IAC-02-P.1.07

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SPACE OUTREACH™
HANDS-ON STUDENT SPACE EXPERIMENT OUTREACH PROGRAM
"UNIVERSITY AMONG THE STARS"

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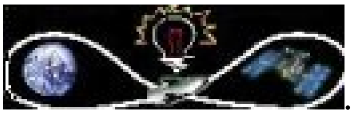
...... "we bring youth into space"......


53rd International Astronautical Congress
The World Space Congress - 2002
10-19 Oct 2002/Houston, Texas - USA

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ABSTRACT

Space Outreach™ is a non-profit space education organization, spun-off from Instrumentation Technology Associates (ITA) Inc., which was incorporated on July 17, 2001 to enable students to participate in real space endeavors. More than 3,000 students and 50 teachers in the United States and internationally have been involved in flying experiments in ITA's payloads on the Space Shuttle. Now, Space Outreach™ has the task of implementing the space education program on a larger scale. Key features will include real-time student involvement in actual space missions as well as on-line tutorials and educational tools. By encouraging young people to "think out of the box", the program will motivate students to learn math, science, and other subjects in a multi-disciplinary, international framework using space research as a tool and help them to develop their own educational methodology with a Space-oriented perspective applied to Earth problems. Seminars will be given at schools and ground control kits will be utilized to facilitate the "hands-on" portion of the space education experience, thereby forging permanent links among school programs, research centers, the scientific world, and the general public.

Space Outreach™ is currently engaged in ***"University Among the Stars"***, which is an international, "hands-on", and interactive space education program that will encompass Grades K1 through 12 as well as university and postgraduate students to encourage young people to consider careers related to space. The program will be focused on microgravity sciences. Phase I (the pilot program) will allow for up to 30 schools to conduct microgravity experiments on Space Shuttle mission STS-107 in 2003. The experiments in Phase II would be flown on the International Space Station (ISS) and include over 50 schools. Finally, the experiments in Phase III would be an expansion of Phase II and include real-time downlinks to the Internet showing the experiment in orbit.

The aim of this paper is to provide details on the ***"University Among the Stars"*** interactive space education program, highlight some of the student experiments being conducted, and summarize some of the obstacles that have been encountered.

INTRODUCTION

Space research is an ideal laboratory for learning that can stimulate an interest in science, technology, and exploration among the youth of the world. Allowing students to perform their own microgravity research experiments in space introduces them to basic scientific principles while at the same time motivating them to learn other subjects. Since space research is new and at the cutting edge, there is much to be discovered. This fact alone can get kids interested because it is new and exciting.

Materials processing and biological experiments in space are ideally suited for hands-on education because the students themselves develop the experimental protocol, prepare the materials and biological organisms for flight, and analyze them after exposure to microgravity. These projects involve many stages: planning, research, procurement, preparation, ground control, post-flight analysis, etc. They also teach students to deal with the practical limitations of science and engineering, especially with respect to the challenging spaceflight environments such as launch/reentry acceleration and vibration, the quality of the microgravity environment (on-orbit perturbations), reliability, safety precautions (especially important for human-tended experiments), and mass/volume/power limitations. By its very nature this type of experimentation requires team effort, cooperation, and a multidisciplinary approach; which parallel the way most projects in science and engineering are conducted in our technological era.

"UNIVERSITY AMONG THE STARS"

"University Among the Stars" is a multi-disciplinary hands-on space education program, providing students at the elementary to university level with the unique opportunity to design and conduct their own experiments in the microgravity environment of space.

The Space Outreach™ program is based on a microgravity student program started by Instrumentation Technology Associates (ITA) Inc., a commercial space company, and utilizes ITA's various payload flight opportunities and hardware. More than 30 schools involving 3,000 students and 50 teachers in the United States and internationally have flown experiments in ITA's payloads on six Space Shuttle missions. The list of past student experiments flown by ITA is shown in Table 1. Space Outreach™ is taking the ten-year track record of ITA's successful hands-on space education program and packaging it to include workshops and seminars, the sharing and downlink of data from space, and the utilization of the latest information technology. Workshops will include the following:

- Briefings on the unique micro-gravity environment and the benefits of space to us on Earth;
- Brainstorming sessions and other assistance to students in designing their experiments;
- Help with setting up ground control systems.

