cluding measures to reduce dangers to the public if an attack occurs.

8 National labs: Despite National Nuclear Security Administration oversight, the national weapons laboratories continue to be plagued with internal security problems, spending irregularities, and low morale. What steps would you take to improve conditions at the labs? Does the current plan of opening the labs' management contracts to competitive bids run the risk of disrupting the operations in the midst of the war on terrorism?

Bush Our national laboratories are doing great work to deal with the threats of the 21st century. These laboratories are a tremendous asset in our efforts to improve homeland security, are the source of unparalleled technological progress, and are helping America win the war on terror. With their budgets at the highest level in years, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories are also on the cutting edge of 21st-century defense research, like combating bioterrorism, protecting the nation's infrastructure from crippling terrorist attacks, and developing a laser that simulates the intense heat of a nuclear explosion.

This is why we spent $6.5 billion on weapons research and production in FY 2004 and why I am asking for $6.8 billion for FY 2005. We must keep morale and security high. My administration has made every effort to improve the way the weapons labs do business, and one of those efforts is allowing competitive bids like those that exist in all areas of government—including those central to the war on terror—so we can use our resources more effectively and let everyone focus on his or her own expertise.

Kerry Our national laboratories play a critical role in maintaining our nuclear weapons stockpile and assuring that our nation's nuclear weapons are safe, secure, and reliable. The national laboratories also have an important role in preventing the spread of weapons of mass destruction and in advancing science for our nation's security.

The laboratories have a proud history of advancing our nation's security, but this record has been blemished recently by poor management and sloppy security practices. Morale at the labs has been badly damaged. John Edwards and I are committed to strengthening laboratory management and oversight and restoring the morale at these critical national assets.

9 Space policy: NASA is being reorganized to reflect the president's long-term vision of manned missions to the Moon and Mars. Many scientists believe the reorganization will drain money from NASA's unmanned science missions. How do you define the relative importance of unmanned science missions versus manned exploration flights? What is the appropriate funding balance between the two?

Bush In January, I announced my vision for the future of America's space exploration program. Achieving this vision will require the combined strengths of both manned and unmanned science missions. Robotic missions will serve as trailblazers—the advanced guard to the unknown. Probes, landers, and other vehicles continue to prove their worth, sending spectacular images and vast amounts of data back to Earth. Today, we have unmanned systems on and around Mars, a system orbiting Saturn, and one on its way to Mercury. Yet the human thirst for knowledge cannot be completely satisfied by even the most vivid pictures or the most detailed measurements. We need to see and examine and touch for ourselves. And only human beings are capable of adapting to the inevitable uncertainties posed by space travel.

As we complete our work on the International Space Station, we are developing a new manned exploration vehicle to explore beyond our orbit. This vehicle will be tested by 2008 and conduct its first manned mission no later than 2014.

America will return to the Moon as early as 2015 and no later than 2020, and use it as a foundation for human missions beyond the Moon. We will begin with robotic missions to explore the lunar surface, researching and preparing for future human exploration. Manned lunar missions will follow, with the goal of living and working there for increasingly extended periods.

Kerry John Edwards and I will continue America's long tradition of leadership in aeronautics, Earth sensing, and space exploration as part of a well-balanced NASA program closely tied to broad payoff for this country. It will not tie NASA to programs such as the Bush administration's Moon–Mars Program that emerged from closely held meetings in the White House with no clear objectives or cost estimates. It will invest in bold new programs tied to priorities, set by scientific experts, in exploring weather, climate, oceans, astrophysics, and other areas. Our administration will rely on the advice of the scientific community to select the most appropriate goals for research and the most appropriate tools for achieving these goals—including the question of whether manned or unmanned missions are most appropriate to the task.

NASA Bows to Pressure to Save *Hubble*

In a turnaround, NASA may extend the life of the *Hubble Space Telescope* by servicing it robotically. But doubts remain over the feasibility of such a mission, and over how NASA would pay for it.

NASA Administrator Sean O'Keefe caused an uproar in January when he announced that, because of safety concerns after the *Columbia* accident, any further space shuttle service missions to the *Hubble Space Telescope* would be too risky for astronauts (see PHYSICS TODAY, March 2004, page 29). Professional societies—the American Association for the Advancement of Science, the American Astronomical Society, the American Physical Society, and the Royal Astronomical Society, to name a few—issued statements in support of servicing the telescope. Congress introduced resolutions in favor of future service missions. Astronauts complained and the public swamped NASA with letters protesting the telescope's demise. But O'Keefe insisted that the only mission heading to the *HST* was a one-way trip by an unmanned propulsion module to help the telescope burn up in a controlled reentry into the atmosphere. Service missions were off the table.

Eventually, though, the agency buckled and requested that the National Research Council investigate options for extending the telescope's life. The resulting report is due out later this year, but in a letter in July, the NRC advised NASA to keep the *HST*'s options open. The NRC recommended that NASA replace the batteries and gyroscopes, add two new


NASA

Despite the request by a National Research Council committee that NASA keep open the option of a shuttle visit to *Hubble,* no money has been set aside for it.

instruments to the telescope, build expertise for a potential robotic service mission, and "take no actions that would preclude a space shuttle servicing mission."

