and -managed fluids experiments that depend on the long-duration, high-quality zero-gravity (zero-g) environment available only on the ISS. Experiments depend on the highly successful hardware design of and astronaut interaction with the Capillary Fluids Experiment (CFE) currently aboard the ISS.

As far as the team knows, the proposed droplet experiment has never been performed in space, on drop towers, on aircraft, or on sounding rockets. The computations themselves are unique and in dire need of experimental testing so as to advance the design of reliable two-phase fluids systems for space flight or advanced experimentation.

Purdue students would develop these experiments in a long-term project class. The zero-g flight experiments class designed for the NASA Reduced Gravity Student Flight Opportunity Program (RGSFOP) is a short-timeframe model for what will be done to create these experiments. Purdue has an ideal combination of experience and skills to manage this project successfully: (1) experience in teaching students low-gravity experiment design, (2) experience in multiyear educational efforts in satellite design and fabrication, and (3) experience in design, fabrication, and delivery.

HDMAX™—QuadHD™ Images from the ISS

Texas A&M University (TAMU) proposes to install the HDMAX camera system on the ISS Window Observation Research Facility (WORF) for the collection of high-resolution imagery for educational purposes. HDMAX is an 8.3-megapixel, 30-frame-per-second progressive frame scan camera utilizing a high-resolution 3840 x 2160 QuadHD complementary metal-oxide-semiconductor (CMOS) sensor. The relative sharpness of an HDMAX display is equivalent to that of a commercial IMAX display, even though it is produced by the small HDMAX package. The standard color HDMAX system utilizes a single-sensor Bayer pattern color filter with an infrared (IR) cut filter. Unique processing allows the camera to achieve an extremely highly perceived resolution.

The proposed system would enable 2- to 3-meter-resolution calibrated motion imagery from low-Earth orbit (LEO) in color, monochrome, or multispectral models (to 1 micron). The HDMAX high-resolution and frame-rate output data, along with unparalleled radiation hardening, make it a flexible and long-lived asset to both U.S. students and scientists pursuing research in Earth observation. In particular, images generated with HDMAX can be used to excite U.S. students about space exploration and engage them in STEM careers.

Fisk University Student Rocket Team

The student rocket team at Fisk University, a historically Black university in Nashville, TN, has a program of competition, training, outreach and workforce development that benefits the community, the Nation, and the university's students. The proposed program has three activities: constructing a sounding rocket, collaborating with a science high school to fly a robot rover, and providing hands-on, state-objective-based experiences in rocket operation for K–12 students. At the conclusion of the sounding rocket demonstration, students will be challenged to create a conceptual design for a rocket capable of a rendezvous with the Space Station.

Appendix B: Detailed Candidate Demonstration Project Descriptions

USDA Agriculture and Natural Resources Geospatial Education for K–12 Youth

Project Location

Both in flight and on the ground.

Grade Level for Participation

Grades 6–12.

Experiment Description

Students in Ag in the Classroom, 4-H, and other youth-serving organizations will use ISS images to learn about hotspots in their region such as pollution and diseased trees and plants.

Student Participation

(1) Based on input from students in more than 500 counties in the U.S., local student projects will request ISS-collected, remotely sensed images based on latitude and longitude of the surface of Earth that define the students' area of interest. Youth in 500 counties have been experimenting with Global Positioning Systems (GPS), and Geographic Information Systems (GIS) are ready to engage in the acquisition and analysis of ISS-collected images in infrared and other formats. Youth will study the ISS images and identify objects and land parcels about which they would like to learn more, based on indications of nonnormal variances found in the ISS-provided remotely sensed images.

(2) Students will identify and visit the exact locations in or near their communities where they will investigate and report on actual conditions that they find on the ground.

(3) Students will learn the power of remote sensing data to observe, track, and understand the importance of ground-level conditions that affect soil, water, and biological matter.

(4) Observations by the students, working with remote sensing experts and other geospatially savvy adults, will lead the participating youth into important science, technology, engineering, math, geography, and agriculture career tracks. Adults will appreciate the students' interest in STEM and learn how they can use these technologies for civic engagement and to fulfill their desire to address community issues.

(5) Students will be introduced to the ways in which remotely sensed imagery can be used to observe water, soil, and plant conditions.

(6) Students will learn to use, understand, and integrate geospatial tools such as GIS, GPS, and remote sensing. Scavenger hunts, geo-caches, and emergency tabletop exercises involving the use of remotely sensed photography will be used to engage the youth in the excitement of geospatial technology. Projects will be selected based on student input and student request. A student-centered approach will generate student interest and engagement.

(7) Students will take field trips to visit users of geospatial tools in their own communities to learn about practical ways geospatial technology is used and makes a difference in organizations in their own communities such as utility companies; public safety agencies such as fire,

police, and emergency services; and agriculture and natural resource agencies. Students will discover how geospatial technology is integrated into many career fields and career options.

(8) Students will inventory problems and conditions that could be tracked and monitored using geospatial tools.

(9) Students will propose community mapping projects based on observed conditions in their own communities that could be addressed. Students will identify community agency personnel that could be partners in addressing proposed community mapping projects.

(10) As an introductory project, students will be introduced to the use of remote sensing photography for observing plant and natural resource conditions in or near their own communities. In some cases, ISS images or USDA remote sensing imagery can be used to get these observations started. Students will use ISS images to learn about the hotspots in their region such as pollution and diseased trees and plants.

(11) USDA and college-level geospatial teachers and specialists will work with teachers, students, and youth groups to help them gain the knowledge, attitude, skills, and aspirations to engage in additional uses of geospatial technology.

(12) Initially, the proposed work will be carried out in pilot test communities where Ag in the Classroom and 4-H youth groups are already involved in leaning to use GIS and GPS tools. The next step in the development of these teams is to introduce recent and time-lapse sets of remotely sensed images to analyze ground conditions in their own communities. Preliminary activity is currently under way in about 500 school districts in all 50 states. Communities for this project will be selected from the pool of the 500 school districts with demonstrated interest in helping students learn analysis and critical thinking skills through the use of geospatial tools including remote sensing data from the ISS.

(13) Students will be encouraged to present their observations and findings to audiences beyond their formal classrooms in such venues as civic organization meetings, parent association meetings, science fairs, GIS days, and county and state fairs and festivals. The results of these student projects will raise the understanding of teachers, parents, and the general public about the observations that the students present. The students will not be the only beneficiaries of these learning activities; they will also involve the community at large, which will gain a greater understanding of the changes in the conditions of the plants, soil, water, and natural resources of their own hometown area.

(14) Annually, the most interesting youth team projects will be featured at county fairs. Some of those projects will be selected to advance to the level of state fair exhibits. In addition, some youth teams will be selected to exhibit their maps and remotely sensed image analysis at regional and national conferences, exhibitions, and festivals.

(15) Currently, several national and international organizations are encouraging the USDA-supported Youth Community Mapping program to grow into their communities. These partnership organizations offer the promise of software grants, travel stipends, and numerous in-kind contributions to supplement the volunteer workforce of USDA's geospatial specialists.

