

that we could have responsibly supported than any budget could have underwritten," says Blandford. "Plenty of things that were proposed that do not appear were very exciting. In a sense, this was the biggest challenge. From the start we knew we were in a highly cost-constrained environment."

All told, five science panels, four program prioritization panels, six infrastructure study groups, scores of town meetings, and more than 700 panel and community submissions contributed to the decadal survey over the two-year process. "This was a Herculean effort to plan for everyone for an entire decade in a field that is moving rapidly," says Rocky Kolb, a theoretical cosmologist at the University of Chicago who did not take part in the survey.

"Sensible and defensible"

Not surprisingly, despite wide endorsement of the survey, everyone can quibble with something in the recommendations. For Shri Kulkarni, director of Caltech's Optical Observatories, the biggest disappointment is that the ex-solar planet program "is inadequate in scope. The report gives lip service, but the allocation of resources is not effective." He notes that in the past "we went too much for big things, and this is costing us now."

Other people complain that good words are not enough: The survey should have recommended funding for the Square Kilometre Array, an international radio telescope.

But perhaps the most chatter is about the large optical telescopes. For starters, people from both US-led GSMT projects are quick to note that the LSST outranked them because of technical readiness, not superior science. From what he hears in the hallways, Harvard University's Christopher Stubbs says, "The people who work in large telescopes are truly stunned."

Another twist is the survey's recommendation that NSF "immediately" throw its lot in with one of the GSMTs—a recommendation that is variously welcomed and questioned. The project scientist for the TMT, Jerry Nelson of the University of California, Santa Cruz, says, "We think having this shoot-out is important and should be done immediately. We would like to complete our partnership." Some of the project's international partners "will feel more comfortable" if the TMT includes the US government, he adds. "It's the principle, not the money." Both GSMT collaborations have significant financial commitments from international and private partners and say that NSF par-

ticipation will not make or break them. "I don't think it needs to shake up either telescope," says Wendy Freedman, who as director of the Carnegie Observatories is spearheading the effort to build the GMT. "I think each will go ahead, and should go ahead." Others question the need for a hasty decision on NSF's part, given that it won't have money for

such a project for years.

The biggest disappointment, of course, is that money is tight. Says Freedman, "The committee had to make hard choices, and I think they made sensible and defensible choices. It's an excellent report and will stand us in good stead."

Toni Feder

Suborbital research hitches a ride on commercial space cruisers

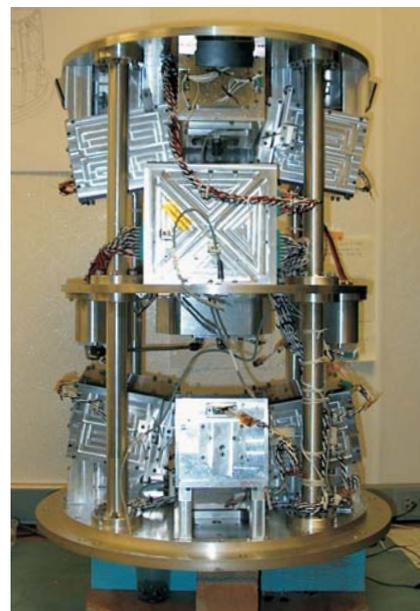
NASA hires industry to transport scientific payloads bound for microgravity environments.

Even with its budget in limbo, last month NASA awarded \$475,000 to two commercial rocket makers through its Commercial Reusable Suborbital Research (CRuSR) Program, which pays to fly scientific experiments to the edge of space and back. The grant will allow Texas-based Armadillo Aerospace and California-based Masten Space Systems, who will split the award, to launch test flights in the coming months that will haul position- and velocity-monitoring antennas and environmental sensors supplied by the Federal Aviation Administration and NASA.

