

Flush with new discoveries, NASA's space and earth scientists now must figure out how to get by on \$3 billion less than they expected—without triggering a civil war

A Space Race To the Bottom Line

SPACE SCIENCE IS GETTING PLENTY OF headlines these days. A new spacecraft is on its way to Pluto, one just arrived at Mars, and another may have spotted water on Saturn's moon Enceladus. But last week, two dozen senior researchers met in a windowless Washington, D.C., conference room to try to avert what some fear could turn into a civil war among earth and space science disciplines scrambling for science's decreasing share of the space agency's budget.

The go-go years of the past decade came to a crashing halt last month, when NASA's 2007 budget request pulled more than \$3 billion out of the long-term science plan (*Science*, 10 February, p. 762). NASA has since canceled two missions close to launch, deferred a handful for a year or two, and effectively killed a half-dozen others slated for orbit in the next decade. To cope with the rapidly unfolding crisis, members of the National Academies' Space Studies Board assigned themselves the task of building a united front among notoriously fractious disciplines to make the best use of scarce dollars. They don't have much time. "Everyone recognizes that we are in this together—and we have to solve it together," says board member Daniel Baker, a space physicist at the University of Colorado, Boulder.

The unprecedented effort to find an acceptable alternative to NASA's 2007 budget request before legislators act on the bill this summer has the blessing both of the agency and Congress. Space agency chief Mike Griffin says he is willing to consider the results (see sidebar, p. 1542). And congressional staffers are cheering them on. "I hope you folks will have the answer to the problem—because we don't," Richard Obermann, a minority staffer with the House Science Committee, told the board on 6 March. Adds David Goldston, the committee's chief of staff, "Whatever pattern is set this year, it will be the pattern for the foreseeable future."

Out of business?

Griffin and other Administration officials dismiss the idea that a \$5.3 billion request for research in 2007 represents a crisis for the field. "There is still a very large overall science budget, just not as large as had been hoped," says Griffin. "NASA's science budget is almost as large as the entire [budget for the] National Science Foundation. I'm unable to see the level of damage here that those who are concerned about it seem to see." Indeed, the proposed 1% boost



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in NASA science over current levels beats out the average 0.5% cut borne by nondefense discretionary programs across all federal agencies.

Scientists, congressional staffers, and NASA science staff say this statement is true but misleading. Two years ago, the agency planned to boost its science budget by \$1.5 billion by 2009. As recently as last year, the increase was still \$1 billion by 2010. Based on such optimistic figures, NASA in recent years began funding work on an ambitious array of projects, most to meet scientific goals set by the National Academies in its various decadal plans.

But those projects are costing far more than planned. The most dramatic example is the James Webb Space Telescope (JWST), whose price tag is now \$4.5 billion—\$1 billion above the planned cost. A host of other projects are in the same boat. Costs for the Stratospheric Observatory for Infrared Astronomy (SOFIA) have ballooned from \$400 million to \$650 million, and several projects considered by the academies to be mid-size efforts now have grown to the size of flagship missions. “The problem is an enormous growth in the cost of doing programs; the numbers don’t add up,” says Thomas Young, a former aerospace executive and board member.

To cope with the budget crunch combined with rising costs, NASA officials are taking drastic steps to curtail costs and limit new starts—mostly by deferring missions, canceling troubled projects, and reducing the amount of money scientists spend to analyze research data. As a result, the number of new science missions launched will decline from a dozen this year to one in 2010. In the meantime, aging spacecraft will begin winking off. “This looks like we’re going out of business,” Baker says.

Defer and delay

For some disciplines, that is no exaggeration. “The last mission we have in earth sciences is in 2012,” frets board member Berrien Moore, co-chair of another academies’ panel writing that discipline’s first decadal plan. “After that, we’d better be going to Mars!”

Congress forced NASA 2 years ago to reverse planned cuts in several earth science missions. But in recent weeks, the agency has canceled the Deep Space Climate Observatory (*Science*, 6 January, p. 26) and Hydros, a \$170 million effort to study soil moisture. NASA officials say that Hydros was a backup to two other missions now in the works, and so it never was a confirmed project—a point disputed by some researchers. The agency also will delay the Global Precipitation Mission by 30 months and slow a precursor mission for a national environmental satellite system by 18 months.