(16) USDA partners in the land grant university system have a network of geospatial faculty and specialists who have agreed to help teach, host, and coordinate annual training events and to prepare teachers and students to be able to incorporate geospatial tools into the teaching of math, science, and technology in the classroom and in the less formal after-school programs, as well as in homeschool programs, which are growing today.

Desired Outcome or Impact

Students will learn the power of remote sensing data in observing, tracking, and understanding the importance of ground-level conditions that affect soil, water, and biological matter. Observations by the students, working with remote sensing experts and other geospatially savvy adults, will lead the participating youth into important career tracks of science, technology, engineering, math, geography, and agriculture. The students' presentation of the studies to public groups will generate public interest in and support for remotely sensed imagery from the ISS because of the imagery's benefits.

Barriers

Development and distribution of curriculum materials; local access to GPS units and digital cameras; local transportation costs.

Strategy

Integrate learning how to use geospatial tools such as global positioning systems, geographic information systems, and remote sensing systems into classroom teaching and after-school activities. Ag in the Classroom and other youth development partners will annually announce the availability of this program and seek applications. A review team will recommend the teams with acceptable applications. Accepted applicants will engage in yearlong learning activities that will provide students with hands-on access to geospatial tools such as GPS and GIS. Youth projects will result in maps of their own local communities that could be shared through Parent-Teacher Association (PTA) exhibits, science fairs, and county and state fairs. The program will be pilot-tested in first year, with expansion in the number of student teams in years 2 and beyond based on lessons learned during the pilot test year.

Partners and Contributors

Land grant university geospatial extension specialists, NASA staff with geospatial skills, USDA field staff and cooperative extension agents, Ag in the Classroom teachers and volunteers, 4-H clubs and volunteers, ESRI, the National Geographic Society, and MyWonderfulWorld.org.

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Reference Web Sites

- *http://www.agclassroom.org*
- *http://www.crn4h.org*

Cost

$300,000 per year.

Astronaut Access Plus (A+)

Project Location

Both in flight and on the ground.

Grade Level for Participation

Grades K–12.

Experiment Description

This is an umbrella payload model that might be utilized by National Laboratory partners. NASA can work with partner agencies to capture short (roughly 15 minutes), unedited video filmed by astronauts aboard the ISS. Agencies can develop one or several content-driven lessons containing key curriculum requirements. The video captured will be delivered to the requesting agency for editing and incorporation into educational products.

The model for A+ is the Education Payload Operations (EPO) Demonstrations, NASA's cornerstone education payload that designs curriculum-based educational activities demonstrating basic principles of STEM and geography. These activities are videotaped, downlinked, and then incorporated into educational products for use by students and educators in schools and in informal education institutions like science centers and museums. Completed projects have explained topics as diverse as lab safety, garbage in space, water recycling, the International Polar Year, and toys in space. Some of the activities cover physical properties, such as Newton's Laws of Motion or Bernoulli's Principle for air pressure, and others are specific to life in space, such as activities that explain power generation on the ISS (how the ISS solar panels work) or demonstrate extravehicular activities. EPO educational outreach products meet national education standards for scientific and technical literacy; they introduce students to scientific concepts and help them build a stronger understanding of the unique environment of microgravity and how humans can live and work in space.

Student Participation

Students will view videos and apply lessons on the ground.

Desired Outcome or Impact

Reach thousands of students with simple, content-driven lessons delivered by astronauts.

Barriers
None.

Strategy
National Laboratory partner agencies may choose to work with the Teaching From Space Office to develop new content topics or leverage existing NASA content, with a focus on their education objectives. The A+ demonstrations could be as simple as providing content for a crewmember to conduct an orbit-based demonstration using available materials, perhaps to be replicated by students on the ground. The ISS products—on-orbit videos of astronaut demonstrations—can be downlinked, edited, built into curriculum materials, and distributed to educators nationally and internationally using the partner agencies' educational program infrastructure.

Partners and Contributors
NASA Teaching From Space (TFS) Office with any other agency.

Contact
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Education Lead
From proposing agency.

Reference Web Site
http://www.nasa.gov/mission_pages/station/science/experiments/EPO.html

Cost
Costs could be scaled to funds available.

Global NetGeneration of Youth Cyberjournalists: Investigating Careers of NASA ISS Leaders Shaping the Future

Project Location
Both on the ground and in flight.

Grade Level for Participation
Grades 9–12.

Experiment Description

The NetGeneration of Youth Global Cyberjournalist Project is a collaboration engaging three high schools in the United States and Canada (pilot schools) with corporate, government, and community-based partners committed to STEM education. The goals of this project are to accomplish the following:

(1) Demonstrate the efficacy of providing youth with a robust science and technology learning environment using state-of-the-art collaborative and interactive technologies, as well as an inquiry-based curriculum to inspire youth to aspire and achieve 21st-century skills and global competencies.
(2) Cultivate multinational teams of students as cyberjournalists who investigate the lives and careers of NASA ISS role models and then design and create multimedia content (e.g., photo essays, PowerPoint slides, press releases, PSAs, videos, and DVDs [digital portfolios] that conveys their discoveries.
(3) Foster the creation of a multinational Web site to archive the digital portfolios.
(4) Extend public outreach and increase public understanding of NASA and the ISS by further disseminating the digital portfolios to peers, educators, and adults around the globe via multimedia channels including print, radio, television broadcast, Internet, online collaborations, videoconferencing, and onsite presentations.
(5) Define a sustainable and scalable model that can be replicated worldwide.

Student Participation

The NGY Global Project initially involves student teams from three schools (pilot schools)—two in the U.S. (Academy of Information Technology and Engineering, Stamford, CT; Dorsey High School, Los Angeles, CA) and one high school in Calgary, AB, Canada. The program is designed to engage and empower students with 21st-century skills in research and communication, media and technology, critical thinking and analysis, self-direction, and global competencies, as well as with unique opportunities to serve as NGY Global Cyberjournalists who collaborate in multinational teams, first to conduct inquiries focused on the careers of NASA ISS role models and then to create digital portfolios to share with peers, educators, and adults around the world. While the exact number of students participating will be determined in Phase 1, the team expects outreach and impact of the digital portfolios to grow exponentially.

Desired Outcome or Impact

(1) Student Level: NGY Global Project will promote knowledge of the history and legacy of ISS and its leaders and understanding of STEM education career paths and opportunities; foster the use of state-of-the-art technologies to develop 21st-century skills; inspire career ambitions and academic achievement; and, lastly, expand opportunities for students to become digital authors by sharing their digital portfolios with diverse audiences.
(2) School Level: NGY Global Project will generate community-wide awareness and interest in STEM and the ISS and will extend the repertoire of curricular and instructional strategies of teachers while serving as an integrative mechanism and capstone project for innovative, cross-disciplinary, project-based learning.
(3) Community Level (local, national, and international): NGY Global Project will expand private and public partnership relationships and promote synergies among schools and external

community stakeholders, thereby extending the visibility and profiles of partners and sponsors. With the focus of student investigations on the inherently motivating field of space science and the captivating personalities of the ISS role models, coupled with the power of multimedia tools, the NGY Global Project will generate intriguing digital portfolios of interest to diverse audiences around the world. The commitment and capacity of core private and public partners to disseminate the digital portfolios widely ensures broad national and international exposure.