The program has already involved thousands of students and motivated many young people by engaging them in a real-world experience of conducting scientific experiments on the Space Shuttle, the Mir space station, and suborbital rockets. This program has helped motivate thousands of students towards a greater interest in math, the sciences, and technology.

HANDS-ON STUDENT EXPERIMENTS

A wide range of experiments can be performed on a single mission using standardized hardware such as those designed by ITA. Simple experiments for younger students may involve plant and seed studies, simple fluid diffusion, and crystal growth. More advanced studies may include cell biology, film formation, microencapsulation of drugs, etc.

Past Student Experiments

ITA and Space Outreach™ have conducted a very successful 10-year program utilizing private sector resources with elementary school through post-graduate universities.

The following is a list of previous student investigations that were carried out through ITA/Space Outreach.

STS	Experiment Name	School	Partners	Type School
STS-52	Larval Development of Brine Shrimp	Titusville High School, Florida	Spaceport, Florida	High School
STS-52	Coreopsis Seed Germination	Citrus High School, Florida	Spaceport, Florida	High School
STS-52	Columbine Seed Germination	Wakulla Middle School, Florida	Spaceport, Florida	Middle School
STS-52	Coreopsis Seed Germination	Tate High School, Florida	Spaceport, Florida	High School
STS-52	Mustard-Spinach Seed Germination	The Peddie School, NJ	N.A.	Middle School
STS-52	Brassica Rapa (Mustard Seed Variety) Reproduction	J.P. McCaskey High School, PA	N.A.	High School
STS-52	Clotting Fibrinogen with a Snake Venom Enzyme	T.C. Williams HS, VA, Jeb Stuart HS,	National Space Society, National	High School

		VA, Dunbar Senior HS, VA	Institutes of Health	
STS-56	Fish Egg Hatching	Pennsville High School, NJ	ORBIS Scientific	High School
STS-56	Zoology and Botany Experiments	Stewart & Whitcomb Elementaries	Lockheed Martin	Elementary
STS-56	Mushroom Mycelial Growth	Unionville High School, PA	J.B. Swayne Spawn Co.	High School
STS-56	Brassica Rapa Production	J.P. McCaskey HS, PA	N.A.	High School
STS-56	Heart Cells in Culture	The Peddie School, NJ	Worthington Biochemical	High School
STS-56	Human Red Blood Cell Morphology	International Space University	N.A.	University
STS-67	Seeds in Space	Brandywine Wallace Elementary, PA	N.A.	Elementary
STS-67	Brine Shrimp and Seeds in Space	Hazel Green HS, AL	N.A.	High School
STS-67	Seeds in Space	Lockheed?	N.A.	
STS-69	Vegetable Seeds	Hazel Green HS, AL	N.A.	High School
STS-69	Vegetable Seeds	Brandywine Wallace Elementary, PA	N.A.	Elementary
STS-69	Cardiomyocite Degeneration	Tufts Univ./ U. of Kansas	Worthington Biochemical	University
STS-80	Formation of DNA/Biliposome-condensate	International Space University	N.A.	University
STS-80	Electro-Rheological Fluid Particle Dispersion in Microgravity	International Space University	N.A.	University
STS-80	California Poppy Seeds	McGaugh Elem. School Seal Beach, CA	N.A.	Elementary
STS-80	Biosurfactants	Southern HS, Baltimore, MD	Center for Marine Biotech	High School
STS-80	Lead Iodide	Glenbrook HS, IL	NSS	High School
STS-80	Water Bears	Glenbrook HS, IL	National Space Society	High School
STS-80	Killifish Embryos	Glenbrook HS, IL	N.A.	High School
STS-80	Metal Durability	Mount Nittany Middle School, PA	N.A.	Middle School
STS-80	Gas Diffusion	Park Forest Middle School Mount Nittany Middle School, PA	N.A.	Middle School
STS-80	Gelatin and Base Diffusion	Park Forest Middle School, PA	N.A.	Middle School
STS-80	Tin Crystal Production	New River Middle School, FL	Spaceport Florida	Middle School
STS-80	Larval Development of Artemia Salina	Titusville High School, Florida	N.A.	High School
STS-80	Fibrinogen Blood Clot Formation	Manhasset High School, NY	American Diagnostica	High School
STS-95	Cardiac Tissue Response to Microgravity	Graduate Student, Mass	N.A.	University
STS-95	Inorganic Crystal Formation	Milton Academy, Mass.	N.A.	High School
STS-95	Nematode worms	Northeast High School, PA	N.A.	High School
STS-95	Fibrinogen	Guid Manhasset High, NY		High School
STS-95	Radish Seed growth with Gibberlic acid	Vero Beach High School, FL		High School
STS-95	Changes of morphology of Endothelial Cells	Morehouse School of Medicine, GA		University
STS-95	Micro-tubule formation	International Space University	European Space Agency	University
STS-95	Sugar crystallization	University of Sao Paulo, Brazil		University
STS-95	Lipase Formation	FEI University, Brazil		University
STS-95	Ligation of DNA Molecules	Oregon State University & ASGSB		University
STS-95	Muscle Cells	Brown University/ISU/ASGSB		University
STS-95	Diatom Reaction	UAH		University
STS-95	Sweet potato cuttings	Tuskegee University		University
STS-95	Biofilm Testing	SW Texas State University and Travis Middle School		University & Middle School
STS-95	Tomato seeds	Houston area elementary schools	Lockheed Martin	Elementary
STS-95	Emulsion Studies in Micro-g	Portuguese elementary schools	CEP (Compagnia	Elementary

