

or SURF. The estimated infrastructure cost is \$150 million, significantly less than the \$575 million for NSF's grander plan. The annual running costs for SURF are estimated at around \$20 million, less than half the \$50 million–\$70 million for DUSEL.

On 12 July, the National Research Council released a report that will also figure into DOE's decision on Homestake. The NRC evaluated the science proposed for DUSEL, the need for it in the context of similar science programs in other regions of the world, and its broader impact. The science has been reviewed several times over the past decade, and the NRC conclusions held no surprises: The three experiments that DOE is now considering are of "paramount and comparable scientific importance," with each addressing "at least one crucial question upon which the tenets of our understanding of the universe depend." The report also gives high marks to an accelerator-based

study to measure low-energy nuclear cross sections. And it notes that a facility in the US would not only provide access and leadership advantages for the physics community, but could also benefit scientists in other fields.

If DOE does run with Homestake, it would be built incrementally. "DOE is more amenable to phasing things in, which allows us to come up with lower costs in preparing the facility," says Kevin Lesko, who led the NSF-supported efforts for DUSEL and is continuing in that leadership role for SURF. He and others point out that DOE has more experience than NSF in running large projects. But, Lesko says, "We hope that NSF can be reengaged and that more experiments would eventually come to Homestake."

Especially given cuts in federal spending, DOE's decision is "complicated," says Strait. "We don't know whether to expect thumbs up, thumbs down, or thumbs sideways." **Toni Feder**

and counting—and, increasingly, of mobile tablets, such as Apple's iPad. The demand for those devices, which typically cost less than \$1000, has particularly paid off for scientists looking to exploit the once pricey high-tech hardware and software that make them tick. In the early 1990s, says Ozcan, "we could have paid several thousand dollars for a 1-megapixel CMOS sensor. It was a dream for a researcher to have the 5- or 8- or 12-megapixel CMOS sensors that we now have in our cell phones."

Smartphones in space

In addition to a camera, most tablets and smartphones—cell phones that support third-party software applications, or apps—also come with other components used in physics research. By interfacing with an Apple iPhone's three-axis gyroscope, accelerometer, and camera, a new app is expected to give astronauts the ability to measure a spacecraft's position, its altitude, and Earth's curvature, all for roughly \$750—the cost of the phone plus a 99¢ app.

The app, SpaceLab for iOS, will also allow users on Earth to simulate some of those measurements. Last month two iPhones loaded with SpaceLab for iOS were delivered to the International Space Station on NASA's final space-shuttle mission.

After discovering that his Motorola Droid smartphone had a three-axis Hall-effect magnetometer, physicist Randall Peters and colleagues at Mercer University in Georgia secured an NIH grant to test the phone's potential as a seismocardiograph, a wireless monitor of heart health. "Unfortunately the sensitivity of the device is limited by the data range of the available app so it is not yet a viable sensor," says Peters.

Some scientists and equipment manufacturers are exploring apps and Web-based software that can interface with external scientific instruments. Earlier this year, Agilent Technologies released a software platform that allows chromatography users to remotely monitor the status of their equipment and analyze the generated data. "The next step will be to allow the user to receive automated alerts and to remotely control the instrument, not just monitor it," says Agilent program manager Linda Doherty.

The software and technology to remotely operate "sophisticated instruments" already exist, says Supratik Guha, director of physical sciences at IBM Research. For example, IBM physicist Rudolf Tromp, through the internet, can remotely operate his "state-of-the-art low-energy electron microscope

Harnessing consumer mobile devices for science

Researchers are exploring ways to utilize the sensors and software inside cell phones and mobile tablets.

All talk, no science? Your cell phone is smarter than that. Just ask electrical engineer Aydogan Ozcan, inventor of a process for imaging transparent biological specimens with a cell-phone camera's LED and CMOS sensor. In June, Ozcan's UCLA biophotonics research team used its cell-phone microscope in Brazil's Amazon rainforest to capture

images of malaria-infected blood. The researchers are now fine-tuning an attachment that converts cell phones into wide-field fluorescence microscopes for water-quality screenings.