Barriers/Challenges

(1) Establishing formal relationships with NASA and Federal agencies to identify and secure access to appropriate ISS role models.
(2) Cultivating a portfolio of partnerships to secure resources and ensure sustainability and replicability.

Strategy

- Phase I (December 2007–spring 2008): Core partners identified; partnership development and school engagement; SMART Technologies to install interactive whiteboards and deliver professional training at pilot schools; NGY program launched/reinforced at pilot schools; Oracle Education Foundation to provide professional development on Think.com (collaborative online community) and ThinkQuest (annual global Web site competition); initiate collaborative planning to foster a "community of practice."
- Phase II (spring 2008): Ongoing staff development; NGY and technology activities.
- Phase III (summer 2008): Retreat with staff and partners to develop collaborative plans.
- Phase IV (fall 2008–June 2009): Program implementation.
- Phase V (summer 2009): Evaluation and revision of program model.

Partners and Contributors

Principal Investigator (PI)/Education Lead

Dr. Ronnie B. Lowenstein, president of Lowenstein & Associates, Inc., will manage the design and implementation of the NGY Global Project and establish a Global NGY Partnership Advisory Committee.

Core Partners/Advisors

- SMART Technologies, an industry pioneer and market leader in developing collaborative and interactive technologies, including the interactive whiteboard with videoconferencing capabilities that link sites around the world, will provide core technologies and technology training to all sites.
- Mick Adkisson, SMART Technologies manager of education and advocacy, will serve as Co-PI in the design and implementation of the NGY Global Project. He anticipates that the six-phased cycle will produce a model that is sufficiently successful to replicate with SMART Technologies' affiliates across the U.S. and within 75 countries.

Pilot Schools

(1) Canada: By end of January 2008, corporate sponsor SMART Technologies will confirm the participation of one high school in Calgary, AB, Canada, that has demonstrated success in integrating SMART Technologies and confirmed interest in piloting the Global NGY Project.
(2) U.S.: The Academy of Information Technology and Engineering (AITE) in Stamford, CT, a college preparatory magnet school, provides a technology-rich learning environment and an internationally themed curriculum to realize their motto: "Empower students to shape the future!"
(3) U.S.: Faculty and students at Dorsey High School in Los Angeles, CA, inspired by the school motto "ad astra" (to the stars), use NASA-themed activities to motivate learning.

Oracle Education Foundation

Americas Director Ms. Thyra Busch offers complementary state-of-the-art resources proven to promote 21st-century skills worldwide. Specifically, the project will leverage Think.com, an online community of 350,000 students and educators from 53 countries; it will also offer training support to enable NGY teams to develop and share the digital portfolios in Think.com and to design and author a Web site capturing that content for entry into the Foundation's annual ThinkQuest international Web site–building competition. In addition to offering motivation and prizes, ThinkQuest represents an opportunity for the entries to be permanently displayed in the ThinkQuest Library, guaranteeing a global audience of over 30 million people each year.

Stamford Achieves, Inc., and 100 Black Men of Stamford

Two community-based organizations dedicated to closing achievement gap in Stamford, CT, have adopted NGY frameworks as a tool for integrating innovative curriculum elements of their community-wide Transitions Initiative. Dr. Christine Casey, Executive Director of Stamford Achieves and longtime NGY advisor since 2002, has agreed to serve on the advisory group of the NGY Global Project.

Leaders Serving as Role Models and NGY Advisors

- Dr. Corinna Lathan, PI for 3DSPACE Experiment jointly sponsored by NASA and the European Space Agency and scheduled to fly on the ISS in April 2008, biomedical aerospace engineer, inventor, and researcher.
- Dr. Lynn Bondurant, visionary aerospace educator and current Director of Evaluation for NASA Explorer Schools.
- Richard Clark, NGY Vice President
- Coran James, Director of NGY NY Metro
- Letty Maxwell, Director NGY DC Academies
- Barbara Jeweler, NGY Maryland

Contact

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Cost

Budgets to be defined as program and partnerships evolve in Phase I. Partners estimate that the first year's cost is about $200,000, covering technology product investment, teacher professional development, content development, program monitoring, partnership development, summer retreat, travel expenses, and local resources in staffing provided by each school site.

References

- Corey Murray Senior Editor, "Youth Voices: NetGeneration of Youth Journalists Cover NASA Partnership Summit," *http://www.eschoolnews.com* (January 22, 2007)
- *http://www.et3online.org/programs/ngy.cfm*

DVDs of student products supplied upon request.

Preparation of a New Generation of Science and Mathematics Teachers

Project Location

On the ground.

Grade Level for Participation

K–12 preservice educators.

Experiment Description

NASA research and engineering projects associated with the International Space Station.

Student Participation

University students interested in pursuing teaching careers in science or mathematics.

Desired Outcome or Impact

Both California and the Nation face a critical shortage of science and mathematics teachers, and these shortages threaten the preparation of a future workforce of scientists and engineers. Collaboration among the California State University (CSU), the largest producer of science and mathematics teachers in the Nation; California Polytechnic State University; San Francisco State University; NASA Ames Research Center; NASA Dryden Flight Research Center; and the Jet Propulsion Laboratory can significantly enhance the recruitment, preparation, and retention of science and mathematics teachers for California and serve as a model partnership for the Nation.

Strategy

This demonstration education project represents the future by developing student-managed and -controlled space instrumentation and tools, curriculums that engage the interest and participation of students, inspirational stories that lead students to STEM fields of study, and widespread participation by underrepresented segments of society. The demonstration education project outlined here is an important step in successfully planning educational activities after the completion of ISS assembly. The project will focus on the development of preservice teacher education curriculum

materials in order (1) to strengthen the preparation of future teachers in the use of instructional strategies incorporating scientific inquiry and problem-based learning and (2) to focus curriculum development on programs, such as the ISS, that represent high priorities for NASA. As more teachers and students become aware of this new venue for discovery, adventure, problem solving, and learning, there will be an abundance of new and innovative educational uses of ISS resources.

Partners and Contributors

The NASA Headquarters Office of Education, Ames Research Center, Dryden Flight Research Center, the Jet Propulsion Laboratory, California State University, Lawrence Livermore National Laboratory, and Land Grant institutions.

Contact

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Cost

Costs could be scaled to funds available.

NDEP Systems Engineering Challenge

Project Location

Both on the ground and in flight.

Grade Level for Participation

Middle and/or high school.

Experiment Description

There will be a series of regional design challenges that leads up to a National Defense Education Program (NDEP)-supported national challenge, with the winning team getting the green light to put its project on the ISS the following year. Scholarships may be given out to teams that make it to the top tier but do not make it to the ISS level. The top team will work with a group of DOD, NASA, and industry scientists and engineers to take a systems engineering approach to the final design of its winning project so that it will function as designed when launched into the space environment.

Student Participation
Individually and in teams, students will take on the design challenges.

Desired Outcome or Impact
Enhanced numbers of students completing advanced high school math and science courses as a result of a successful experience with the NDEP Systems Engineering Challenge.

