A Sky High Education

by Emily Sopensky

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Abstract
Getting an engineering education doesn't have to be restricted a desk or terra firma. University students and even some high school students can participate in the NASA Reduced Gravity Student Program and conduct experiments in zero gravity aboard the infamous Vomit Comet, a Boeing KC-135A plane, which was designed as a mid-air fueling tanker and was the unseen star in the movie *Apollo 13* that gave onscreen star Tom Hanks his weightlessness during his great performance.

Source: NASA [March 24, 1999. 99e02971]
The payoff. U of Michigan aerospace engineering student Dan Herman gives the thumbs up while floating in space.

Introduction
NASA's Reduced Gravity Student Opportunities Program is a unique educational opportunity that links schools around the U.S. with NASA. Conceived by and administered by the Texas Space Grant Consortium (TSGC), the NASA program offers students the chance to design, then conduct an experiment aboard a Boeing KC-135A that simulates zero gravity by flying parabolas. Begun in 1997 on a trial basis, 48 university teams from 39 schools flew in the spring of 1998 as well as three high school teams. In 1999, the program expanded to 77 university teams from about 55 schools that flew in March or August 1999. Open to any U.S. university student and even to some high school students, over 400 students and journalists have flown under the program to date.

The aim of the program is to provide a sound and exciting educational opportunity for students with initiative and ability. While the initial lure is for students to experience the fun of weightlessness, the program is chock-full of one-of-kind opportunities to learn. For example, while at NASA for the two weeks that it takes to ready their experiments for flight and then to make the flights, students can meet astronauts and go to lectures given by them and senior NASA scientists. They are exposed to the ingenuity of their peers from other universities and they are guided in logistics and intern opportunities by NASA JSC co-ops.

Source: NASA [March 25 99e03124 or 99e03125]
Fig. 1 Ellington Airfield, Clear Lake, TX. University of Michigan team members are junior Erica Pendergrass (team lead), Jack McNamara, Dan Herman, Travis Patrick, Michael Lee, and the author. We are smiling because we just flew the infamous Vomit Comet in the name of science. By the time we get to the closest eatery outside the airfield's perimeters, we will be starved and ready to chow down.

[picture]
Source: Emily Sopensky
Fig. 2
A student lies on grass postflight until color slowly returns; no one bothers him.

After the flight, Pendergrass explains what worked and what did not on today's flight. She is also the only one in her team today who was absolutely unaffected by the drastic transitions from 2 Gs to 0G every three to four minutes onboard the plane. Patrick lies stretched on the grass where he remains for the next hour until color slowly seeps back to his face and his stomach learns that there are no more parabolas to churn up peace and equanimity. It is a pleasant spring day to be outside, so no one bothers him. Others, including the author, are quick to regain equilibrium and are already buying exclusive "Vomit Comet" T-shirts to commemorate the occasion.

The program has been so successful in attracting and educating students that the head of Johnson Space Center, George Abbey, has a penchant for doubling the capacity of the program each year—an action that

is considered a mixed blessing by the enthusiastic, hard-working, and dedicated staff of both NASA and the TSGC.

NASA's Reduced Gravity Student Opportunities Program

We, along with 44 other teams, participated the 1999 spring break in a three-year-old NASA program for conducting experiments in zero gravity. Zero G is created while the plane makes steep climbs, then drops nose down in a "nose-over" maneuver. The sequence is repeated 40 to 50 times in two to three hours. This routine, called "flying parabolas," has been used since 1959 to help train astronauts in weightlessness. Companies and other government agencies regularly schedule experiments to fly in the induced zero gravity environment.

Source: NASA [March 25, 1999. 99e03092].
Fig. 3. After Pendergrass steps up the decibel in the experiment's acoustic chamber, she and I float over to the video monitor to see if the liquid is being dispersed according to plans.

Real-world learning opportunities abound
But before they ever get to the Johnson Space Center, students have ample opportunity with this program to gain real-life experience and to practice what they learn. Here are just a few examples:

- **Team dynamics.** Forming a team that stays together to design, build, and run an experiment is extra duty for most students. Some schools and faculty give course credit under independent study. Or, like the U of M students who used a lab course to design their first prototype for their experiment, some students structure aspects of their experiment into existing electives. Then again, giddy with the prospects of flying weightless, some squeeze this in as an extracurricular activity.

