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Monday, August 8, 2005

Small Satellites May Play Big Role In Future Interplanetary Missions

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Proponents of small satellites say that tiny spacecraft have potentially big roles to play in planetary exploration.

Today's small satellites--generally spacecraft weighing around several hundred kilograms--are confined largely to low Earth orbit where they perform remote sensing missions, conduct science operations and serve as technology testbeds and communication relays.

But some forward thinkers are already looking ahead to interplanetary missions and see small satellites as a good fit with the space exploration agendas outlined by the world's spacefaring nations.

The European Space Agency, for example, is taking a look at a low-cost, multiple spacecraft Venus mission that would utilize small satellite technologies, including a small, deployable weather balloon of sorts, to study the planet. The Indian Space Research Organization last year short listed a gravity-mapping nanosatellite for inclusion on its Chandrayaan-1 lunar orbiter mission.

Andy Phipps, a senior engineer at the British small satellite company Surrey Satellite Technology Ltd., said his team recently completed a so-called technology reference study funded by the European Space Agency to identify the

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technologies and design philosophy needed for the proposed Venus mission.

Phipps said his team spent 18 months and several hundred-thousand Euros developing a mission concept featuring two orbiters packed with miniaturized instruments and a tiny aerobot that would be dropped into Venus' corrosive atmosphere.

The aerobot, consisting of an instrument-laden gondola suspended from a balloon, would add about 90 kilograms of mass to one of the orbiters, a data relay satellite that would be placed in a highly elliptical orbit around Venus. The aerobot would be dropped into Venus' atmosphere where it would float at an altitude of 55 kilometers, circumnavigating the planet several times during its projected 15- to 22-day mission.

The other orbiter would be packed with miniaturized instruments and would circle the planet at a lower altitude, imaging the planet and making scientific measurements.

The proposed orbiters themselves would be relatively small for interplanetary spacecraft, weighing several hundred kilograms apiece. NASA's Mars Reconnaissance Orbiter, in contrast, will weigh nearly 2,200 kilograms at launch and require an Atlas 5 rocket to reach orbit.

The two satellites and the inflatable robotic stowaway would launch on a single Russian-built Soyuz rocket equipped with an upper stage. The total projected mission cost, Phipps said, is several hundred-million dollars, or about one-tenth of what the U.S. and Europe spent on the Cassini-Huygens mission to Saturn.

The proposed Venus Entry Probe mission is only one of a half-dozen mission ideas the European Space Agency is considering as it looks ahead to the 2015-2025 timeframe to try to understand what technologies it should be investing in now.

Phipps said the technology needs of the Venus Entry Probe mission are considerable and include: highly protective cover glass to shield imaging instruments from acid rain; steerable planar array antennas to increase data return from the aerobot; higher efficiency solar cells; low-mass structural components that can withstand the planet's corrosive environment; and lightweight thermal protection system for the aerobot's entry vehicle.

Phipps' colleagues will be presenting the Venus Entry Probe mission concept at the 19th Annual Small Satellite Conference in Logan, Utah, Aug. 8-11.

Also presenting at the conference is a group of Canadian scientists and engineers that have come up with a nanosatellite mission dubbed Lunette that would map the gravitational field of the far side of the Moon.

Kieran Carroll, a Lunette team member and director of technology development at Gedex Inc., a Toronto-based start-up company specializing in terrestrial gravity mapping for mineral exploration, said better maps of the Moon's irregular gravitational field would shed more light on the lunar interior, aid the cause of exploration by potentially locating useful resources below the Moon's surface and help engineers better plan and operate missions in lunar orbit.

Carroll said that when spacecraft began orbiting the Moon in the 1960s it became clear just how lumpy and irregular the Moon's gravitational field is compared to the Earth's. Spacecraft tracking data obtained during the Apollo program and more recently from NASA's Lunar Prospector mission have produced decent -- yet far from perfect -- gravity maps of the near side of the Moon. But gravity maps of the Moon's far side, Carrol said, are "largely guess work at this point" because Earth-based tracking stations lose sight of spacecraft as they travel over the lunar horizon.

The Lunette mission would solve that problem, Carroll said, by substituting spacecraft-to-spacecraft tracking for Earth-based tracking. Lunette is a five-kilogram payload that would be added to a low altitude, lunar polar-orbiting satellite mission such as the Indian Space Research Organisation's Chandrayaan-1, or NASA's Lunar Reconnaissance Orbiter. The payload consists of a three-and-one-half-kilogram nanosatellite and a small amount of equipment that would need to be left behind on the parent spacecraft for the mapping mission.

The Lunette nanosatellite would be released from its parent spacecraft and then maintain a distance of 100 kilometers. The two spacecraft would send signals back and forth using low-power transponders. By measuring slight changes in the signal, the differential effect gravity has on each spacecraft can be measured, enabling scientists and engineers to create a detailed map of the Moon's lumpy gravitational field.

"All the gravity models of the Moon have been done using similar techniques except tracking stations on the Earth have sent signals to spacecraft at the Moon," Carroll said. "That's a classic range-rate tracking exercise NASA does on almost all spacecraft it sends into deep space."

While that tried and true technique works fine for mapping the side of the Moon that faces Earth, it does not work so well for the far side of the Moon, Carroll said. "What we aim to do is to do Doppler tracking on the far side of the Moon by tracking between one spacecraft and another."

The Indian Space Research Organisation short listed Lunette for inclusion on Chandrayaan-1 last year, Carroll said, but had to move on when the team was unable to secure an immediate funding commitment from the Canadian Space Agency.

Likewise, the window of opportunity for including Lunette on the Lunar Reconnaissance Orbiter has closed. NASA already has chosen its payloads for the 2008 mission, and the NASA official in charge of the project said it is too late to accommodate something like Lunette. "Effectively the door is closed because of the timing," NASA Lunar Reconnaissance Orbiter program manager Mark Borkowski said.

Carroll said the team is still trying to line up a funding commitment for the mission, which he said could be done for a "Canadian-sized prize" of just a few million dollars provided accommodations for the tiny nanosatellite can be secured aboard some future Moon-bound orbiter.