			Espacial Portuguesa	
STS-95	Mouse Osteoblast cell growth	Graduate Student, Israel	ISU	University
STS-95	Planaria Regeneration	UniVap University, Brazil		University
STS-95	Silver crystal growth	College Maxime Alexandre High School, France	ISU	High School
STS-95	Strawberry Seed Germination	Palmetto High School, Manatee County High Schools	Manatee County Chamber of Commerce	High School

Table 1 - List of Student Experiments

SPACEFLIGHT OPPORTUNITIES & EQUIPMENT

Microgravity Opportunities

Numerous opportunities exist for student microgravity experiments including the Space Shuttle (up to 14 days duration), the International Space Station (up to 90 days), sounding rockets (U.S. and Brazil, between 4 and 14 minutes), and parabolic aircraft (approximately 25 seconds per parabola).

The types of vehicles utilized will depend on the nature and duration of the investigations. Some experiments require only several seconds to complete while others may require months. Scheduling availability may also be a factor in the selection of the vehicle type.

Future Experiments: STS-107

The next Space Shuttle Mission with student hands-on space experiments will be onboard Space Shuttle mission STS-107 scheduled for 2003. The payload is a Middeck Locker located inside the Shuttle Middeck and operated by the astronauts. The Commercial Instrumentation Technology Associates, Inc. (ITA) Biomedical Experiments payload (CIBX-2) Fig. 1, encompasses more than 20 separate experiments including cancer research, commercial experiments, and student hands-on experiments from 10 schools. Some of the student investigations onboard STS-107 include:

- Biofilm Formation, Southwest Texas State University,
- “FinS”, Fish in Space early development experiments, Chestermere Lake Middle School, Canada,
- Effect of Zero-G on Bacteria and Crystal Growth Experiments, Milton Academy,
- EdVenture Lab Challenger Center Crystal Growth Experiments, The Challenger Center,
- Elementary Student Crystal Growth Experiments, Lockheed Martin et al.

Fig. 1 - CIBX Payload

Microgravity equipment

DMDA

The Dual Materials Dispersion Apparatus (DMDA) is a self-contained laboratory unit that can mix fluid samples at predetermined times in microgravity. The DMDA has flown on over half a dozen Shuttle missions and several sounding rockets. During launch [left], the two fluids are separated. The DMDA aligns them [center] in microgravity, allowing the fluids to mix [right], Fig. 2. In space, the flight crew activates the DMDA and the blocks are repositioned to align the wells with each other. The contents of the wells vary with the type of experiment. For example, a pair of wells may contain a protein solution and a chemical to start crystallization. A trio of wells may have biological cells that are moved to first expose them to a growth factor, followed by exposure to a fixative. The DMDA wells may be outfitted with small proprietary devices to enhance the experiment. The DMDA can accommodate microgravity experiments in several fields including cell biology, thin film membrane casting, macromolecular and inorganic crystal growth, seed germination, collagen research, fluid sciences and diffusion experiments, and the microencapsulation of drugs.