The promise of frequent, relatively inexpensive flights to suborbital space has attracted a growing number of researchers who are poised to send, or even accompany, experiments on multi-use commercial spaceships. The fledgling commercial space sector is now testing manned and unmanned rockets that could cruise for three or more minutes in a steady-state, low-vibration microgravity environment at altitudes around 100 km. Commercial space vehicles can take an experiment to space and bring it back at far less cost than conventional unmanned, single-use NASA rockets or a trip to the International Space Station, if one can even be arranged.

Science in the "ignorosphere"

Last month's award has energized the growing hybrid community of microgravity scientists and commercial space-vehicle developers, which eight months before had held the inaugural Next-Generation Suborbital Researchers Conference in Boulder, Colorado. That conference sprang from a workshop convened by NASA at the December 2008 American Geophysical Union meeting; workshop attendees discussed an array of environmental data that could be collected and experiments that could be conducted in the meso-



JOSHUA COLWELL

The Collisions Into Dust Experiment, which studies gentle collisions (slower than 1 m/s) between small particles in a microgravity environment, is being modified from its space shuttle configuration to one that allows it to fly on a commercial suborbital rocket.

sphere, which is 50–100 km above Earth.

That region gets called the ignorosphere "because we've ignored it for so long in terms of atmospheric observations," says Bretton Alexander, president of the Commercial Spaceflight Federation, which coordinated the conference in February. Besides climatology, Alexander says, a scientist in a manned suborbital vehicle "can look up at stars and do astronomy. You can look down at the Earth with hyperspectral sensors. You can test out orbital space technology in a very inexpensive way."

"With three minutes, you can study transient behavior of entire systems and not just components," says Purdue University aeronautics researcher Steven

Aerospace engineering students from Purdue University get to see their experiment—to study the effects of a reduced-gravity environment on liquids of different masses—take flight on a suborbital rocket, behind on the left, at Armadillo Aerospace’s facility in Rockwall, Texas. From left to right are Russell Hammer, Jeremy Voigt, Jeremy Smith, and Jake Bills.



Collicott, whose experiment on critical surface wetting in microgravity was one of three selected for a free trip on an upcoming suborbital test flight by Blue Origin, an aerospace company in Kent, Washington. Another project chosen was an experiment by Louisiana State University chemist John Pojman on fluid mixing induced by interfacial tension. In the third, University of Central Florida astrophysicist Joshua Colwell will use dust-particle collisions to study accretion efficiency in the early stages of the solar system’s formation. Colwell says more frequent access to space will benefit scientists and educators in general: “The broader scientific community and educators need to know that there will be relatively inexpensive launches to high altitudes in a year or two.”

Seed-corn investments

The CRuSR program is seeking \$15 million annually through 2015 as part of a \$572 million request in the Obama administration’s fiscal year 2011 NASA budget for the establishment of an Office of the Chief Technologist. Charged with managing space technology programs, the office will provide awards to inventors for ideas ranging from pie-in-the-sky to flight-ready technologies, such as the commercial suborbital rockets. Programs include NASA’s Centennial Challenges, which are open to the citizen-inventor; new academic research grants and fellowships in space technology; and NASA’s Small Business Innovation Research program.

Over the past decade NASA’s pace of discovery has slowed, says Robert Braun, the space agency’s chief technol-

ogist. “NASA has not made the seed-corn investments in research and technology required to take grand steps in exploration, aeronautics, and science missions. By investing a small portion of NASA’s budget, we will enable much grander missions in the future.”

Braun says he’s optimistic that the space technology programs will be funded in an otherwise controversial budget, which includes the president’s plan to cancel or scale back the over-budget and tardy Constellation Program to build the space shuttle’s replacement. Constellation’s grounding could lead to a loss of jobs and would delay human exploration of the Moon or Mars. At press time, Congress was in the process of reconciling different versions of the NASA authorization bill passed by the House of Representatives and the Senate, both of which proposed funding CRuSR at its requested level.

Although the space technology programs have enjoyed a relatively warm reception from members of Congress, the Commercial Spaceflight Federation and NASA aren’t taking any chances. They have rallied support from notable members of the space community, who together with 14 Nobel laureates—10 of them physicists—wrote a letter in August to members of the House praising the president’s plan to “revitalize NASA’s investments in technology, commercial spaceflight, student research, and robotic exploration precursors.”

