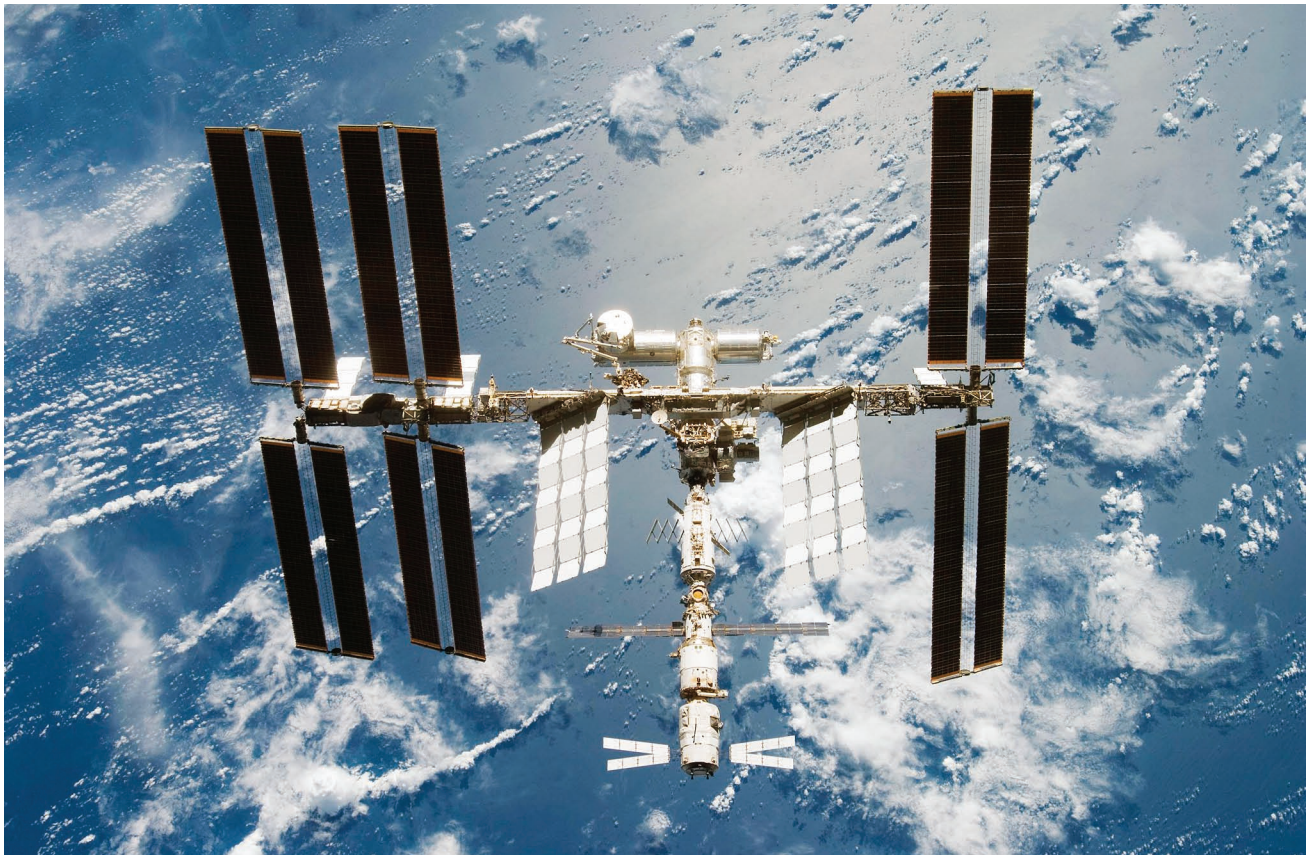

Interplanetary Internet Tested

Delay-tolerant network will weave a different kind of web in space

THE MANY paths a message can take through the Internet make that network robust and efficient—and the envy of those whose job it is to design communications schemes for the far-flung spacecraft leaving Earth each year. After more than a decade of development, NASA is in a rush to have a communications network ready by 2011 that can efficiently carry data between Earth and the multiple probes, rovers, orbiters, and spacecraft exploring the solar system—effectively binding them together to form an interplanetary Internet. Tests performed on the International Space Station last May were the second of three tryouts of the network's key technologies, called Delay Tolerant Networking, or DTN, protocols.