  Teams can have a flight crew of up to four undergraduate students and one professional journalist. Any two of a flight crew's four students can go on each of two flights, enabling each student flyer and journalist at least one flight a piece. A ground crew can also assist teams.

- **Funding**. Since the program is not funded, students must find their own sources. Discovering potential pockets, like one of the state space grant consortia, the dean's discretionary fund, or even hitching onto

a professor's research funds, are all part of the exercise of learning about the real world. Developing a budget, meeting with school administrators, negotiating with key vendors for equipment loans or sponsorships are just a few of the funding exercises students will encounter.

- **Logistics.** Designing an experiment is always engaging. But actually building one is another matter. Developing design specifications even for the most skilled design engineer can often be a trial-and-error process. In this program, students often learn quickly the value of a good technician. Then, there are the seemingly simple logistics of getting a half-ton experiment and four to six team members to Houston. This is not so simple for undergraduates who are often under 25, the age that most car rental agencies still consider the minimum for renting cars or vans.
- **Meeting the requirements.** Experiments must possess meaningful technical and scientific merit. Teams must also get official endorsement from their respective educational institution as well as FAA physical exams. Those who make it to Houston and intend to fly must still complete a full day of physiological training before being certified to fly.
- **Staying the course.** Finding an appropriate experiment for 0G is just the beginning. Assembling a team, choosing a leader, finding a faculty advisor, writing and filing a proposal are activities that signify the beginning of a process that requires dedication and commitment. Getting physicals, arranging transportation and lodging, organizing class schedules to avoid missing exams are a few more activities not found in the college catalog. Building, testing, refining the experiment, and planning for contingencies also take time and careful deliberation that sometimes weed out the less serious student. "Staying the course" is also about sustaining the enthusiasm and interest of all team members.
- **Working with the media.** Journalists from all types of media converge on the Ellington Field for this program. Reporters from CBS's Good Morning America to National Public Radio's All Things Considered to magazines like this one see the absolute spontaneity that blesses this program and the students that partake of it. The shear exuberance is palpable in both students and journalists. As part of the program, NASA provides high resolution photos available to all media and students for downloading to websites, student newspapers as well as mainstream outlets. Some journalists take advantage of another NASA benefit: The agency will set up live feeds to any radio or TV station that wants to talk to the students after their flights. Students learn first-hand how to be interviewed "live" with no retakes. NASA and the Consortium recognize that an experiment is never done until the results are communicated to others.

A sampling of experiments

By the time the experiments get to the proposal stage, most students have figured out how to make the titles sound boring and testy. However, most deserve more investigation. To give you an idea of the range of project topics, here are a few from 1998's class of flying teams:

- University of Colorado studied performance testing of rachetless hand tools.
- Georgia Institute of Technology proposed acoustic shaping in microgravity: Phase 2 (they did Phase 1 in 1997).
- University of Alabama used video to capture data on a droplet of fuel ignited in an electric field.

During the March 1999 flights, when the U of M flew the team was invesitaging an LDR emitter. The **Liquid Droplet Radiator (LDR) Pointing Experiment** tested the design of a *convergent liquid radiator emitter* that could be used to cool spacecraft. Theoretically, the potential for cooling spacecraft surfaces is ten times more efficient than conventional radiators at dissipating thermal energy by emitting streams of liquid droplets in a converging pattern over the heated surface. The convergence can only be tested in a microgravity environment because Earth's gravity affects their trajectory of the droplets.

Here are two samples of experiments that flew in August 1999

- **The Benefits of Tissue Sealant for the Closure of Open Surface Wounds in Microgravity** (Brown University). Difficulties of performing surgery in microgravity have demonstrated that much research remains before we can confidently carry out even minor surgical procedures in space. Conventional suturing of open surface wounds may not be appropriate in microgravity. Such procedures in a

microgravity environment may be prone to an increased risk of infection. Sutures that have been made in microgravity have revealed that surgeons have a tendency to "past point" and sutures tend to be not as well made. Tissue sealants have been tested clinically and have proven to be just as effective as suturing in closing open surface wounds. The cosmetic outcomes are indistinguishable from wounds closed with sutures. Given the many advantages of tissue sealants such as 2-OCA, we are proposing that 2-OCA may be an effective alternative to suturing for closing these wounds in microgravity. The microgravity conditions available aboard the KC-135 are an ideal opportunity to test the viability and effectiveness of 2-OCA in closing open surface wounds in microgravity.