For solar physics, the top-ranked mission in a 2003 decadal study by the academies—a magnetosphere mission—now will not be launched until 2013. Two other high-ranked missions—two separate constellations of small

Mission	Purpose	Status
SOFIA (Stratospheric Observatory for Infrared Astronomy)	Infrared observing aboard aircraft	On hold
NuSTAR (Nuclear Spectroscopic Telescope Array)	Image high-energy x-ray radiation	Canceled
Hydros	Study Earth’s soil moisture	Canceled
Terrestrial Planet Finder	Image Earth-sized extrasolar planets	Deferred indefinitely
Global Precipitation Measurement Mission	Conduct first comprehensive precipitation measurements	Deferred
Dawn	Visit two large asteroids	Canceled/Under review
JDEM (Joint Dark Energy Mission)	Look for evidence of dark energy	To be competed
Orbiting Carbon Observatory	Carbon measurements	Delayed 1 year
Landsat Data Continuity Mission	Remote sensing	Delayed 2 years
Mars Sample Return	Martian geology	Delayed indefinitely
Space Interferometry Mission	Search for Earth-like planets	Delayed 3 years
WISE (Wide-Field Infrared Explorer)	All-sky survey	Delayed 1 year

satellites to examine the interaction between the ionosphere and the thermosphere and understand how energy moves in Earth’s magnetotail—are on indefinite hold.

Rising costs and flat budgets also will force NASA to compete several new astrophysics flights. Constellation X—a group of four orbiting telescopes that will image the x-ray universe—will face off against the Laser Interferometer Space Antenna, designed to detect gravitational waves, and a Joint Dark Energy Mission with the Energy Department. The winner will get a green light to start work in earnest in 2009 or 2010 for a launch later in the next decade. The other two will have to wait their turn.

NASA also has stopped early work on the Terrestrial Planet Finder, a spacecraft that researchers had hoped to orbit in the next decade in search of Earth-sized planets. The Space Interferometry Mission, another planet-hunting mission, won’t be orbited until 2015 or 2016, and its cost has grown to \$4 billion.

Stanford University astrophysicist Roger Blandford also fears for the future of the Explorer program, NASA’s attempt to launch smaller missions run by principal investigators. The agency earlier this month canceled the Nuclear Spectroscopic Telescope Array, which was to open up the high-energy x-ray sky, and postponed the next solicitation for an Explorer from 2007 to 2008—delaying the launch of the next mission to 2014 at the earliest.

Planetary scientists are perhaps most bitter about the 2007 budget request. Their program, complains Reta Beebe, a board member and an astronomer at New Mexico State University in Las Cruces, “has unfortunately become the source of funds supporting other NASA programs.” She and others note that of the \$3.1 billion taken out of the 5-year budget projections for science, nearly all came from planetary missions. NASA recently canceled the Dawn mission to the asteroids Vesta and Ceres, rejected pleas to begin a large mission to Jupiter’s moon Europa, and cut the astrobiology budget by a whopping 50%. (On 10 March, Griffin agreed to review the decision on Dawn.) The agency also abandoned plans to launch a Mars sample return by 2016.

“The proposed budget transforms an existing, vibrant program into a stagnant holding pattern,” says Beebe. “The damage is immediate and increasingly irreversible. . . . We are reenacting the events of the 1970s,” she says, when a series of exciting missions was followed by a 15-year drought.

Yet even that grim prediction doesn’t match the crisis in the space life and microgravity sciences field, which had \$1 billion for both ground- and space-based research as recently as 2004. With the advent of the exploration initiative, that figure has plummeted to near zero. Donald Ingber, a Harvard University biologist and board member, insists that such cuts will make long-term human space flight impossible, given

Bumpy Ride for Data-Driven NASA Chief

"Show me the data" proclaims the framed sign over Michael Griffin's desk. It is a warning to visitors to his ninth-floor office at NASA headquarters in downtown Washington, D.C., that the 56-year-old aerospace engineer and applied physicist brooks little idle chatter, speculation, or wheeling and dealing. "I don't try to be blunt," says Griffin, nearing his first anniversary as head of the \$16.6 billion U.S. space agency. "I just tell the truth."