While the NRC was debating the merits of various *HST* options, NASA was quietly evaluating just one approach: a robotic rescue mission. Since March, NASA has been testing the Canadian-built special purpose dexterous manipulator (Dextre)—a plug-in device for a robotic arm on the International Space Station.

NASA's Goddard Space Flight Center, which is carrying out the tests, gave Dextre high marks. On a mock-up of the *HST*, the robot was able to disconnect and reconnect power cables and remove and replace science instruments—albeit 10 times slower than an astronaut. The servicing would be the most complex space mission yet given to a robot. With new batteries, gyroscopes, and a pair of new science instruments, the 14-year-old telescope could remain functional to 2013.

Robotic surprise

On 9 August, O'Keefe announced to Goddard staff that NASA would ask Congress for additional resources in the 2005 budget to pay for a robotic service mission to the *HST*. It was his strongest endorsement to date for keeping the telescope alive, and it caught many by surprise—including Al Diaz, newly appointed NASA associate administrator for science, who hastily organized a telephone conference with reporters.

"I would feel more comfortable if NASA were actively keeping open both options—a shuttle servicing mission and a robotic servicing mission—as recommended by the NRC committee," says John Bahcall of the Institute for Advanced Study in Princeton, New Jersey. But, adds Bahcall, who served last year on a NASA committee on extending the *HST*'s life, "if successful, [a robotic mission] would be very good for the nation, providing not only servicing of the *Hubble* but also giving the US an important technology that has many other potential important applications."

While NASA's plans for a rescue mission were progressing, the *HST* was showing signs of old age. Most of the gyroscopes for positioning the telescope are already dead. The space telescope imaging spectrograph died on 3 August, and engineers are becoming increasingly concerned that the *HST*'s batteries may fail in 2007. STIS had unique spectroscopic capabilities for studying supermassive black holes and was one of the few space-borne instruments sensitive to UV light.

Robotic compromise

Under time pressure to service the *HST*, NASA approached industry for off-the-shelf ideas, says Paul Cooper, vice president for R&D at MD Robotics, the Brampton, Ontario, builders of Dextre. Of the 26 proposals sent to NASA over the past year, two close contenders—Robonaut by the Johnson Space Center and the University of Maryland's Ranger system—were ruled out because they are several years away from being flight-ready.

NASA will have to solve many problems if a mission using Dextre is to succeed. One unknown is how Dextre would rendezvous with and dock to the *HST*. But the greatest challenge for the robot is one of the simplest tasks for an astronaut: closing the instrument bay doors on the telescope after installing new equipment.

Congress has given no indication that NASA's funding request will be approved during this, an election year. The final tab, estimated at $1 billion to $1.6 billion for a robotic service mission, is higher than the cost for a space shuttle flight. Only $300 million, for the *HST* de-orbiting module, is currently in NASA's budget—which is being increasingly squeezed because of the president's plan to send manned missions to the Moon and Mars.

Although it's a compromise, astronomers are relieved that NASA is considering a robotic servicing mission rather than letting the *HST* die. "It's technically feasible but more risky [in terms of fixing unexpected problems during the service mission] than using the shuttle," says Steven Beckwith, director of the Space Telescope Science Institute in Baltimore, Maryland, which schedules observing time on the *HST*.

Bahcall is confident that the telescope can be rescued. "We have had more near-fatal situations than a department full of hospital heart patients, but somehow the ingenuity of the engineers, the originality of the scientists, and the strong backing of Congress and the general public have kept [the *HST*] alive. I hope it will continue to bring us beautiful and inspiring pictures of the universe for another 10 years."

Paul Guinnessy

Panel Chooses Superconducting Option for the International Linear Collider

The international particle physics community is almost unanimous in its desire for a TeV electron–positron linear collider. Such a facility would be at least 30 km long and cost $5–7 billion. But for more than a decade, competing international collaborations have devoted intensive R&D to two different RF accelerating technologies for the collider (see PHYSICS TODAY, September 2004, page 49). Now, at last, the community has settled on one of the competing technologies.

The International Committee for Future Accelerators has endorsed the recommendation of the 12-member International Technology Recommendation Panel (ITRP) that the RF accelerating cavities be made of superconducting niobium operating at 2 K rather than copper at room temperature (see http://www.ligo.caltech.edu/~skammer/ITRP_Home.htm). Although the superconducting technology was championed by DESY, the German Electron Synchrotron laboratory in Hamburg, the choice does not imply a specific site for the collider, nor does it imply DESY's detailed TESLA design. "We've chosen a technology, not a specific design," says ITRP chair Barry Barish of Caltech. The principal laboratories developing the "warm" copper alternative have been SLAC in California and KEK in Japan.