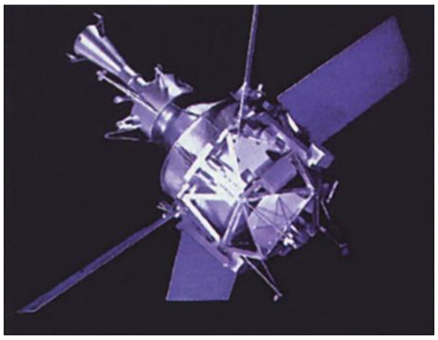
ASTROPHYSICS

Einstein Probe Remains Earthbound

A NASA-funded effort by Stanford University to test Einstein's theory of relativity faces $70 million in cost overruns and an additional 6-month launch delay. This setback is the latest in a long-running series of technical snafus and political tensions that have plagued the experiment. Frustrated



Time warp. Launch delay and cost overruns confront relativity test.

NASA managers say they will decide this summer whether to kill the Gravity Probe B effort, but they seem unlikely to carry through with the threat.

Originally slated for a 1999 launch, the probe is designed to measure how Earth's mass warps space-time. Physicists say the results could provide hard evidence to prove Einstein's theory. To make those delicate measurements, the science package of the spacecraft is contained within a supercooled structure that resembles a giant thermos bottle. But problems with gyroscopes contained inside that package, coupled with inadequate cooling in the neck of that bottle, are forcing time- and money-consuming fixes. The situation is "annoying, very embarrassing, and very frustrating," concedes the mission's principal investigator, Stanford physicist Francis Everitt.

How much money and how much time those fixes will take is a matter of heated debate. Much hinges on a series of tests slated to begin in May and conclude later this summer. Everitt insists that there is at least a 50–50 chance that the probe can still be launched as scheduled by September 2001, with a cost overrun of about $40 million. But an independent panel assembled by NASA space science chief Ed Weiler puts the cost overrun at $70 million. The panel is also significantly less confident that Stanford will meet the September launch date. Rex Geveden, the program manager at NASA's Marshall Space Flight Center in Huntsville, Alabama, says, "No one is taking that date seriously." He thinks April 2002 is more likely.

Science obtained a copy of the report of the panel, which was led by retired Lockheed Martin engineer Parker Stafford. It concludes that "the project is in good shape from a technical standpoint," but says Stanford needs an experienced integration and test manager as well as NASA engineers onsite to monitor progress. The Stafford panel also takes NASA to task for repeatedly threatening to cancel the program, which the report says undermined Stanford's confidence and led the university team to be less than forthright about the technical difficulties it encountered.

Irritated NASA officials complain that Stanford managers have not been clear about technical problems, and they assert that the Stanford team has repeatedly gone over their heads by lobbying Congress for support. But Everitt insists Stanford has been up front all along. Nor does he think the extra funding will be a terrific strain, as NASA promised in 1994 to set aside $53 million in case of probe overruns.

That money, however, is not in the bank. Weiler says he must cut other programs to save the probe. In jeopardy are the Europa orbiter, which could be delayed by more than 2 years, or plans for new spacecraft in a series of ongoing midsize science payloads, says the space science chief. The other option, he threatens, is to kill the probe, but Weiler admits he hesitates to do so given the $450 million and 3 decades already invested in it. Weiler intends to wait until critical tests are completed this summer before making a final decision. Even Everitt agrees that if the probe does not come through the tests with flying colors, then "it will be very reasonable for NASA to ask very serious questions."

–ANDREW LAWLER

HELIOSEISMOLOGY

Solar Physicists Get a Glimpse of the Far Side

The far side of the sun seems inaccessible, obscured from our view by 1.4 million kilometers of hot, seething gas. But because the sun rotates every 27 days, that hidden face emerges without fail to shine upon us and, at times, launch dangerous storms our way. Now, researchers may have learned how to detect storms brewing on the far side of the sun, 2 weeks before they swing toward Earth, thanks to a technique that literally hears the rumbling of big sunspots through the sun itself.

The technique, dubbed "helioseismic holography," relies on acoustic vibrations that ring the sun like the solar system's largest bell. On page 1799 of this issue, solar physicists Charles Lindsey and Douglas Braun of the Solar Physics Research Corp. in Tucson, Arizona, explain how they unraveled tiny stutters in those vibrations and traced them clear across the sun to a massive disturbance on the other side. Although their first acoustic hologram of this region is smudgy, the researchers say their images should improve. Says Lindsey: "In a very short time, we will monitor the far side of the sun routinely for large active regions."

That prospect has lit up the solar physics community. "It's so exciting that we can now manage to look at the far side of a star," says Bernhard Fleck, the European Space Agency's project scientist for the Solar and Heliospheric Observatory (SOHO), which gathered the helioseismic data. "Using the entire sun as an acoustic lens is an elegant and brilliant idea." Those who stare at the sun for its potential impacts on Earth are equally enthusiastic. "This presages a daily analysis of activity on a region of the sun that has been completely out of bounds to us," says Ernest Hildner, director of the Space Environment Center at the National Oceanic and Atmospheric Administration in Boulder, Colorado.

Although it took a decade for Lindsey and Braun to make their concept work, they maintain that it's simple in principle. Gas churns within Texas-sized convection cells near the sun's surface. Those motions propel acoustic waves into the star, where they skip and reflect until the entire sun hums in a complex, low-pitched cacophony. Many vibrations cancel out, but some reinforce one another to create resonant frequencies, like the deep tones within an enormous organ pipe. The Michelson Doppler Interferometer aboard SOHO and ground-based instruments spot those frequencies by using Doppler-shifted sunlight to reveal throbbings of the sun's surface, which rises and falls by tens of kilometers every few minutes.

During their travels, the acoustic waves speed up when they encounter high gas pressures and temperatures deep within the sun or strong magnetic fields near the surface. Sunspots and other storm centers at the surface usually lie within vast regions of strong and tangled magnetic fields, called plages. These magnetic fields press the sun's surface downward by 100 kilometers or more. That shortens the distance that some acoustic waves travel, making them reflect within the sun more quickly than they otherwise would. It's like a dent in the organ pipe, Lindsey says: Waves bouncing off such a region get slightly out of phase with the rest and disrupt the resonant frequency.

Lindsey and Braun saw such a pattern when they analyzed SOHO data from 1998. On 8 April, a major active region appeared on the eastern limb of the sun as it rotated. Tracing backward, the researchers calculated that the region lay on the far side oppo-

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