Barriers
One difficulty is defining problems for the NDEP Challenge that are interesting to work on but do not yield an excess of unrealistic solutions and can be accomplished remotely. The NASA ISS flight schedules and mission priorities are TBD at this time, and the extended scheduling timeframes might make it difficult to keep project teams engaged over extended periods of time. Furthermore, the NDEP program interest focuses on U.S. K–12 involvement, and U.S.-only student participation may limit potential partners.

Strategy
Commit to 3 years of NDEP-sponsored competitions and then assess program utility before the project team will consider renewing its ISS collaboration agreement with NASA. In years 2 and 3, the people at the new Finals competition will get an update as to how the previous year's winner(s) did (that is, did the project go to space, and did it work?).

Partners and Contributors
Department of Defense, NASA, university and industry scientists and engineers, and (TBD) national competition coordinators.

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Education Lead
Bob McGahern
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Reference Web Site
Under construction.

Cost
Costs could be scaled to funds available.

The RosettaSpace Project

Project Location
The RosettaSpace Project is primarily a ground-based research project that culminates in annual flight investigations aboard the International Space Station National Laboratory.

Grade Level for Participation
Grade 9 through graduate school.

Experiment Description
The Human Genome Project technologies that revolutionized the biosciences on Earth have rarely been used in space. When they were, however, the results were surprising and important.

Sponsored by the National Space Grant Program, the RosettaSpace Project provides students with the opportunity to make primary discoveries about the nature of life beyond Earth through hands-on research that culminates in a spaceflight experiment aboard the International Space Station. The RosettaSpace Project is both affordable and feasible because the flight investigations use space flight hardware developed by Bioserve Space Technologies that is already aboard the ISS. Specimens can be easily transported in coffee-can-sized microlabs or middeck-equivalent lockers.

Under the mentorship of professional scientists at Space Grant organizations as well as other colleges and universities, students will select organisms for study, then learn and apply some of the most important research tools in contemporary biotech to explore the responses of selected microorganisms on the ground and in space. Students will be encouraged to use benign microbes that were used in the pioneering Human Genome Project. Such organisms are the best understood living creatures on Earth, so the results of the investigations will be useful to the broadest scientific community. The students will then compare the terrestrial biology of those organisms to the biological responses they exhibit in the unique microgravity environment of space.

This research builds on techniques introduced in high school and adds new investigations that expand a student's skill and experience with cutting-edge biotech research. An example of a RosettaSpace investigation follows. Please keep in mind, however, that the students and their university mentors will design their own experiments.

Characterize the environment that sustains the organism. Life exists and evolves in response to its environment. Of all the environmental factors that changed to shape life on Earth, gravity did not change. When life from Earth goes to space, it encounters an environment never experienced in the 4.5-billion-year history of life on Earth. Unusual environments elicit unusual biological responses, and this is particularly true in space in ways that can only now be discovered. So the first study the students might undertake is to describe the physical, chemical, and biological features that dominate the terrestrial environment and determine how these would change in space.

Determine how changes in the environment affect the biology of the organism on Earth and simulate the space environment to understand how the change in gravity might affect organisms in space. In this study, students would explore how changes in the microbe's environment on Earth elicit different biological responses. Then they would be challenged to identify all of the physical features of the space environment that could affect an organism's biology in space. Changes in gravity do not only affect an organism directly; they also change the organism's environment in unique ways. The organisms respond biologically both to the direct effects of space microgravity and in response to the unusual new features of the growth environment.

Determine what caused the biological changes seen in space. Through this process, the students will learn the importance of experimental controls and how the analysis process often generates additional investigations.

To characterize the biological responses of the organisms, students might conduct whole genome analyses of their organisms at different points in time over a period of hours to days. They might then conduct proteomic surveys to determine how the pattern of proteins changed before flight, at several points during the space flight, and after the return to Earth. These patterns could be correlated with various imaging techniques to see if they can be used to detect physical as well as biological changes and relationships in their organisms as a result of environmental changes.

Many other studies, including knockouts, metabolic analyses, cell counts, population studies, fluorescent tags, and so on, can be featured instead of the ones above or pursued in following years. In addition, it is possible that this research could be extended to other worlds as part of NASA's exploration of the Moon and Mars.

Participating students will be encouraged to network with each other across the country to compare results and determine whether any trends are seen from one organism to another, just as professional scientists do.

A Web site will be established to share findings from all participants. In addition, students will be encouraged to submit their results for publication in scientific databases.
If the quality of the work is high enough, students might earn the high scientific accolade of having their report accepted for publication in a peer-reviewed professional journal.

Student Participation
This is a hands-on project. It is expected that students will participate in all phases of the experiment design, development, test, and analysis, just as professional space flight researchers do. This participation includes developing the training protocols for the astronauts who will conduct the investigation in space.

Desired Outcome or Impact
Through the RosettaSpace Project, its designers hope that the participating students will achieve scientific "firsts" by revealing the space biology of key organisms that that were used in the groundbreaking Human Genome Project and, in the process, help pioneer the emerging field of space biotechnology. They will develop competence in state-of-the-art biotech techniques, including bioinformatics, and establish their home states as the world experts in the space biology of their selected organism. If successful, their investigations could help demonstrate the value of space biotechnology.

Barriers
The most significant barriers to participation would be if flight opportunities were not available annually and if transportation costs, which at this time are not known, were to become prohibitively expensive.

Strategy

Through the National Space Grant Program's state-based Space Grant Consortia, each state will select one of the benign microorganisms that were used in the groundbreaking Human Genome Project as the focus of their student projects. The Space Grant Consortia competitively selected in each state will be responsible for designing the ground studies and space flight experiments, analyzing the results, and publishing the data both in peer-reviewed publications and in international databases. Bioserve Space Technologies will provide the space flight research instruments and handle the flight manifesting and support of the flight investigations. Funding will be obtained from public, private, and philanthropic sources.

Partners and Contributors

In addition to the National Space Grant Foundation, RosettaSpace partners include the Space Grant Education and Enterprise Institute (San Diego, CA) and the Alliance of Commercial Enterprises and Education for Space (ACES) (San Diego, CA). Co-PIs already committed to the RosettaSpace Project include Nobel Laureate Baruch Blumberg, inventor of the most widely used vaccine in the world; Bruce Pittman of the Graduate Engineering School at Santa Clara University and the Alliance of Commercial Enterprises and Education for Space (ACES), who was instrumental in the development of Pioneer Venus, SpaceHab, and the Infrared Astronomical Satellite (IRAS); Dr. Michael Wiskerchen, Director of the California Space Grant Consortium and professor at the University of California (UC), San Diego; Dr. Dan Holley, professor of biosciences at San Jose State University; Dr. Cheryl Nickerson, space biosciences pioneer and professor at Arizona State University; and Dr. Louis Stodieck of the University of Colorado and Bioserve Space Technologies, who will provide in-kind contributions to reduce the cost for student flights. Lynn Harper and Greg Schmidt of the NASA Ames Research Center will provide technical and programmatic support.

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Reference Web Site

http://rosettaspaceproject.googlepages.com/home2

Cost

Costs could be scaled to funds available.

Coastal Water Imager Demonstration and Evaluation

Project Location

On the ISS and the ground (laboratory and field studies)/NOAA Cooperative Remote Sensing Science and Technology (CREST) Center, City College of the City University of New York.