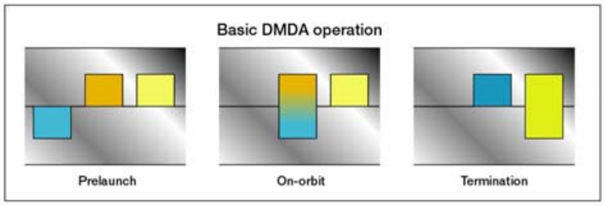


Fig. 2 - DMDA Block operation

This approach allows the diffusion of one material into another, so that crystallization or other processes may proceed without the convection that would occur on Earth. Upon deactivation, the blocks are moved to isolate the opposing wells from each other or (alternatively) to expose the wells to chemicals such as fixing or preserving agents. The design permits the execution of a large number of specimens with slight variations in experimental conditions so the optimum experiment design can be determined. This allows for low-cost access to space for student experiments. Following activation by the flight crew, the DMDA operates autonomously using electric motors that drive the DMDA blocks to precise stop points. The DMDA has flown numerous times aboard sub-orbital rockets, the Space Shuttle, and other spacecraft since 1989.

<u>LMA</u>

The Liquids Mixing Apparatus (LMA) developed by ITA, Fig. 3, is a manually operated system that, holds larger fluid volumes than the DMDA and is used to mix two or three liquids or biomaterials in microgravity at predetermined times. Each vial contains up to 5 milliliters of experiment materials in two or three separate chambers.

Fig. 3 - LMA's for student experiments

These materials can be mixed in various volumetric proportions and at different rates. An LMA vial consists of a transparent syringe containing pistons and valves. The fluids (which may include solids in suspension) are in two or three compartments, depending on the requirements of the experiment. Typically, four vials are in a lightweight tray inside a containment bag. Several trays are carried in a temperature-controlled middeck locker. Upon activation, the astronaut pushes the plunger, as shown in Fig. 4, in a vial to move the liquid from one chamber into another.

If 3-fluid vials are used, this procedure is repeated at a later point in the timeline to mix the third fluid (typically a fixative) into those vials.

All of the experiments listed in Table 1 were performed either in the DMDA or the LMA.

Fig. 4 - Astronaut William Gregory activating LMA vials onboard STS-67

<u>MISSION: DISCOVERY COLLABORATION WITH SPACE DAY FOUNDATION</u>

Mission: Discovery is a new joint collaboration between the newly established Space Day Foundation, ITA, and Space Outreach™ to field test and implement the multi-phase multi-year student microgravity program and give students the opportunity to participate in authentic scientific research in space. These inquiry-based projects will be mentored by scientists, educators and engineers who are experts in the field. Students develop the hypotheses, methodology and experimental materials, then analyze the results, comparing them with ground control experiments. In the process, their teachers learn new instructional strategies and skills aligned with the National Science Education Standards.

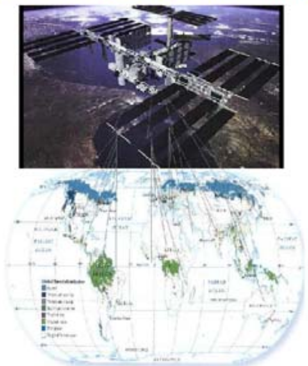
The Space Day Foundation will provide a platform from which diverse organizations can launch new space-related initiatives that promote math, science and technology education. The Foundation is guided by a distinguished Council of Advisors composed of leaders in the fields of aerospace, education, science, business and government.

The new partnership will field test and implement a train-the-trainer model in which the microgravity phenomena, hardware and ground control capabilities are explained and that knowledge is transferred for Mission: Discovery facilitating broad student involvement across North America.