The DTN protocols will extend the terrestrial Internet into space by overcoming a number of obstacles, including the extraordinary length of time it takes packets to move between separate hops in a deep-space network, the intermittent nature of network connections, and bit-scrambling solar radiation.

"The communication delays are huge, and they are variable, because the planets are in orbit around the sun," says Vint Cerf, co-inventor of the Internet's TCP/IP protocol and a key member of a group of computer scientists who began working on DTN in 1998. On Earth, packets move from source to destination in milliseconds. By contrast, a one-way trip from Earth to Mars takes a minimum of 8 minutes. The constant motion of celestial bodies means that packets have to pause and wait for antennas to align as they hop from planet to probe to spacecraft.

So sending communications in space is very different from

SKY NET: Using computers on the International Space Station, engineers tested the protocols for a future interplanetary Internet in May 2009. *PHOTO: NASA*

update

doing so on Earth, where the stable topology of the Internet is taken for granted.

"What we have to do instead is to tell all the nodes that these are the changes that are going to occur," says Scott Burleigh, a software engineer at NASA's Jet Propulsion Laboratory, in Pasadena, Calif., and one of the original developers of DTN. "You are going to be able to communicate from A to B at this data rate starting at 12:30 and ending at 3:30, and then you are not going to be able to communicate on that link anymore...until next Tuesday."

An initial test of DTN in space last October was successful. The code was loaded on a comet-studying spacecraft called Deep Impact as that probe headed out for a flyby of Comet Hartley 2. "We turned on the software on the spacecraft and on about a dozen nodes on Earth and just left it running, completely automatic for about a month," Burleigh says. During the test about 300 images were transmitted over distances that stretched up to 24 million kilometers. Although a couple of bugs were found, no packets were dropped, and no bits got corrupted. The software even survived the unintentional reboot of one of the Earth-based antennas. "The protocols underneath it were able to recover the data and actually get stuff through," says Keith Scott, a principal engineer at Mitre Corp., in Reston, Va., who has been working on DTN with Burleigh and others.

A key to DTN is a technique called "store and forward." Basically, every node hangs onto the data it receives until it can safely pass it on. On Earth, the data would simply get dumped if there was a problem and be retransmitted by the source.

The second test, conducted by Kevin Gifford at the Payload Operations Control Center at the University of Colorado, Boulder, used computers on board the ISS to send images to Earth.

For a third test, scheduled for early October and involving the Deep Impact spacecraft, engineers will introduce a security protocol as well as a new file-transfer protocol. After that, DTN will be "pretty much ready for deep-space research," says Jay Wyatt, the NASA program manager who has been coordinating the project. At that point, the researchers are hoping other space agencies will try it also.

Mitre's Scott chairs a working group at the Consultative Committee for Space Data Systems, an international organization that recommends standards for spacecraft communications. They are considering adopting DTN. Then, mission by mission, a network would grow, weaving an interconnected Web between the planets, the space station, and spacecraft. —Elise Ackerman

PETER CADE/GETTY IMAGES

Of Cows and Power Lines

A team of researchers from Germany and the Czech Republic has discovered that, all factors being equal, cattle and two species of deer tend to align themselves along a north-south axis using some innate magnetic sense and that this preferred alignment is disturbed when they graze under high-voltage power lines.

For their research, Professor Hynek Burda and his team at Germany's University of Duisburg-Essen pored over images from Google Earth. When they spotted cattle that were at least 150 meters away from power lines, the researchers detected a significant alignment among the animals along the north-south axis. By contrast, images of cattle grazing within 50 meters of high-voltage overhead power lines showed no preferred body alignment. The exception was when the power lines ran east to west. In that case, the cattle tended to align along the direction of the power lines.

More at http://www.spectrum.ieee.org/energy/environment/of-cows-and-power-lines