Comer, director of legal affairs and technology policy for Intel Corp, an industry member of the task force. "The US government is falling behind in its commitment to basic physical sciences research, which is a critical part of our competitive future."

Nils Hasselmo, president of the Association of American Universities, another task force member, said, "We have trend lines and they are disturbing as far as US leadership in research and innovation are concerned. We have downward trends in the participation of American citizens in science and technology while at the same time there is a dramatic increase in [S&T] competition from elsewhere. The handwriting is on the wall and in the statistics."

Although the president's basic research funding proposal was causing angst in the science community, Nobel physicist Burton Richter attributed science funding woes to both political parties. Speaking on behalf of the task force, Richter said, "What they [political leaders] are doing to the physical science budgets is bipartisan shortsightedness. It was no different under the Clinton administration than it is under the Bush administration, and we'll suffer for it in the long run because the rest of the world is accelerating their R&D while we seem to be decelerating ours."

The benchmarks include "signs of trouble" indicators for education, the US workforce, knowledge creation, R&D investment, and the high-tech economy. Several other benchmarks focus on specific high-tech research fields, including nanotechnology, information technology, energy, aerospace, and biotechnology. David Peyton, director of technology for the National Association of Manufacturers, called the benchmarks "the latest iteration of a process that's been going on for a number of years, but this is the most comprehensive set of numbers and we've tried to be careful to present the state of the world in a snapshot and in trend lines." They will be used, he said, to "work the hill" and to persuade policymakers in both Congress and the administration to provide stronger funding for basic science.

The benchmarks, created with data from a host of studies and reports, include the following findings:

Education

▶ Undergraduate science and engineering degrees are being awarded in the US at a lower rate than in other countries. The ratio of college undergraduate degrees in the natural sciences is only 5.7 per 100 college students in the US, while Finland, France, Ireland, Spain, Sweden, and the UK award between 8 and 13 degrees per 100 students. In Asia, Japan awards 8 per 100, and Taiwan and South Korea each award about 11 per 100.

▶ The US has a smaller share of the worldwide total of science and engineering doctoral degrees awarded each year than either Asia or Europe. In 2000, about 89 000 of the 114 000 doctoral degrees given in science and engineering were earned outside the US.

Workforce

▶ From 1994 to 1998, the number of Chinese, South Korean, and Taiwanese students who chose to pursue PhDs in their own countries nearly doubled. By contrast, over that same period, the number of students from those countries pursuing PhDs at US universities dropped 19%, from 4982 to 4029.

▶ Since 1980, the number of science and engineering positions in the US has grown at almost five times the rate of the US civilian workforce as a whole.

Knowledge creation

▶ The US share of science and engineering papers worldwide declined from 38% in 1988 to 31% in 2001. Europe and Asia are responsible for the bulk of the growth in scientific papers in recent years.

▶ From 1988 to 2001, the US increased its number of published science and engineering articles by only 13%, while Western Europe increased its article output by 59%, Japan by 67%, and East Asia by 492%. Though both Japan and East Asia started from a far smaller base in 1988 and still do not publish as many articles as the US, their dramatic growth rates are striking.

R&D investment

▶ From 1995 through 2001, China, South Korea, and Taiwan collectively increased their gross R&D investments by about 140%, while the US increased its by 34%.

▶ US federal funding of basic research in engineering and physical sciences has experienced little to no growth over the last 30 years. As a percentage of gross domestic product, funding for physical sciences has been in a 30-year decline.

Entrepreneur Launches Low-Cost Space Rockets

Elon Musk will be keeping his fingers crossed later this month when his latest venture, a low-cost rocket called *Falcon I*, launches from Vandenberg Air Force Base in California. Musk, a 33-year-old South African former internet entrepreneur who has a physics degree from the University of Pennsylvania, says that launch costs are a major reason why humanity has not yet successfully exploited space. "At the current rate, it will never happen," he says.


SPACEX

Falcon I could be the start of low-cost access to space.

Musk created and bankrolled Space Exploration Technologies Corp (SpaceX) three years ago, after selling his stake in Paypal, the online payment system, to internet auction house eBay for hundreds of millions of dollars. With his first rocket, *Falcon I*, each launch costs $5.9 million to put a 520-kg payload in low-Earth orbit. A bigger medium-lift rocket, *Falcon V*, is expected to put payloads in geosynchronous orbit for $15.8 million, compared to $60 million for Boeing's Delta medium-lift launch rocket.

The cost savings come from reducing the launch team from hundreds of people to 15–20, making the first stage reusable, building most of the rocket in-house, and deploying the latest technologies. Unlike current rockets, *Falcon V* is designed to be able to lose an engine and still deliver a payload to the correct orbit. SpaceX, based in El Segundo, California, already has signed customers such as the government of Malaysia and the US Department of Defense, and interest from the science community is growing. Researchers from the University of Washington, MIT, and the University of Queensland hope to launch the *Mars Gravity Biosatellite* on a Falcon in 2007. Musk has received dozens of inquiries from potential customers. "I would be happy if *Falcon I* achieved a four-to-six launch rate per year. It looks like we will probably do even more launches of *Falcon V*, once that gets going."

Paul Guinnessy