INTERNATIONAL ASPECTS

Key features of the ***"University Among the Stars"*** program will include worldwide real-time student involvement in actual space missions as well as on-line tutorials and educational tools. The importance of linking students from different countries via the Internet for joint space education activities is to bring together the youth of different cultures and nationalities for a cooperative educational endeavor "with no borders". In order to achieve this, a system to provide video downlinks of data from the space experiments to a ground facility is currently under study. This will start as a pilot program onboard the ISS. Schools will access the data via the Internet. On-line forums and databases will be used to share data among the students and teachers. Any school in any country with Internet access could participate in the program.

Student Hands-on Microgravity Experiments are Downlinked to Multiple Schools around the World Students Work together - "No Borders"



EUROPEAN OPERATIONS

Space Outreach™ has started operations in Europe. A European office, located in Italy, is working to establish and promote hands-on space activities among Italian and other European schools. Space Outreach™ aims to provide students with the opportunity to work together with the young people of other cultures, and to create new curricula for learning "about and through space", which may lead to new future job and career opportunities for these students. At present, contacts have been established with Italian local and central governmental Institutions - such as the Ministry of Public Education and in particular with Salerno's Education Council - to obtain funding and activate a Space course in most of the area schools.

Moreover we are planning - in a joint venture with ARTS s.r.l. - a Ground and Communications Segment Simulator, which will consist of mock-ups on the ground for educational purposes. It will be possible to control facilities and to execute experiments in mock-ups from the ground utilizing a user-friendly interface. The same operations can also be done from the Internet, giving high visibility to the world youth community in preparing future generations for careers in space and other scientific fields.

CHALLENGES

While the flight of student experiments in space by ITA and other organizations has been largely successful to date, the endeavor has not been without challenges. As Space Outreach™ expands ITA's heritage program into the ***"University Among the Stars"*** initiative, it can be expected that student researchers will continue to encounter many of the same challenges faced by their professional colleagues, most notably in the areas of routine access to space and the funding of experiments.

Regular and reliable access to low-Earth orbit is crucial not only for microgravity science but to all space activities in general. In the United States, one of the greatest challenges that has been encountered are Space Shuttle mission delays, as well as the long lead times needed to integrate payloads aboard the Shuttle. The lengthy lead-time is expected to be a significant challenge for future ISS-based payloads, where the technical and programmatic documentation requirements are extensive, and these products are expected very early in the mission process.

Changes in the Space Shuttle launch manifest have also been a challenge. An example of direct relevance is the STS-107 mission of the Space Shuttle *Columbia*, in which student experiments from ten schools will be flown aboard ITA's CIBX-2 payload. This mission has been repeatedly postponed over a period of four years as a result of technical issues with the Shuttle fleet (most recently involving cracks in the propulsion system), payload manifesting (whether the Triana satellite would also be aboard), and programmatic priority given to ISS assembly flights. STS-107 is currently scheduled for launch in the first quarter of 2003. However, if NASA revises the ISS crew rotation period to six months and reduces the Space Shuttle flight rate accordingly, as was recommended by last year's report of the ISS Management and Cost Evaluation (IMCE) Task Force, finding flight opportunities for student microgravity experiments will be an even greater challenge.

Such delays have unique consequences for student-led microgravity experiments. Students and teachers need a reliable and predictable system because they are on tight schedules and need to have a good amount of preparation time. Even if the Shuttle were to launch approximately at the scheduled time, there is always the risk of launch slips, which drag out the process. This makes it difficult to complete student experiments within the constrained academic timeframes dictated by terms and semesters. A student could be preparing their experiment over the course of an academic year or longer, and if the Shuttle mission slips they may not be in school anymore to see their work accomplished. This can be extremely frustrating for young researchers, and in the worst-case may sap some of the enthusiasm and motivation for science and technology that the space experiment was supposed to foster in the first place.

In addition, the student or academic institution may want to repeat an experiment. The basis of all science is the repetition of experiments with slight variations in the experimental parameters. But if the gap between flight opportunities is in the period of years, it is no longer practical to re-fly the experiment and obtain the supplementary data. The lack of timely regular access to space prohibits this and is counter productive when teaching science fundamentals. This is not conducive to student outreach and space education.

