

# Data from Space

*Adaptive array network could improve access to NASA's Earth-observing satellites.*

BY JOHN TOON

@ An adaptive array antenna system being studied by NASA and Georgia Tech could make information from the space agency's Earth-observing satellites more widely and rapidly available.



**ABOVE AND UPPER RIGHT:** Georgia Tech researchers install equipment and analyze data from an antenna array being tested on the roof of the Georgia Centers for Advanced Telecommunications Technology (GCATT) building.

Sophisticated signal-processing techniques and simple proof-of-principle antenna arrays built from PVC pipe, aluminum foil and copper wire could revolutionize the way NASA obtains data from its Earth-observing satellites.

If the adaptive array system being studied by NASA and Georgia Institute of Technology researchers ultimately proves feasible, it could dramatically decrease the cost of building and maintaining ground stations, thus enabling the cost-effective construction of many more such facilities. Ultimately, that could make information from the space agency's Earth-observing satellites more widely and rapidly available.

The "off-the-shelf" technology has already demonstrated that it can successfully receive one satellite telemetry frequency.

"The dream would be to provide total global coverage with these antenna systems and to network the systems together to make these NASA information services available to anybody sitting at a computer, almost like video-on-demand," explains Mary Ann Ingram, a professor in Georgia Tech's School of Electrical and Computer Engineering. "Timely information from Earth-observing satellites could be useful in many ways, such as directing operations to fight a forest fire."

Information from satellites such as Earth Observing-1 (EO-1) is now downlinked to various 11-meter dishes, primarily in the Arctic Circle, where sub-zero temperatures create maintenance and reliability issues for their complex aiming mechanisms. Typically, satellites such as EO-1 are in contact with these antenna systems between five and eight times a day for 10 minutes at a time. The present antenna systems cost about \$4 million each, and require resident crews to operate and maintain them.

The NASA/Georgia Tech project envisions replacing these antennas with a network of inexpensive antenna arrays that would have no moving parts and use sophisticated software — instead of careful aiming — to gather data from the satellites. The network could lower operational costs while improving access to the information.

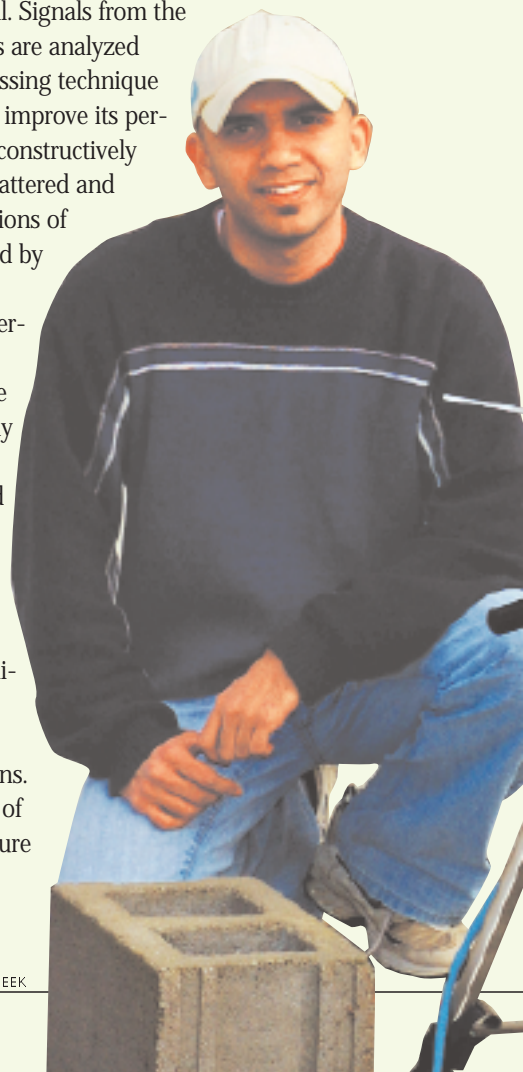
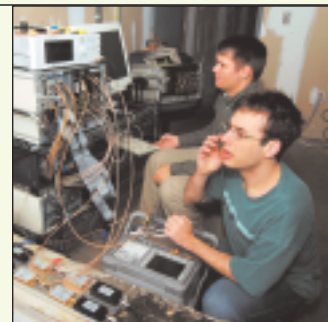
"When people use cell phones to make calls, there are no moving parts on the antennas," notes Dan Mandl,

mission director for NASA's EO-1 program at Goddard Space Flight Center near Washington, D.C. "What I would like to do is build a continuous cell-like network around the world that would provide almost unlimited opportunities to downlink data."