Griffin's two predecessors, Daniel Goldin and Sean O'Keefe, were known for being mercurial, visionary, and political—anything but plainspoken. And Griffin's no-nonsense approach to fixing what ails the U.S. space program—from a crippled space shuttle program and a half-completed international space station to an overmortgaged science portfolio—has earned him a large reservoir of good will in the White House and on Capitol Hill.

But that pool is drying up (*Science*, 10 March, p. 1359). President George W. Bush wants NASA to focus on building a new rocket to take humans back to the moon. Lawmakers are pressing to keep space shuttle jobs and contracts intact as long as possible. NASA's international partners worry that the agency still might back out of finishing the space station, leaving them and their hardware in the lurch. And scientists need continued big annual budget increases to build the many ambitious missions planned for the next decade (see main text, p. 1540).

To keep these disparate groups happy, Griffin last fall asked the White House to give NASA a whopping 8.8% increase in 2007. He warned the Office of Management and Budget (OMB) that a lesser boost would force him to halt the growth in science. When Bush decided to ask Congress for a 3.2% increase, Griffin kept to his word—prompting an angry reaction from scientists and their allies on Capitol Hill.

Under fire, Griffin's refreshing forthrightness can come across as political insensitivity. He dismisses the community's outcry as "a hysterical reaction, a reaction out of all proportion to the damage being done." But those words are likely to antagonize rather than assuage science advocates. Griffin is famous for responding rapidly to e-mails; he carries his BlackBerry everywhere. Yet he's uncomfortable with the face-to-face socializing and back scratching that his predecessors practiced so adroitly. "You have to form relationships, not just send an e-mail," says one who has worked closely with him. Although Griffin responds rapidly, adds another, "his impatience often shows."

Griffin's style befits his career as a project engineer, industry manager, and lab department head. He also spent a difficult few years at NASA headquarters overseeing the agency's doomed lunar and Mars exploration program, an idea that George H. W. Bush proposed but Congress ultimately ignored.

This time around, he knows he will need help from all quarters. "I need the scientific community to worry about more than just what happens to science," Griffin says. To win them over, however, he may want to serve up a slice of tact and empathy along with the data.

What follows is an edited transcript of a 7 March interview with *Science's* Andrew Lawler.

Q: You told Congress in 2003 as a private citizen that NASA needed \$20 billion to do everything on its plate. What's changed?

What's changed is that I am an agency head. Every agency head would like to have more money. The average [nondefense discretionary program] took a half-percent decrease in the 2007 budget—so we got 3.7% above average. I think that is extraordinary. My response is to say thank you. Is it as much as we would like to have? Of course not.

Q: How much would you like to have?

I'm not going to answer that question.

Q: In a November letter to OMB, you asked for 8.8%.

There are months of work that go into preparing a budget with all kinds of trades, and that was a missive from a snapshot in time.

Q: Has your promise last year not to take "one thin dime" out of science come back to haunt you?

No. I found we could not complete the station and the shuttle and make any kind of progress in replacing the shuttle with the CEV [Crew Exploration Vehicle] and the CLV [Crew Launch Vehicle] without restricting the growth of science. We just ran out of money.

Q: Why should science take the fall?

Your readers should understand that everybody in NASA paid the piper. I cannot accept an argument that manned space flight operations got everything they wanted when they in fact took a huge whack.

Q: But isn't it the science aboard the station that is taking the whack?

I chose to assemble now and utilize later.

Q: Why is there no post-2010 plan to do science on the station?

I inherited what I inherited. Clearly, the [National Academies'] report [on space station science] is very specific and unequivocal in its position that we don't have a good space station utilization plan. But we have several years now to develop one, and we will.

We still have an extraordinarily healthy science program. Some missions have been delayed, some things of a doubtful nature have been canceled, and a couple of things are on the chopping block because the promised technical performance has not come true.

Q: Is there any prospect of ending the shuttle program before 2010, thereby freeing up money for exploration and science?

We're flying out the shuttle program in an orderly and disciplined way and using it to finish the space station. We have been working on it for 20 years, and we have multiple international commitments. Other things we would like to do—including exploration and science—are going to have to sacrifice for the next few years to allow that to come true.

unknowns about radiation hazards and the impact of microgravity on human health. "This will set the manned program back by decades," he warns.

Civil war or solidarity?