The CRuSR funding is a relative drop in the bucket, but that small investment is being held up as one example of how commercial space vehicles

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can serve national science interests and not just taxi wealthy tourists into space and back. A trip to suborbital space will cost a 100-kg tourist or science experiment between \$100 000 and \$200 000, says Armadillo Aerospace vice president Neil Milburn. "Our gut feeling tells us that the scientific-payload market is probably as large as, if not larger than, the market for space tourists."

Training the scientist-astronaut

Although CRuSR has no plans to fund human flight, suborbital training classes are gaining in popularity. The National Aerospace Training and Research (NASTAR) Center in Pennsylvania is offering scientists who would like to accompany their experiments into space a rundown on the physiological stresses they may encounter. In particular, NASTAR trains scientists to focus on their experiments and not be distracted by "that pretty view outside the window," says NASTAR graduate and planetary scientist Daniel Durda, who analyzes airborne observations of planetary and asteroidal occultation events at the Southwest Research Institute.

Alternatively, a researcher could hire a NASTAR-trained scientist-astronaut, says geophysicist Brian Shiro, who started the nonprofit Astronauts4Hire to recruit aspiring astronauts to run science experiments on commercial flights. "Our 17 members are a mix of established professionals and students pursuing graduate degrees in a range of science and engineering fields," says Shiro. One potential Astronauts4Hire customer may be NASTAR-trained Collicott, who says that in space he'd rather be a tourist than a scientist. "If I'm ever up there," he says, "I want to look out that window." **Jermei N. A. Matthews**

The state of physics in US high schools

More than 1.3 million students were enrolled in high-school physics courses in 2008–09, and some 37% of graduating seniors in 2009 had taken at least one physics course. That proportion has risen steadily since 1987, when it was 20%. A recent survey by the American Institute of Physics (AIP) finds that while enrollment is up, access to physics courses is unchanged: Since 1987 the proportion of students who attend a high school that offers physics has hovered in the 91–94% range; physics is more widely available in public than in private schools.

The curriculum continues to diversify, with both conceptual and advanced physics growing in popularity. In 1986–87, the roughly half million students enrolled in a standard, algebra-based physics course accounted for 80% of students taking physics in high school. Twenty-two years later, the same number took the standard class but constituted fewer than half of all students taking physics. Enrollment in advanced placement physics, for example, grew from 4% of students to 13%.

For the first time, AIP looked state-by-state at enrollment in and availability of high-school physics courses.

More details can be found in two AIP reports based on a survey of high-school physics teachers, *High School Physics Availability* and *High School Physics Courses and Enrollments*. Other recent reports by AIP's statistics group include one on textbooks used in high-school physics classes and one on the representation of Hispanic Americans at the bachelor's degree level in physics and geoscience. The reports can be viewed at <http://www.aip.org/statistics>.

Toni Feder

news notes **Astronomy for capacity building.** Astronomy for the Developing World aims to harness existing activi-

ties and spark new ones in the service of research and education. Building on the success of the International Year of Astronomy 2009, the project is a collaboration between the International Astronomical Union (IAU) and South Africa, which won a competition to host the project's office, according to a 30 July announcement. The office has an annual budget of about €200 000 (\$265 000) and a charge to coordinate both fundraising and educational activities.

Under the project's umbrella, and with the help of regional hubs intended to tailor implementation to local needs, astronomers will give lectures and make extended visits to developing countries. Astronomy institutes in developing countries will be paired with counterparts in developed countries to receive long-term guidance. Astronomy-related events will be organized for children and the public.

"It's using astronomy as a tool for capacity building—raising the technological, scientific, and cultural level of a country," says Leiden University's George Miley, IAU vice president for development and education. There is enormous potential in tapping the astronomers, engineers, and teachers who are willing to volunteer in this work, he says. "The real limitation has been the lack of a coordinating office." **TF ■**

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