Working Toward More Affordable Deep Space Cubesat Communications: MSPA and OMSPA

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While the cost to build and launch spacecraft tends to scale down with size, the cost to communicate does not. In fact, deep space cubesats generally need more communications capability on the ground because the capability onboard the spacecraft is so mass-, power-, and volume-constrained. Hence, an increasing number of cubesats slated for deployment beyond geosynchronous orbit are looking to NASA's Deep Space Network (DSN) for support. This presents the DSN with a two-fold challenge: (1) providing communications for the growing numbers of cubesats with a limited number of ground antennas, and (2) doing so at an attributed cost that cubesat missions can afford.

As part of its strategy for addressing this two-fold challenge, the DSN has been investigating various techniques for providing simultaneous, multi-spacecraft communications via a single antenna. Such techniques are further along for downlink than for uplink. In fact, one of the downlink techniques, Multiple Spacecraft Per Antenna (MSPA), has already been in use for more than a decade. It involves having multiple spacecraft, within an antenna's half-power beamwidth, share the antenna by transmitting at separate frequencies to separate receivers. To date, only two spacecraft have typically been serviced at a time in this manner (2-MSPA). The DSN is currently in the process of upgrading this capability to handle four spacecraft at a time (4-MSPA). In the future, it has plans to upgrade to a spacecraft capability greater than four (n-MSPA). In addition to allowing the DSN to service more missions, such MSPA techniques would also provide cubesat users with opportunities for reduced aperture fees. While NASA users do not actually pay these fees, they do count toward a mission's bottom-line cost during selection.

The DSN is also investigating a technique known as Opportunistic MSPA (OMSPA). In this technique, the additional receivers characteristic of MSPA are replaced by a single recorder. If one or more cubesats determine that they will be within the half-power beamwidth of another spacecraft's ground antenna, they can arrange to opportunistically transmit open-loop while the other spacecraft communicates via a traditionally scheduled link. These open-loop transmissions get captured on the antenna's recorder and can be subsequently retrieved for demodulation and decoding. Unlike MSPA, the number of OMSPA users is not constrained by the number of available receivers. And, the OMSPA user does not have to schedule the antenna pass; the user only has to know when it will be in the ground-antenna beam of a spacecraft that does have a scheduled communications link. So, if offered as a service in the future, it might involve some sort of nominal flat fee, rather than an antenna-time-based fee.

The process of data recovery, however, does introduce a latency not encountered with MSPA. So, OMSPA may be better suited for routine downlink; MSPA for time-critical downlink.

Prospective cubesat users wanting to take advantage of these techniques need to pursue mission designs that maximize shared beam opportunities. Three example deep space destination classes with potential beam-sharing opportunities include: Mars and Venus missions, “flotillas” of cubesats in heliocentric Earth Trailing and Earth Leading orbits, and Sun-Earth Lagrange point 1 and 2 orbits coinciding with heliophysical and astrophysical observatory locations.