Short of an abrupt cancellation of the shuttle and station programs, there are few prospects for a dramatic change in science's fortunes. Indeed, this year's overall increase of 3.2% for NASA may look good in a few years, board members fear. And even if the shuttle is retired in 2010 once

the space station is complete, the space agency's budget documents note that the dividends will go into the exploration program rather than science.

"We're not going to be able to execute the decadal [studies] as they exist," concludes Lennard Fisk, board chair and a geophysicist at the University of Michigan, Ann Arbor. A 1% increase in NASA's science budget, he says, translates into "a major retrenchment." And scientists say they would rather make the hard choices than leave them to NASA man-

agers. If they don't, Blandford warns, "choices that should be scientific and technical will be left to the political process."

After hours of discussion, board members broadly agreed to protect research funds for the university community and for smaller missions. That decision puts larger efforts in each discipline on the chopping block. Moore suggested that to find earth science savings, the \$430 million Landsat mission slated for launch by 2010 could be reviewed, and astronomers privately and



Q: Is that why NASA canceled NuSTAR and the asteroid mission Dawn—and soon maybe the flying observatory SOFIA [Stratospheric Observatory for Infrared Astronomy]?

Dawn was canceled because it was overrun by 20%. That's a matter of project discipline. Dawn's cancellation has nothing to do with [the NASA] budget. SOFIA is so far overrun on cost and schedule that only if we can convince ourselves that it is past its technical problems—well, the question is, can its people get to the finish? I insist on imposing discipline on our projects.

Q: But why are the shuttle and station exempt from this rule?

Or the James Webb [Space Telescope]? Our highest priority missions will be completed. And other things in science are suffering to pay for James Webb. So what's your point?

Q: Why should projects like Webb be exempt, if the smaller ones often are being managed more innovatively than large projects?

Our science program is structured to pay appropriate and ample respect to National Academy priorities. Now at present, in the astrophysics line, James Webb is the highest priority. Fifteen minutes after I arrived at NASA, I learned there was a billion-and-a-half shortfall in James Webb. My choice is either to continue to respect the academy's priority and find the money from lower priorities, or I could disrespect the academy's priorities and cancel James Webb.

That is a bind. My choice will generally be to respect academy priorities. If the academy revisits the issue of whether a single flagship mission is worthy of the sacrifice of numerous lesser, possibly more innovative, more timely missions, that would be a judgment for the scientific community to make. I'm listening. But I do not view that as a judgment that a NASA administrator ought to make.

Q: NASA's credibility as a nonpartisan purveyor of science was damaged in the flap over recent complaints by agency scientist Jim Hansen. What are you doing to change that?

Even Jim Hansen has not said that anyone has interfered with his publication of his technical conclusions. Jim said he was inappropriately denied an interview he should have been able to conduct. And I think he was right. And the person who denied him that interview is no longer here. I can only assure you, as the head of NASA, that no one here wants or will tolerate any restriction on the prerogatives of technical people to publish their conclusions to their community and have them be debated on their merits in their communities.

Q: What do you say to those scientists who are angry at the 2007 request?

We have a space program that requires some sacrifices. I'm sorry they have to happen, but they do.

—ANDREW LAWLER

cautiously suggest that deferring JWST by a few years could rescue smaller astrophysics missions in the near term. The largest planetary mission now scheduled is the Mars Science Laboratory, slated for a 2009 launch; among solar physicists, the big-ticket item is the Solar Dynamics Observatory due for orbit in 2008.

But some researchers already are parrying the attack on larger programs. William Smith, president of the Association of Universities for Research in Astronomy, warned in a 6 March

letter to the House Science Committee that NASA's great observatories provide \$70 million annually for research analysis. Canceling flagship missions "would simply shift the imbalance, not eliminate it," he says. Attempts to defer, descope, or kill JWST or the Mars Science Lab also would provoke major battles in each discipline and in Congress.

Even if NASA likes what the space board proposes, the fight is sure to move quickly to Capitol Hill, where projects with the most politi-

cal muscle could triumph despite the academies' priorities. Still, researchers say they have to try. "Dividing a growing pie is not all that difficult," says George Paulikas, board vice chair and a retired aerospace executive who is heading up the academies' effort.

But the alternative to consensus is too awful to contemplate, he adds. Can independent-minded scientists agree on a plan that spreads the pain around? "Stay tuned until April," he says.

—ANDREW LAWLER