Grade Level for Participation

Grade 12 through undergraduate and graduate levels.

Experimental Description

The team proposes an inexpensive proof-of-concept experiment for a four-channel, high-resolution imaging sensor optimized for coastal water observations and retrievals of bio-optical parameters, including chlorophyll and its fluorescence, as well as the detection of harmful algal blooms. The team further proposes to use the ISS to test and validate its approach with a nadir-pointing imager, using channel selections optimized for retrievals of coastal water properties including chlorophyll concentration, fluorescence, and suspended solids that are based on extensive theoretical analysis and laboratory and field studies by the CREST team and other researchers. The four channels for the proposed imager are centered at 665, 685, 753, and 865 nanometers. The proposed spatial resolution is about 200 meters, and the resultant swath is about 200 kilometers. The first three channels are designed to optimize fluorescence retrieval and elastic water leaving reflectance, which can then be used efficiently to determine chlorophyll concentration and flag algal blooms, while the 665- and 753-nanometer channels can additionally serve for ISS retrievals. Furthermore, the additional combination of the 753- and 865-nanometer channels may be made suitable for general atmospheric correction. This set of bands should improve NIR retrieval algorithms and fluorescence height models and test their applicability for use in future missions to extend satellite observation capabilities to coastal waters. The relatively simple approach the team proposes will permit students to participate in all aspects of the work, including the modeling of ocean color processes and field validation, and to understand and appreciate the importance of critical proof-of-concept experiments.

Technical Background

An important measure of coastal water health and bioactivity is the quantitative measure of chlorophyll and its fluorescence. It is well recognized that while existing satellite missions, including MODIS and MERIS, are effective in retrieving important water parameters, including chlorophyll and its fluorescence in the open ocean, they are ineffective for coastal water applications due to the noncovarying complexity of coastal waters, as well as the fact that their bands are not optimized to the appropriate spectral channels for coastal water observations. However, recent studies indicate that a significant improvement in both the fluorescence and chlorophyll retrieval for many coastal water conditions will be achieved by using a central observation channel aligned closely to the maximum fluorescence peak at 685 nanometers. Previous channel designs avoided this band because of concerns of spectral overlap by oxygen absorption features at 687 nanometers. Nevertheless, in coastal waters, the 685-nanometer channel can be very informative, while errors introduced by the overlap can be tolerated if a suitably accurate model of the atmosphere is used. However, for existing sensors, the NIR-based atmospheric correction in the coastal waters

remains a significant issue because this approach assumes that no water signal is present in these channels (Black Pixel Assumption), and this problem has led to approaches using even longer wavelengths (shortwave infrared, or SWIR). Due to the Station's low orbit, the proposed high-resolution sensor (less than 200 meters) should be able to explore regions both near the coast and off shore at high resolution simultaneously. Since the swath is approximately 200 kilometers and the horizontal aerosol scales are on the order of 10 kilometers, the atmospheric retrieval obtained over offshore "Black Pixels" can be effectively used in the adjacent coastal zone. Finally, since the team does not require observations below 665 nanometers, aerosol retrieval errors are much less than they would be for current sensors.

Student Participation

Student participation and training will be carried out at all levels, from that of high school seniors, many of whom already participate in CREST research projects through existing outreach programs, through undergraduate- and graduate-level research projects. This participation will include part-time and summer internships for high school and junior college students. Undergraduate seniors will be assigned research as their senior design project. Full-time graduate students up to the doctoral level will be assigned research projects, which will form part of their master's or doctoral thesis. The student interaction will consist of (1) a preparatory stage that will encompass satellite principles and operation, satellite data, and image analysis; (2) participation in critical laboratory experiments and in field campaigns; (3) optimization of retrieval algorithms using realistic coastal simulation models and analysis of the performance of existing and proposed spectral bands; (4) comparison with MODIS and MERIS data and retrievals over both open ocean and coastal areas; and (5) feedback from this work for the final instrumentation design. Student participation in the mission will be shared with a wider audience through very comprehensive Web postings and student presentations at national and international conferences of work and results as they develop.

Desired Outcomes

The expected results are twofold.

(1) It is expected that the program will lead, at relatively low cost, to the demonstration and proof of concept of a new imager for coastal waters that can provide improved retrieval of fluorescence and relevant water leaving reflectance features in the NIR. These results can be expected to guide and inform the planning and execution of more comprehensive full-scale missions.

(2) A broad spectrum of students at all levels will participate in a meaningful manner and witness all steps in an important proof-of-concept mission, from conceptual beginnings to satellite implementation and testing. The impact of this participation and the appreciation it fosters for the cycle of interdisciplinary activities involved, along with the fact that this is a real research and development (R&D) project whose results matter to the science community and will help guide future missions, will serve to give those involved a unique perspective on team projects on which many future national remote sensing instrument developments depend, since these developments require well-integrated teams working on multidisciplinary scientific projects with important impacts on humanity's understanding of Earth's environment.

Barriers

(1) Timely completion of the multiband single-chip imager.
(2) The availability of suitable launch schedules.

Strategy

(1) Describe a detailed scientific basis for the proposed imager and invite expert peer reviews and suggestions.
(2) Incorporate best advice and prepare detailed specifications for a four-channel imager optimized for coastal water. Have one of the experienced manufacturers implement it in coordination with ISS requirements.
(3) Integrate imager hardware and data communications systems with the ISS.
(4) Download and analyze information and make it widely available to the scientific community.
(5) Validate results against other satellite data (in open ocean) and against in situ field measurements in coastal waters where possible.
(6) Assess efficacy of imager for a variety of coastal waters.
(7) Make recommendations for future, more comprehensive satellite missions.
(8) Involve students in all aspects of implementation in accordance with their level of comprehension.

Partners and Contribution

The NOAA National Environmental Satellite, Data, and Information Service (NESDIS) will help in scientific review, design, and implementation. A potential industrial partner who will manufacture the imager is to be determined.

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Reference Web Site

http://earth.engr.ccny.cuny.edu/newpage/index.html

Cost

$1.3 million (with cost sharing amongst different parties to be determined).

Water Resources Management Using a Passive Microwave Radiometer (WatRad) on the International Space Station

Project Location
Both in flight and on the ground.

Grade Level for Participation
K–12 teachers, high school and undergraduate students.

Experiment Description
This project aims to develop a new tool (WatRad) for water resources management using passive microwave images taken from a radiometer to be mounted on the International Space Station. This project effectively integrates both research and education within its design, implementation, and operational components. Students will be highly involved in the design and monitoring of the future sensor. Indeed, students who are interested in Earth science studies will be the main beneficiaries from such a project. Students will be more interested and motivated to learn when they are involved with something tangible and exciting. They will also be energized and excited about the prospect of future work at national space agencies such as NASA and NOAA.

The great advantage of passive microwave sensors is their capability to "see" through clouds and their interesting sensitivity to liquid water at or near the soil surface. Furthermore, microwave image acquisition does not depend on daylight. Stored images are accessible to students and scientists.