Mandl compared NASA's existing downlink system to old-fashioned pay phones located off expressway exits. "If you witness an accident, you can open your cell phone and call for assistance," he says. "But if you don't have a cell phone, you have to get off the highway at the next exit and hunt for a pay phone. What we would like to do is give these satellites the equivalent of cell phones to allow anytime, anywhere contact."

The proof-of-principle adaptive arrays being tested by Ingram and her research team are built from inexpensive components, including common PVC piping and aluminum foil. Signals from the four antennas are analyzed using a processing technique that learns to improve its performance by constructively combining scattered and reflected versions of the signal, and by suppressing noise and interference. That eliminates the need for costly front-end hardware and precise aiming of the antenna arrays, and allows flexibility in the location of ground stations.

"Instead of one big aperture from an



11-meter dish, we're going to use several smaller apertures being developed by NASA Glenn Research Center in Cleveland, in collaboration with industry and academia. We will connect them with digital signal processing," Ingram explains. "A smaller aperture has a wider beam, so the tracking requirement won't be as great. They may pick up interference, especially in tracking a satellite at a low-elevation angle, but because we combine multiple apertures, we can null out the interference."

The arrays individually won't provide the same data rate as NASA's large structures, but having more of them spread out around the world will compensate for that. Network capacity studies show that two ground stations, each with seven 0.75-meter dishes or eight electronically steered antennas, could equal the data capacity of NASA's existing 11-meter dish at Poker Flats, Alaska — at a significantly lower cost.

Because they don't depend on precisely aiming a dish, each array could potentially communicate with more than one satellite at a time. "What we'd really like to have is a shared antenna resource in which software is used to separate out the signals," Mandl explains. "As we get more satellites up in space, this will become more important."

In testing done on the Georgia Tech campus in Atlanta, the researchers were able to downlink EO-1 information in the S-band, a frequency used for transmissions at

low data rates. They had to develop a special filter to eliminate interference from terrestrial repeater stations of popular satellite radio services.

"We have demonstrated the lower rates in S-band, and during the upcoming year we will work on X-band for higher rates," Mandl says. "Ultimately, we would like to target data rates in the range of 300 megabits per second. The technology could also be used in future research to implement Ka, thus enabling even higher data rates."

To extend satellite reception time, the researchers are also examining several technical issues such as array-based synchronization and optimization of the tilt angles of the planar apertures of the electronically steered antennas. For example, this optimization could quadruple the download capacity for a ground station with eight co-located electronically steered antennas.

If successful, the adaptive array project would give NASA more flexibility in the design of future high-data-rate satellites that may generate terabits of data on each orbit of the earth. Reliably downlinking that amount of information will require a new approach, Mandl notes.

This effort is funded by NASA's Earth-Sun System Technology Office (ESTO) and represents a collaborative effort between Georgia Tech, NASA Goddard Space Flight Center (Greenbelt, Md.), NASA Glenn Research Center (Cleveland, Ohio), Saquish Group, Inc., and the University of Colorado at Boulder.

@ Read more at:  
[gtresearchnews.gatech.edu/reshor/rh-ss05/array.html](http://gtresearchnews.gatech.edu/reshor/rh-ss05/array.html)

**CONTACT**

**Mary Ann Ingram at  
404-894-9482 or  
mai@  
ece.gatech.edu**

*BELOW: Georgia Tech researchers led by Professor Mary Ann Ingram are developing an adaptive array antenna system that could revolutionize the way NASA obtains data from its Earth-observing satellites.*