- **Investigation of the Effects of Microgravity on the Manufacture of Foamed Metals** (Purdue University). This experiment aims to show that foamed metals processed in microgravity are free from naturally occurring defects associated with buoyancy effects. Reducing the weight of metallic components, while maintaining stiffness and strength, is always an important design objective. From the trunk of an oak tree to the pods of a honeycomb to the bones in the human body, studies show that a matrix of individual cells can significantly decrease material weight while preserving strength. The porous structure of foamed materials (including glass and polymers) makes them ideal candidates for a variety of applications. Foamed ceramics are used in the manufacturing of semiconductor materials. Metal foams are used as baffles and flow straighteners in wind tunnels, as well as thermal insulators in certain applications. Foamed metals are also suitable for use as shock absorbers.

Conclusions

What is so appealing about the Reduced Gravity Student Opportunities Program to students of all ages is the absolute opportunities it offers. Whether it's learning pure science, research and design techniques, or even the dynamics of working in teams, the program offers exceptional opportunities no matter what educational discipline the student is pursing. It's one thing to plan and execute an experiment alone in a lab or classroom for credit. It's another to take the experiment further, learn for learning's sake as well as involve others in the quest for a mutual goal. Teaching students how to think for themselves is often the toughest task a teacher has. Usually this task is minimized when the incentive is appealing. Flying the Vomit Comet is just such an incentive. Some students and their schools have been so inspired that their projects have gone on to riding the space shuttle as payload.

Extolling the virtues of the program is easy because all participants—the students, their advisors, the schools, NASA, and the Consortium—reap the benefits of a giant, exhilarating, and inspiring learning experience. The program offers a whole new world of education waiting for students with initiative to tap.

General Information

For general information about NASA and the Reduced Gravity Student Opportunities Program, try these websites.

- www.tsgc.utexas.edu/floatn. This is Texas Space Grant Consortium's website, which includes proposal specifics including deadlines. TSGC is a group of 34 institutions that includes universities, industrial organizations, non-profits, and government agencies within Texas that together ensure that the benefits of space research and technology are available to all Texans. It is one of 52 space grant consortia participating in the National Space Grant Program. Modeled on the Land Grant and Sea Grant programs, the National Space Grant Program was begun in the 1980s to provide outreach and a means of linking academia, government and the public sector.
- www.nasa.gov. This website gives you everything about what NASA's doing from QuickScat, the scatterometer launched in June 1999 that provides daily snapshots of winds swirling above the world's oceans to Benjamin Franklin's climate studies. You can even send your name to Mars on the Mars 2001 Lander!
- http://www.csr.utexas.edu/cgi-bin/htsearch. NASA Means Business. The latest educational opportunity coming from TSGC looks for business plans that take multi-disciplinary approach to developing experiments. Involving MBAs and EEs from various disciplines, this is a national competition that last

year solicited a business plan for Mars exploration, only six proposals made the grade this year. Stanford's for example did NOT make it. The reward is $1,000, a trip to a conference with NASA bureaucrat.

- www.space.com/business/people/nasa_comp.html. For up-do-date reporting on all space programs, including this year's details about some of the 1999 student projects, go to <www.space.com>. See for example, its coverage of NASA Means business. < >
- www.tsgc.utexas.edu/flyhigh. In April 1999, 20 teams of Texas high school students flew in the Texas Fly High/Class of '99. Read about it at this website.
- http://www.ksc.nasa.gov/shuttle/missions/sts-88/images/images.html It is 3:35:34 a.m. EST December 4 1998 when Mission STS-88 launches from Pad 39A at Kennedy Space Center, Florida. The Space Shuttle Endeavour lights up the night sky as it lifts off. The shuttle's payload includes a U of M undergraduate experiment called VORTEX. The students' VORTEX experiment evolved from taking advantage of another opportunity. See especially STS-88 Endeavor launching from Pad 39-A.

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