The NOAA CREST scientific team at the City University of New York will develop the project. The acquisition of such unique images will allow students to observe the dynamics of several phenomena related to hydrology and climate, such as floods, droughts, encroachment on wetlands, and heavy rains. These resources can be easily integrated into the curriculums of several departments, such as civil engineering, geography, and Earth science. Moreover, interesting information about precipitation and wind direction can be retrieved from these data.

It is important to mention that these images can be received at NOAA CREST's new Satellite Receiving Station. The reception of these images will expose hundreds of students, teachers, and faculty to different aspects of space science, including instrumentation design and calibration, image acquisition, data processing and analysis, and result analysis. Image treatment and analysis are two important steps in this science because they allow the translation of the numerical signal sensed by the satellite into a physical parameter (e.g., temperature) and the retrieval of additional products (e.g., soil moisture) through the analysis of the treated image (since the soil temperature is related to its wetness). To achieve these objectives, a receiving module will be developed as a part of the satellite receiving station. Several students of the City College of the City University of New York are currently involved in the implementation of the new receiving station. Furthermore, a Web template will be developed to make the acquired images, as well as derived products, available for the scientific community.

It is worth mentioning that given the lower altitude of the International Space Station (approximately 360 kilometers) compared to that of the current passive microwave satellites (approximately 800 kilometers), there is an interesting potential to improve the spatial resolution and develop new applications of these images.

Student Participation

Students will be involved in this project at different levels. Firstly, they can participate in the data acquisition and treatment as part of NOAA CREST's receiving station activities. After that, they can analyze received microwave images as part of hydrology, Earth science, and geography classes. Special training workshops for high school teachers will also be organized to assist them in incorporating this new spatial product in their science classrooms. More advanced research projects could also be defined for graduate students to develop new applications for the images provided by the proposed sensor.

Desired Outcome or Impact

This project has several interesting outcomes. For one thing, it gives high school summer interns and undergraduate students the opportunity to get involved in highly motivating projects during which they can learn how to bring a new product to the application stage. Additionally, this project will provide scientists and faculty with data and tools to understand the dynamics of several phenomena related to both climate and hydrology.

Barriers

The design details of WatRad will depend on the ISS facilities and the size of the spot allocated to this project. If the team assumes that the spot will be similar to that given to similar missions such as AgCam (under development by North Dakota University), the installation of WatRad is feasible. Additional technical adjustments need to be done to adapt the sensor to the ISS constraints and environment.

Strategy

To be determined.

Partners and Contributors

At this preliminary stage of the project, several institutions and organizations have already indicated their interest in becoming involved in this project: the Jet Propulsion Laboratory (JPL), the NOAA–University of Colorado at Boulder Center for Environmental Technology (CET) and Cooperative Institute for Research in Environmental Science (CIRES), and the Canadian Space Agency (CSA).

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Education Lead
To be determined.

References
NOAA CREST Web Site: *http://www.ccny.cuny.edu/NOAA-CREST*

NOAA CREST is continuing to achieve its goals in state-of-the-art research in remote sensing science and technology in line with NOAA's mission and support goals. CREST thrust areas are now consolidated into three clusters: (1) Remote Sensing Applications to Climate and Air Quality, (2) Marine and Coastal Remote Sensing, and (3) Remote Sensing Applications in Water Resources and Hydrology.

NOAA CREST is also progressing very well toward its goals of recruiting, training, and graduating students in NOAA-related sciences, engineering, and technology, with a special emphasis on including underrepresented minorities in order to provide a diverse future workforce for NOAA. It has established a solid student recruitment procedural infrastructure from high school to college level. A number of K–12 education and outreach initiatives have been developed, such as Students Apprenticeships in Research (STAR), which is a collaborative effort with junior high schools, as well as summer internship and the National Ocean Science Bowl (NOSB), an academic competition for high school students that focuses on ocean-related topics.

A significant number of existing courses have been modified to incorporate NOAA-related sciences into the curriculum. At CUNY, four graduate and four undergraduate courses are offered that relate to and apply NOAA science and data. In spring 2006, the City College of CUNY introduced a new multidisciplinary engineering and science curriculum leading to a bachelor's degree in either field; it has had over 35 applications so far.

Cost
Around $500K.

Student Experiments for the ISS To Support EVA and Closed-Loop Life-Support Technology

Project Location

Purdue University School of Aeronautics and Astronautics.

Grade Level for Participation

Undergraduate.

Experiment Description

Proposed are student-built and -managed experiments created by Purdue students in a long-term project class that functions similarly to existing microsatellite design-build-test classes at Purdue and elsewhere. The proposer's zero-gravity flight experiments class for the RGSFOP, AAE 418, has worked well for 12 years and is a short-timeframe model for what will be done to create these experiments. Between the RGSFOP course and the satellite course, the proposer has an ideal combination of the following:

(1) Experience in teaching students low-gravity experiment design.
(2) Colleagues experienced in multiyear educational efforts in satellite design and fabrication.
(3) Experience in design, fabrication, and delivery of Purdue School of Aeronautics and Astronautics faculty, students, and machine shop personnel.

Two initial zero-g fluids experiments are proposed; both build on previous work by the proposer (Steven Collicott) and his collaborator (Mark Weislogel). At this early time, it is not clear how the collaboration will proceed. Some issues make coordinating the students awkward (such as less than full overlap between the quarters at Portland State University [PSU], OR, and the semesters at Purdue) or beneficial (such as the fact that the shift between quarters and semesters means that the team has a longer "working" year when students from both schools address the problem). Collicott and Weislogel have collaborated for many years on informal topics and through formal contracts, such as for Collicott's design work on Weislogel's Capillary Fluids Experiment (CFE). The technical objectives in the bent-tube experiment are to (1) test predictions of existence, linear stability, and ultimate (energy) stability for a partially wetting liquid in the bent circular tube geometry; (2) acquire video and image data on the gross characteristics of droplet, annulus, and plug size and shape for comparison with numerical models; and (3) explore the dynamics of transitions between topologies for the liquid.

Payload characteristics are planned to be highly similar to those of the six vessels in the successful CFE program. The proposed experiments are self-contained liquid systems of materials already common in simple astronaut interfaces (one valve and two knobs) in which much of the fluid physics occurs sufficiently slowly for 30-frame-per-second video data acquisition to be valuable. The interface with the ISS and crew will involve fastening the apparatus to a tabletop, as in CFE, and placing a video camcorder and a light in useful locations, also as in CFE. Astronaut interaction will be about 2 to 3 hours at a time and will likely include starting the video, opening the main valve, manipulating liquid volume in the multiple test chambers, tapping the experiment (to test stability in the face of small perturbations), replacing videotapes, draining the test cells at the conclusion of

a test, and restowing the equipment. Operational procedures from the Telescience Support Center at Glenn Research Center (GRC) will be ideal for Purdue's location. The long-duration interface experiment is similar but could require days to pass between interactions.

Technical Background

Proposed are two possible original two-phase fluids experiments that depend on the long-duration, high-quality zero-g environment available only on the ISS. Both possible experiments build on the highly successful hardware design and astronaut interaction of the Capillary Fluids Experiment (CFE) currently on the ISS.