Probably the most significant element in student space experiments is the present lack of access to space on a timely and regular basis. This is crucial because while student experiments have been conducted in the past by ITA and Space Outreach on a gratis basis on a fairly regular basis, many formal programs to fly on the Shuttle were very expensive to the taxpayers and sometimes took years to implement. We believe that the private sector with government funding can formally implement a program to encourage the young minds of the nation to consider a career in space activities. Clearly, we need to be more responsive to the needs of the students, the educators, and the taxpayers.

The second major challenge faced by student space researchers is also one that is well known to their professional colleagues. There is simply not enough funding. It is clear that private sector resources are very scarce particularly as the U.S. economy slows. However, this is an important investment in the future. Corporate sponsorship is lean and difficult to get, In the event of a launch slip, money is still required for documentation, payload maintenance/storage, and additional training sessions for the crew. In the case of government payloads, contractors on cost-plus contracts actually receive more money if there is a launch slip. Commercial entities do not have this advantage. This may require student investigators and their backers to go back to their academic institutions and other sponsors to ask for more money, but given the size and resources of these types of organizations, this is often not feasible.

Despite these problem areas it is clear that the private sector approach has flown significantly more student space experiments on the Shuttle than any other program. We are hopeful of bringing together both the private sector and government agencies to jointly fund an expansion of an existing program which should be modeled based upon its success.

CONCLUDING REMARKS

There is a great need for improved education and new ways to motivate young people. The microgravity environment of space is an ideal tool for furthering both of these objectives. This unique environment allows both student and professional researchers to conduct experiments impossible to perform on Earth, such as developing new materials, products, and pharmaceuticals. By becoming involved in scientific experiments in space, students will be exposed to an extremely powerful educational experience that can serve as a positive motivator for the remainder of their academic and professional lives. The Space Outreach™ program is now in place and is ready to expand on greater levels, particularly in the field of international cooperation. The latter is especially important to impress upon young people the need to feel a part of a much larger global community, and take part in real-world activities.

ACKNOWLEDEGMENT

The author and co-authors wish to address a warm and affectionate appreciation to Mr. John M. Cassanto – President of ITA, Inc. - for having made Space Outreach possible through his pioneering efforts in "hands-on" space education.

The author wishes to extend his gratitude to all of his co-authors for their enthusiasm, zeal and professional effort in jointly writing this paper. A special thanks goes to Eric Choi for reviewing our publication.

Thank you to the illustrious Mr. Pasquale. Stanzione - "Provincia di Salerno" Education Council – who has a profound intellectual sensitivity, passion for school improvement and student needs. His interest in Space Outreach™ activities, engagement to support my participation in WSC 2002 and desire to jointly organize education programs, makes all of us able to continue our mission in the field of Space Education.

Moreover, I want to thank Dr. R. Russo, mentor and forward-thinking person - Parco Scientifico & Tecnologico di Salerno Managing Director – for inviting me to collaborate and manage youngsters and general public educational programs, and jointly perform scientific research, and to teach in the Master degree courses.

A special thanks goes to my Editor-in-chief, Dr. C. Guariglia, my colleague Dr. R. Paolillo, and all WAZU Magazine editorial staff for providing the opportunity to be their special correspondent at the most important appointment with Space, WSC 2002.

My sincere gratitude to Dr. M. De Chiara, Mr. V. Francese and Mr.G. Zinicola for having helped me make important contacts.

My esteem for Ing. F. M. Sacerdoti (ARTS s.r.l.), Dr. P. E. Battaglia (ASI) and Dr. D. Tambasco to have granted me their time to discuss new strategies and opportunities.

I appreciate Dr. C. Mirra (IntoSpace) and Dr. Ph. Willekens (ESA) for having appointed me Chairman of the IAF P.5/T.5 session jointly with Dr. Teresa A. J. Williams (NASA).

My gratitude goes to Prof. M. Marinaro and Prof. A. Vitolo (University of Salerno) and Prof. B. Sadovnikov (University of Moscow) for their concern in our matter.
A very big *"Thank You!"* is addressed to our friend Mr. George W. S. Abbey, Jr. for his invaluable, fun and delightful hospitality in his pleasant 1970's *"castle"* in Seabrook.
Finally, I want to kiss my family and beloved persons, in particular my nephew Mario and niece Myriam, and apologize with all persons that eventually I am involuntarily forgetting.

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