option in the past, Tilford says, because "it's hard to plan on something that isn't there." EOS managers say they learned of the Air Force's Atlas intentions early this summer. However, a description of the Air Force plans appeared last February in public documents issued as part of the President's budget request.

NASA officials had long maintained that EOS' goals required orbiting the instruments on big platforms because certain sensors must monitor the same part of the Earth at the same time. But the review panel asserts that other options could also work. A smaller platform could hold instruments that truly need to make simultaneous measurements, while other sensors could make nearly simultaneous observations from small satellites orbiting in close formation.

Splitting up the instruments would allow NASA to launch the most important sensors as soon as possible and leave the less critical ones for later. Some might fly as early as the mid-1990s, says Frieman. He points out that government leaders need EOS data to help resolve pressing questions about climate change.

Smaller craft would make the program more resilient, he adds, because NASA could change the instruments on a later satellite to answer questions raised by data from early missions. Moreover, distributing the instruments among several satellites would provide better protection against mishaps such as the Challenger accident or the equipment glitches now hobbling the Hubble Space Telescope and the Galileo probe.

"People [on the review panel] were mindful of the fact that, when carrying an enormous number of instruments, if there's any difficulty, the whole mission can be destroyed," Frieman says.

The panel also calls on NASA to speed up its satellite development process. Recent NASA projects have typically taken nine years to move from chalkboard to launchpad, whereas the Defense Department has repeatedly designed, built and launched complex space experiments in less than two years, the panel notes.

NASA has considered splitting the single EOS-A payload onto two Titan rockets, but the review panel recommends going even smaller by using three Atlas rockets or a mixture of Atlas and even smaller rockets.

The idea of separating the instruments upsets some scientists, especially those whose research projects might not survive a program redesign. At the same time, many researchers and policymakers criticize NASA for holding on too long to the concept of flying large EOS satellites. While agency officials say they are considering new options, they appear to be "somewhat reluctant," says one member of an independent advisory committee charged with evaluating the future of the U.S. space program.

— R. Monastersky

Sizing up atoms with electron holograms

In their ongoing quest to see the all-but-invisible, physicists have developed a method for using patterns of scattered electrons to observe the three-dimensional atomic textures of materials. In this emerging technology, called electron holography, investigators exploit the wave-like properties of electrons to make their observations (SN: 10/15/88, p.252).

Now scientists have used a lensless electron projector to discern the arrangement of atoms in several types of materials. In the Sept. 16 PHYSICAL REVIEW LETTERS, Hans-Werner Fink and Heinz Schmid of IBM's Zurich (Switzerland) Research Laboratory and their colleagues describe the technique and the calculations that helped them create holograms of carbon fibers and of thin gold films. Since doing that work, they have produced a holographic image of DNA — published here for the first time — demonstrating that the approach also works with biological materials.

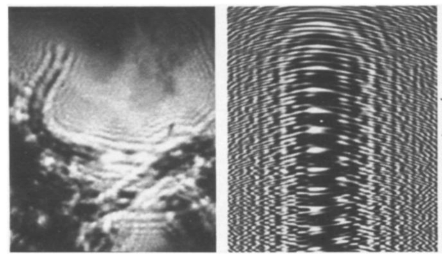
Fink and Schmid illuminate their samples with a beam of electrons emitted from an ultrathin tungsten tip similar to that used in scanning tunneling microscopy. By sharpening this tip to a width of one atom, they create a beam coherent enough to make atomic-scale holograms.

"Holograms are not direct pictures of objects; they are sort of smeared-out representations," explains Hans Jürgen Kreuzer, a physicist at Dalhousie University in Halifax, Nova Scotia. He and Dalhousie colleague Andrzej Wierzbicki worked with the IBM scientists to make a model for predicting the scattering patterns and to interpret experimental results. "We now have a theory that eliminates the guesswork," Kreuzer says.

But these researchers and others agree that the images still need work. The pictures display wavy patterns as well as hints of the real structure. "It's somewhere in between what you can see directly and a true hologram," says Dilano K. Saldin, a physicist at the University of Wisconsin-Milwaukee. "They claim that you can see atomic detail, but [the images] are not very clear."

Saldin and others rely on photoelectron and Auger spectroscopy data to reconstruct three-dimensional images (SN: 9/1/90, p.134). These images represent what most people think of as true holograms. Saldin expects Fink's group to develop comparable reconstruction schemes for the new technique.

One advantage of the electron projector, says Kreuzer, is that "you can fine-tune it depending on what you want to see." It can shoot out low-energy electrons for seeing overall shape and structure, and then high-energy electrons to resolve finer details. In addition, the scientists can adjust the distance between the tip and the sample.



Fink et al./IBM, Dalhousie Univ.

Electron hologram of DNA (left) and simulated hologram of a double helix of carbon.

The electrons emitted by the projector pack far less power than those used in transmission or scanning electron microscopy, two common imaging methods involving electrons. "Therefore, the amount of beam damage is much smaller," says Saldin. The new technique thus enables researchers to make holograms of biological molecules, such as DNA, without having to replace carbon atoms with larger atoms like gold.

"We are quite convinced that within a few years there will be thousands of these instruments in materials science and biomedical laboratories," says Kreuzer. "It is very powerful."

— E. Pennisi

Signs of early ozone loss

Researchers monitoring ozone levels over the South Pole report signs that the ozone hole may have started developing earlier than usual this year.

Balloon-borne sensors measured ozone values as low as 195 Dobson units during the second week of September, a week earlier than usual, says Samuel J. Oltmans of the National Oceanic and Atmospheric Administration in Boulder, Colo. He adds that the timing of the ozone depletion does not necessarily mean that this year's hole will be more severe than previous ones.

The ozone hole opens in September when sunlight returns to the extreme south, energizing reactions in which chlorine pollution breaks down ozone molecules in the lower stratosphere — between about 12 and 23 kilometers in altitude. The depletion progresses until early October, when warm winds invade the region and shut down the cycle of chemical destruction.

Although the balloon measurements hint that the hole might be opening early this year, these sensors probe only the region directly over the pole and cannot track the development of the entire hole. Indeed, satellite observations over a broad region show the hole forming essentially on schedule, says Arlin J. Krueger of NASA's Goddard Space Flight Center in Greenbelt, Md. □