One experiment investigates the formation and stability of a number of possible topologies for a wetting liquid droplet in a circular arc of a gas-filled tube, which consists of the same physics as a noncondensable gas bubble in the same geometry filled with a nonwetting liquid. The simplest case, a straight tube with a circular cross-section, has long been susceptible to analytical solutions for much of the possible liquid topologies. William G. Lindsey and Collicott, as reported in *Physics of Fluids,* studied the wall-bound 3-D droplet in 2006. However, the bent-tube geometry is important in two-phase heat-transfer loops and water-air separation systems in space flight. The bent-tube geometry is almost entirely inaccessible by analysis, and thus experimentation is critical to understanding the system and to observing unanticipated phenomena. This experiment is proposed as a student-designed and -built ISS experiment. Detailed geometry, purpose, and other descriptions are available in the American Institute of Aeronautics and Astronautics (AIAA) conference paper AIAA-2007-5517, "Zero-Gravity Stability Solutions of Droplets in a Bent Circular Cylinder," by J.P. Braun and S.H. Collicott (July 2007).

A second experiment, on a less applied topic, is also easily suitable for this format. One portion of the work of Charles Ward, regarding the ultimate equilibrium of a wetting liquid mass in a cylindrical tube, has brought a healthy controversy to the fluid mechanics community. This second experiment builds on the existing discussions or arguments about Ward's work and seeks to fly cylinders with a range of aspect ratios and carefully selected liquid volumes so as to provide a comprehensive test of one of Ward's predictions—that the liquid will minimize energy by splitting into two separate domains, one at each end of the tube. This will be an experiment for which the astronaut will inject the liquid into all cylinders, as is done in CFE. Subsequently, either the astronaut will occasionally photograph the experiment as the days go by, or the project team will have a self-timed digital still camera to acquire an image every hour or so.

Student Participation

The team proposes to create informal technical links between the class (professor and students) and NASA engineers working in EVA and closed-loop life support. For example, a kick-off visit at GRC or JSC is simple for Purdue because of the proximity of GRC and annual trips to JSC for the RGSFOP program. Additionally, the great impact of this program on Purdue's standing and reputation and the ease of building on Purdue's fame as one longstanding hotbed of activities related to or supporting human space flight may free up Purdue funds for such travel. Technical discussions between the proposer and aerospace industry engineers about low-gravity fluid dynamics are common. This program will highlight research and technology advances at Purdue beyond those

specifically targeted by the experiments, thereby increasing further this type of technical sharing between the researcher, NASA, and the aerospace industry.

Desired Outcomes

The bent-tube experiment will verify predictions of existence, linear stability, and ultimate or energy-based stability of a variety of topologies for liquid volumes in the gas-filled bent tube. The new knowledge generated by this testing, and especially that generated by on-orbit observations that are not possible on the ground, will lead to more sound choices in the design of space flight two-phase thermal control systems and water-based life-support systems. Future complex experiments may also build on these experiments with simpler hardware for experience that will lead to the reliably successful design of ancillary fluids systems. The history of zero-g fluids experimentation has a number of failures because this is a uniquely difficult field in which to build up a wealth of practical experimental experience. The knowledge gained by the students benefits the engineering community; NASA engineers and university faculty will have a more valuable collaborative relationship; and journal papers to communicate the advances to the global scientific community should result. At Purdue, the team will eagerly seek to begin work on the next student-run ISS experiment.

Partners and Contributors

Experienced ISS experiment engineering support, perhaps out of NASA Glenn, to assist the team in meeting materials, strength, and similar safety requirements will certainly accelerate the science effort.

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Cost

Costs could be scaled to funds available.

HDMAX™—QuadHD™ Images from the ISS

Texas A&M University (TAMU) proposes to install the HDMAX camera system on the ISS WORF facility for the collection of high-resolution imagery for educational purposes. HDMAX is an 8.3-megapixel, 30-frame-per-second progressive frame scan camera utilizing a high-resolution 3840 x 2160 QuadHD CMOS sensor. The relative sharpness of an HDMAX display is equivalent to that of a commercial IMAX display, even though it is produced by the small HDMAX package. The standard color HDMAX system utilizes a single-sensor Bayer pattern color filter with an IR cut filter. Unique processing allows the camera to achieve an extremely highly perceived resolution.

The proposed system will enable 2- to 3-meter-resolution calibrated motion imagery from low-Earth orbit (LEO) in color, monochrome, or multispectral models (to 1 micron). The HDMAX high-

resolution and frame-rate output data, along with a radiation-hardened design, make it a flexible and long-lived asset to both U.S. students and scientists pursuing research in Earth observation. Texas A&M proposes to utilize engineering undergraduate students from the Space Engineering Institute (SEI) to perform flight hardware integration and testing for this project. This will support the SEI program's demonstrated approach for improving engineering student retention and enhancing training in order to improve student preparation for engineering careers. Currently, SEI has a total of six student teams for the academic year of 2007–08. In addition, Texas A&M proposes to utilize high-resolution images generated with HDMAX to excite K–12 students and their teachers about space exploration and careers in STEM careers.

Project Location

Both in flight and on the ground.

Ground

- Texas A&M proposes to engage SEI students across Texas in the HDMAX payload flight hardware test and integration. SEI student teams are interdisciplinary and include all levels (freshman, sophomore, junior, senior, and graduate students). Texas A&M has extensive experience in engaging students in NASA space payload design and flight programs (StarNav I on STS-107, Khalstar part of the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) project, HDMAX for Express Rack and HDMAX Evolved Operational Camera [HEOCam]), as well as in high-altitude flights (GeoCam and Hyper-GeoCam flights on the High Altitude Student Program [HASP]).
- Texas A&M proposes to invite teachers from the Texas A&M Engineering Experience for Educators (E3) Summer Teacher Program and Teacher Summit 2008 to participate in the development of classroom activities that will utilize the high resolution of the HDMAX camera. Furthermore, it proposes to support selected teachers in pursuing a flight certification with ZERO-G Corp., where they will be given access to one HDMAX camera to record their flight experience. Video from the flight will be used to kick off the activities leading to Exploration Week.

Flight

The flight experiment will include gathering Earth-observation images that will be utilized to evaluate erosion changes on coastal lines and tropical glaciers. In addition, the team proposes to use the camera to collect high-resolution documentation video showing activities of the astronauts aboard the ISS that can support NASA space education and interest goals.

Grade Level for Participation

K–12, undergraduate, and graduate engineering students. K–12 students will participate in Exploration Week and pre–/post–Exploration Week through classroom activities that were developed by the teachers, with participation by both teachers and students. In addition to K–12 students, undergraduate engineering students from the Space Engineering Institute will be involved in the testing and integration of the flight hardware. SEI students are already actively involved in outreach, and the program proposes to engage them in attracting both teachers and students to participate in the Exploration Week and post–Exploration Week collaborations.

Experiment Description

Pre–Exploration Week

- Students will watch a high-resolution video of their teacher's experience on ZERO-G Corp. flights.
- Students will learn the basics on the photogrammetric technique and how they can use their geometry and trigonometry knowledge to extract information from images for a known camera position. They will use sample images to extract information on the geometric characteristics of objects such as coastal lines and/or tropical glaciers.
- Students will be encouraged to work on teams, and the teacher will be able to select the top-performing team for a trip to NASA Johnson Space Center (JSC) during Exploration Week at Mission Control.