Ozcan is among a growing number of scientists seizing the opportunity created by the global prevalence of cell phones—more than 5.3 billion of them

Photonics researcher Aydogan Ozcan (standing) and his graduate student Onur Mudanyali compare microscopic images taken by a tabletop optical microscope and by a Sony Ericsson smartphone, which was used to capture diffraction shadows of blood cells.

OZCAN RESEARCH GROUP/UCLA



from his home kitchen table,” says Guha. Tromp’s colleague James Hanon is working on an iPhone app to monitor the same instrument.

“What doesn’t get enough credit is how the high demand for mobile devices has driven innovation in processors,” says Gaurav Khanna, a theoretical astrophysicist at the University of Massachusetts Dartmouth. Khanna is involved in an NSF project cosponsored by Apple and graphics-hardware manufacturer Nvidia to evaluate the performance of mobile-device processors for scientific computing applications. He says that although current wireless bandwidth isn’t sufficient for supercomputing operations “even if you link 1000 iPads together,” the hardware inside mobile devices is up to the job. They’ve been designed to have “extremely high performance without draining the battery too quickly,” he says.

A global sensing system

Until recently, the most common use for personal mobile devices by scientists had been to access and share research results, says Enrique Canessa, a scientist at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy. Last November at ICTP, Canessa and colleague Marco Zennaro hosted an international workshop on mobile science

that featured sessions on designing apps for data collection and analysis. The workshop also introduced a moniker for mobile science research—m-science—and launched the primer *m-Science: Sensing, Computing and Dissemination*, which can be downloaded for free at <http://www.m-science.net>. Canessa says he expects the book to raise awareness of the “huge possibilities of mobile science” and to “motivate a new generation to participate in this rapidly developing new field of research.”

To that end, Canessa and Zennaro have designed a potentiality index to assess countries on their ability to participate in mobile science. The index, which takes into account an area’s density of broadband subscribers and density of working scientists, shows smaller, developed nations like the Netherlands to be most ready for m-science; it also suggests that developing nations, despite being the fastest adopters of mobile technology, will be limited by the relatively low density of scientists in their populations.

A global sensing system is the promise of m-science, says Zennaro. With minimal participation, “we could build the largest scientific instrument ever built; one that could aggregate data on an unprecedented scale.”

Jermev N. A. Matthews

Old satellite dishes become new telescopes

Recycling offers radio astronomers a cheap ticket to expand interferometers, train students, and boost science in developing countries.

“It’s not a new concept, but now is the time,” says Justin Jonas, associate director for science and engineering with the Square Kilometre Array (SKA) South Africa Project. With optical fibers replacing satellite communications dishes, radio astronomers around the world are converting the obsolete dishes into telescopes. Many dishes across Africa, for example, have been identified as conversion candidates, and one in Ghana is set to go forward. The UK’s Goonhilly Earth Station, which in 1962 received the first transatlantic television broadcasts, is getting a makeover. Other recent or planned retrofits can be found in Australia, New Zealand, Japan, and elsewhere.

“Adding one telescope doesn’t make a scientific revolution, but if you could double the number [in the European Very Long Baseline Interferometry Network (EVN)], that would revolutionize

our field,” says Huib van Langevelde, director of the Joint Institute for VLBI in Europe, based in Dwingeloo, the Netherlands. “Our images would be much more accurate and look better, and we could sample a larger number of sources.”

Many recycled dishes are also used to train students and to promote science

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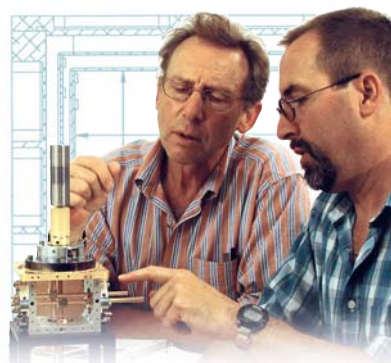
Postage stamps marked the inauguration of satellite communications in many African countries. Now some of those satellite dishes are finding new life as radio telescopes.

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