Exploration Week

- Teachers and their top-performing team will be invited to JSC for direct communications with the crew during the flight experiment.
- All students will be able to watch the crew demonstrating the use of HDMAX and listen to discussions between the crew and students and teachers at Mission Control.
- Students will receive imagery data from HDMAX and will work on extracting information on subjects like the morphology of coastal lines, the size of tropical glaciers, and the height of the Empire State Building.

Post–Exploration Week

- QuadHD movie: Texas A&M will capture video of astronaut life on the ISS using HDMAX. Such a high-resolution video, along with the Earth images captured from the ISS WORF facility, can be combined to form an HDMAX high-resolution "movie" that could be displayed in commercial theaters using digital camera technologies. Taking a trip to the local cinema for an HDMAX show will be the closing activity of the Exploration Week.
- Photogrammetry Contest: Students will submit their results to a NASA-designated Web site. The winning team(s) will be invited to spend a day at a NASA Center and meet with an astronaut.
- Teachers and K–12 students will be invited to submit proposals that utilize HDMAX for future activities.

Desired Outcome or Impact

The desired outcome of this experiment is to excite students about space exploration and STEM careers. The project team proposes to work with local, state, national, and NASA educational agencies as well as industry (the ZERO-G Corp. teacher certification program) to reach a minimum of 100 teachers/classrooms participating in this experiment during the Exploration Week. This will impact up to 10,000 students.

Barriers

Strict school schedules make it difficult to accommodate activities such as Exploration Week.

Strategy

The team expects to attract teachers from summer programs such as the TAMU E3 Teacher Summer Program to engage them in planning the classroom activities and flight experiment. These teachers will have their classroom material ready and will not need additional preparation time for the Exploration Week. In addition, teachers with flight experience are likely to be much more enthusiastic about space exploration activities than other teachers.

Partners and Contributors

Texas A&M University has experience in teacher programs and flight experiment programs. Partners and contributors include TAMU's Spacecraft Technology Center and Space Engineering Institute, Florida Atlantic University, and an industry partner yet to be determined.

HDMAX Users

HDMAX, with its high resolution and radiation-hardening properties, can become an asset for many U.S. scientists pursuing research on Earth observation or provide imagery data to scientists with experiments on board the ISS. Scientists at Texas A&M University were consulted for the initial science objectives for this project. Furthermore, NASA could use the camera to collect videos for public education and outreach.

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Education Lead

To be determined.

Reference Web Sites

- Space Engineering Institute: *http://sei.tamu.edu*
- Spacecraft Technology Center: *http://stc.tamu.edu*
- TAMU Teacher Programs E3 Teacher Summer Program: *http://essap.tamu.edu/e3/*
- Teacher Summit 2008: *http://www.cehd.tamu.edu/articles/teacher_summit_sponsoring_programs*

Cost

Costs could be scaled to funds available.

Fisk University Student Rocket Team

Project Location

On the ground (Fisk University, Nashville, TN).

Grade Level for Participation
Grades K–12, undergraduate, and graduate.

Experiment Description
The project consists of three parts: a sounding rocket, a robot rover, and educational outreach. These parts address the requirements of the NASA University Student Launch Initiative competition to be held April 19, 2008, at Marshall Space Flight Center. In addition, these parts are included in an ongoing program at the university to meet the objectives of competition and training for the students, outreach to the community, and workforce development for the Nation.
The sounding rocket will be approximately 13 feet in length and 8 inches in diameter and will weigh about 50 pounds when loaded. The entire airframe will be constructed of carbon fiber composite material. Generally, the team will use commercially available solid-fuel motors. The rocket will be recovered in a computer-controlled, staged deployment of a drogue parachute at apogee and of a main parachute at an altitude of 300 feet. The electronic payload will consist of a down-looking color video camera with superimposed alphanumeric data, video transmitter, computer, inertial velocity sensor, barometric altitude sensor, GPS receiver, and telemetry transmitter. An externally mounted thermocouple will measure temperature. A sensor to be determined will measure the vibration of the rocket during flight. The voltage of an onboard fuel cell with be monitored to determine the effects of flight.

Ground-based units will receive the video, audio, and telemetry transmissions and transfer the information in real time to the Internet, where students at the outreach schools may view it. Students will be given instructions to interpret the numeric data during the flight. At the conclusion of the sounding rocket demonstration, students will be challenged to create a conceptual design for a rocket capable of a rendezvous with the Space Station.

Students at Martin Luther King Science High School have been given the internal diameter and length of the robot bay, along with the maximum allowable mass for their robot. The high school students are allowed to determine the mission for their robot.

Groups of university students will visit various K–8 schools, where they will follow a student-written lesson plan that focuses on Tennessee state objectives in science, math, and reading. The K–8 students will participate in various hands-on activities, including the construction and flight of an egg-carrying rocket. Changes in the students' proficiencies in science, math, and reading will be assessed before and following the 5-day program.

Williamson County Schools has requested that Fisk University and Middle Tennessee State University hold teacher workshops to enable the teachers to form rocket clubs at the eight high schools in the county. The faculty advisors and various members of the team will conduct these workshops.

Student Participation
Students have done all planning, execution, and evaluation of the project with oversight from the faculty advisors (Professor Kent Wallace and Dr. Rudy Gostowski), the Senior Advisory Board

(Dr. David Owens, CEO, Griffin Technologies, Nashville, TN, and Dr. Rita Geier, Associate to the Chancellor, University of Tennessee at Knoxville, and Senior Fellow, Howard H. Baker Jr. Center for Public Policy), and the Junior Advisory Board (previous student project managers and deputy project managers).

Desired Outcome or Impact

University students will design, build, fly, and analyze a reusable sounding rocket that will reach an altitude of 1 mile. Also, the students will provide educational experiences in science, math, and reading with measurable outcomes for K–12 students. Finally, students at a science high school will design, build, operate, and analyze a robot rover that will conduct a preplanned mission after riding on the sounding rocket.

Barriers

The most significant barrier is financial support. A lesser barrier is the absence of an aeronautical engineering, aviation technology, or engineering program at Fisk University.

Strategy

Additional cash and in-kind support is being sought from various businesses and organizations. Technical experience deficiencies are being mitigated by assistance from the advisory boards, local businesses (Griffin Technologies and the Arnold Engineering Development Center), and local clubs (such as the Music City Missile Club).

Partners and Contributors

Tennessee Space Grant Consortium, Tennessee Section of the American Institute of Aeronautics and Astronautics, Nashville Section of the American Chemical Society, Griffin Technology, Music City Missile Club, Martin Luther King Science High School (Nashville, TN), Margaret Allen Middle School (Nashville, TN), McKissack Middle School (Nashville, TN), Williamson County Schools (Williamson County, TN), John Coleman Elementary School (Smyrna, TN) and Central Middle School (Murfreesboro, TN).

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Reference Web Site
http://faamt.org

Cost
2006–07, $12K; 2007–08, $20K.

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Learning is like rowing upstream;
not to advance is to drop back.

—Chinese Proverb

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